Do fathers care? Measuring mothers' and fathers' perceptions of fathers' involvement in caring for young children in South Africa

by

Gareth D. Mercer

B.Sc., The University of British Columbia, 2008

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in

The Faculty of Graduate and Postdoctoral Studies

(Population and Public Health)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

July 2015

Abstract

Fathers can be an important source of support for children. However, in South Africa, many children do not reside with their biological father and little is known about fathers' involvement in children's care. A questionnaire that reliably measures fathers' involvement and is adaptable to varied residential arrangements would facilitate future population-level research. We explored whether children who reside with their biological father have better health than children whose fathers live elsewhere. We also assessed whether a questionnaire adapted from surveys in the United States would reliably measure South African fathers' involvement in caring for infants. With data from the 1998 Demographic and Health Survey, we used multilevel logistic regression to estimate associations between father-child co-residence status and four child health outcomes: breastfeeding for $\geq$6 months; immunization completeness; recent acute respiratory infection; and recent diarrhea. We found that children with non-co-resident fathers were not at higher risk of these health outcomes. As part of a separate longitudinal cohort study in the Western Cape, we had a sample of mothers complete questionnaires about their infants' fathers' care involvement when infants were 2 weeks, 16 weeks and 6 months old. Using Item Response Theory models we estimated the distribution of the fathers' levels of involvement in five hypothetically distinct modes of care. We used total information functions to assess the precision of father involvement estimates. Most fathers were reportedly spending time with infants, doing routine care activities and providing financially. Fewer fathers were involved in important care decisions or doing household chores. For most fathers in the sample, the questionnaire gave precise estimates of involvement in three modes of care: Accessibility, Direct Caregiving, and Practical Support for Mother. In contrast, items measuring Material Provisioning and Responsibility gave imprecise estimates for the majority of fathers. Our findings reinforce existing evidence that co-residence status is an inadequate proxy for care involvement. Future population-level research into fathers' influences on children's health should directly measure fathers' care practices. With further validation, the questionnaire assessed in this study could be used to measure the more direct modes of infant care.

Preface

I had primary responsibility for conceiving of the project and research questions; designing, conducting, and interpreting the analyses; and writing the dissertation.

Together with my research supervisor and the other investigators, I contributed to writing the protocol for the Mother Infant Health Study. Data collection for the study (including the Fathering Sub-study) was done by local research assistants, with training and oversight given jointly by me and a professional clinical research co-ordinator. Data collection was also directly overseen by the local principal investigators (Mark Cotton and Monika Esser) and less directly by the UBC principal investigators (David Speert, Tobias Kollmann and Julie Bettinger). I had primary responsibility for the following additional aspects of the Fathering Sub-study: writing the protocol, adapting and revising the fathering questionnaire, and assessing the quality of data collection. I also secured Canadian Institutes of Health Research funding for, and organized, a feedback meeting following the study.

All steps of the research project were completed with input from and under the guidance of members of my research supervisory committee.

The Mother Infant Health Study (including the Fathering Sub-Study) protocol was approved by the human research ethics committees at the Children's and Women's Health Centre of BC (Project title: "The Mother Infant Health Study", Certificate number: H12-01181) and Stellenbosch University (Certificate number: S12/01/009).

Table of Contents

Appendices

List of Tables

List of Figures

Acknowledgements

I am grateful to my supervisor – Julie Bettinger – and supervisory committee – Rachel Jewkes, Ying MacNab, David Patrick, Jane Buxton, and Clyde Hertzman – for their expert guidance and warm encouragement throughout the course of this project.

I am also grateful to all who made the Mother Infant Health Study a reality: Monika Esser, Mark Cotton, David Speert and Tobi Kollmann for their oversight, and especially to David for generously providing funding for the MIHS Fathering Sub-study; Amy Slogrove and Moleen Zunza for their major contributions to the study design and for their emotional and intellectual support; and the staff members of the Children's Infections Diseases Clinical Research Unit (KID-CRU) and the Vaccine Evaluation Centre, with extra thanks to Carlos Moffatt, Marchalaine Hendricks, Kim Marty, and Wenli Zhang for their incredible dedication.

Heartfelt thanks to Robert Morrell and Elena Moore for their generous mentorship and encouragement during my time in Cape Town.

Thank you to the participants of the Diemersfontein, Rawdons and Pretoria Hegemonic Masculinity workshops, the "Families, Kin and the State in South Africa" workshop, and the "Promises and Challenges of Researching Fathering in South Africa" workshop for the feedback they gave while this research was still in progress.

Thank you, finally, to the Peter Wall Institute for Advanced Studies for funding the Mother Infant Health Study, the Canadian Institutes of Health Research for funding the MIHS Fathering Sub-study dissemination events, and the UBC MD/PhD Program, Canadian Institutes of Health Research and Vanier Canada Graduate Scholarships Program for my personal funding.

This work is dedicated to Family (in all its rich diversity) . . .

. . . to my own family (Rachel, Leon, Mum, Dad, Terri, Reta, and Ian) . . .

. . . and to the families who generously took part in the Mother Infant Health Study.

Chapter 1

Introduction

Rates of child and infant mortality in South Africa are high relative to those of countries with similar per capita gross domestic product [1]. In addition, South Africa is one of the few countries where the under-five mortality rate has declined little over the last decade [2, p. 30]. Various data sources suggest that reductions in infant and child mortality observed over the latter half of the 20th century were halted and somewhat reversed during the 1990s. The Inter-agency Group for Child Mortality Estimates at the United Nations Children's Fund estimate that the under-five mortality rate was 60.8 per 1000 live births in 1990, rose to a high of 80.3 per 1000 in 2003/4 and had declined to 52.9 per 1000 by 2010 [1]. The increase during the 1990s is thought to be the result of increasing HIV prevalence and deteriorations in health care quality. The decline during the latter half of the 2000s coincides with implementation of a national programme for preventing mother-to-child transmission of HIV, so is likely partially attributable to reductions in vertical HIV transmission [2, p. 30][3, p. 62].

Approximately one fifth of child deaths occur during the neonatal period (first four weeks of life), one half between one and twelve months of age, and the remainder between one and five years of age [3, p. 64]. The dominant causes of death vary somewhat by age-group but, outside of the neonatal period, HIV/AIDS and respiratory and gastrointestinal infections cause most deaths. National death notification statistics for 2007 suggest that intestinal and respiratory infections directly caused as many as one third of the deaths of children aged one month to four years old [3, p. 65]. However, these statistics are known to underestimate the percentage of deaths having HIV/AIDS as an underlying cause. Statistical models and demographic surveillance sites, which are more sensitive to the contribution of HIV-infection, suggest that this may be the single largest cause of child deaths, accounting for around 35% [2, p. 31][3, p. 66]. Malnutrition is another important underlying cause, with around 60% of children who die in hospital reported to be underweight (greater than two standard deviations below mean weight-for-age) and half reported to be severely malnourished (greater than three standard deviations below the mean) [3, p. 66]. HIV infection and malnutrition compromise children's immune system function, thereby increasing their susceptibility to, and the severity of, common infections. In addition, illnesses, particularly infections, increase children's risk of malnutrition by reducing their dietary intake and/or by disrupting their physiological nutrient utilization [4, p. 18]. In this way, the majority of child deaths in South Africa result from the synergistic effects of malnutrition and infectious illnesses.

The relatively high average child mortality rate conceals large inequities in the distribution of child mortality risk across the South African population. The South African Demographic and Health Survey, a national household survey conducted in 1998, generated some of the most detailed data available to describe these inequities. It documented that the under-five mortality rate was 65% higher in non-urban children than in urban children, 200-400% higher among Black children than among children in other population groups, and 250-300% higher among children whose mothers had completed no education than among those whose mothers had completed secondary school or some post-secondary education. There was also a two-fold difference in under-five mortality between provinces with the highest and lowest rates [5][6].

There is a clear imperative to reduce child mortality and to increase equity in child health in South Africa. It is likely that multifaceted strategies will be necessary to achieve improvements [7][2]. Some strategies may focus on improving accessibility and quality of health services. The post-Apartheid government has demonstrated a commitment to improving maternal and child health by investing in new primary-level clinics and by removing user fees for services at primary- and district-level facilities [7]. Nevertheless, there are large discrepancies between well-resourced and poorly-resourced areas of the country in the coverage of key maternal and child health interventions (e.g.: proportion of births occurring in a medical facility and proportion of children fully immunized) [8, 2]. The government-funded public health sector is also grossly under-resourced relative to the for-profit private sector, which draws a disproportionate percentage of health professionals into providing care to a wealthy minority of the population [9, p. 1027]. An example of one important health service intervention would be to ensure that all HIV-infected pregnant women and their babies are offered vertical HIV transmission prophylaxis [2, p. 37].

However, the existence of long-established, even widening, socioeconomic inequities necessitates additional interventions outside of the health care system. Recognizing the central importance of families in mediating and moderating the causes of child mortality, some authors have recommended that interventions ought to focus on strengthening and supporting families [10]. HIV, as an infection transmitted between family members during their most intimate interactions, has highlighted the potential gains to be achieved by focusing on families, rather than individuals, in efforts to prevent HIV transmission [11]. Families are also of central importance for achieving adequate child nutrition and for preventing and treating common childhood illnesses.

Over the past couple of decades, there has been growing awareness internationally of the need to better integrate men into efforts to promote reproductive- and child-health. Prior to this, most interventions tended to target women [12, 13]. In one sense, this approach was justified because, in many cultures, child birth and caring for young children were traditionally the responsibility of women. However, it has also been problematic because it ignores the reality that, in most societies, men have more power than women in decisions related to family members' wellbeing [14]. Ignoring the importance of the role played by men may have limited the reach and effectiveness of many of these interventions. In addition, the orientation of reproductive health services towards women tended to reinforce the perception among men that utilization of these services should be the responsibility of their female partners [12, 13].

This awareness has been part of a wider ideological shift in the field of international development around the necessity to actively involve men in efforts to achieve gender equity. This position was first crystallized in a major way in the plan of action adopted at the 1994 UN-sponsored International Conference on Population and Development. The plan of action included explicit objectives to "...encourage and enable men to take responsibility for their sexual and reproductive behaviour...” and to promote “...equal participation of women and men in all areas of family and household responsibilities, including family planning, child-rearing and housework....” [14] The goals of this plan of action were twofold: to improve the health of women, children and men as worthy outcomes in their own right, and to obtain more equal involvement of men in family planning and childcare as paths to achieving gender equitable societies.

Achieving the above goals holds clear promise for improving infant and child health in South Africa. For example, as described above, HIV infection is a major contributor to child mortality. Maternal HIV death is a also significant risk factor for subsequent child mortality [15]. Including women’s partners in antenatal HIV testing and counselling could prevent horizontal transmission among couples in which one parter is infected and the other is not. Research in sub-saharan Africa has also demonstrated that participation of male partners in prevention of mother-to-child transmission services is associated with lower risk of HIV transmission to children [16]. Furthermore, dominant gender norms in South Africa have been implicated as root causes in some of the most pressing public health concerns in the country. By legitimizing men’s physical and sexual dominance over women, these patriarchal norms promote high rates of HIV transmission [17] and contribute to the epidemic-levels of rape and intimate partner violence perpetrated by South African men [18, 19]. Finally, related ideals of masculine conduct can prevent men from accessing necessary health services, including HIV testing and treatment [17]. Therefore, transforming inequitable gender attitudes has immense potential to improve the health of women, men and children.

In Africa, much of the research that has attempted to understand and promote men’s equal involvement in family responsibilities has focused on sexual and reproductive health, particularly HIV testing. In contrast, very little is known about men’s involvement in caring for children [20]. This is despite the fact that there is now considerable evidence from research in North America and Europe showing that greater involvement of fathers in caregiving improves children’s psychological, behavioural, and social outcomes [21]. Another limitation of existing research is that much of it focuses narrowly on men’s problematic behaviours, such as their infidelity and sexual risk behaviours. This has contributed to a stereotypical perception of men as “obstacles to health instead of partners in promoting family health.” [12, 13, p. 5] Examining the positive ways that men are involved in family life can help to challenge negative stereotypes and inform interventions that seek to engage men as agents of positive change [22].

With these points in mind, the general aim of this study is to explore fathers’ contributions to the care and wellbeing of young children in South Africa, and to identify factors which support and impede these contributions. More specifically, we aim to evaluate the utility of two different approaches for measuring biological fathers’ involvement in their children’s lives. Our research objectives and specific research questions are as follows:

1. To determine whether children whose biological fathers reside with them tend to have better health outcomes than children whose biological fathers do not reside with them.

    (a) Among children under 5 years of age in South Africa, do those living with two biological parents compared to those living with a mother but not a father tend to be more likely to have been breastfed for at least six months or to have received all age-appropriate immunizations?

(b) Among children under 5 years of age in South Africa, do those living with two biological parents compared to those living with a mother but not a father tend to be less likely to have had a recent acute respiratory infection or diarrhoeal illness?

(c) Does mother's marital status or having additional adult family members living in the household modify the association between living with two biological parents and experiencing breastfeeding, immunizations, respiratory infection or diarrhoeal illness?

(d) To what extend does the association between having a co-resident biological father and each of the above child health outcomes vary across children living in different neighbourhoods?

(e) Do neighbourhood levels of gender equality in educational levels, unemployment rate, and concentration of low-income households modify the association between having a co-resident father and each of the above child health outcomes?

2. To evaluate a questionnaire designed to measure fathers' involvement in caring for infants in South Africa.

   (a) In what ways and to what extent are a sample of South African fathers involved in caring for their children at 2-weeks, 16-weeks, and 6-months after birth? What characteristics are most strongly associated with father's levels of involvement?

   (b) Does a questionnaire adapted from research on US fathers provide reliable and valid measures of South African fathers' involvement in five distinct modes of child care?

   (c) Do co-resident fathers have significantly higher levels of care involvement than non-co-resident fathers? Is there evidence that any questionnaire items function significantly differently for non-co-resident compared to co-resident fathers?

   (d) What is the level of agreement between fathers' and mothers' reports of fathers' involvement in different modes of child care?

We intend for our findings to inform future population-level research into the involvement of men in child-rearing. This future research could be used to design interventions to promote beneficial forms of men's involvement, both for the purpose of improving child health and for transforming harmful gender norms.

We have chosen to restrict our focus to fathers of young children. We justify this focus because of our interest in contributing to reductions in child morbidity and mortality. However, research into the nature and sources of men's caregiving at other stages of the life course (for example, in parenting school-aged children and adolescents, and in caring for sick individuals) is also warranted. We also acknowledge that better understanding men's positive contributions is only one part of the problem. Further research is also needed on the ways in which men's behaviour can be harmful for children. However, this will not be a focus of the present study.

In the following chapter we review theoretical and empirical literature on the relationship between fathers' contributions and children's wellbeing. We highlight some gaps in the existing literature, which the above research questions are intended to address. In chapters 3-5 we present the analytic approach, results and discussion for research questions 1a-e. Chapters 6-8 address research questions 2a-c. In Chapter 9 we present a unified discussion of our findings and recommendations for future research and interventions.

Chapter 2

Literature Review

This chapter reviews the theoretical and empirical evidence base for studying fathers' influences on their children's health. We have two aims in reviewing this literature: i) to describe various conceptual frameworks that this study draws from; and ii) to highlight the existing knowledge gaps that our research questions are intended to address. We begin by defining a few terms used throughout the review. We then review conceptual literature on the determinants of child health and on the sources and types of contributions fathers may make to their children. We synthesize ideas from this theoretical material to identify pathways through which fathers may influence their children's health. In the final section of this chapter, we review empirical evidence for the influences that fathers can have on children's health.

Definitions

Conventionally the word *father* is used to denote a child's male genetic parent, or the man married to the child's mother. In this study we have chosen primarily to focus on fathers who meet this biological definition. Our reasons for this are that existing household surveys in South Africa use the biological definition to identify children's fathers, most research on the influence of household membership on child health focuses exclusively on biological fathers, and most theoretical research on the parenting practices of fathers has been oriented toward biological fathers. For this reason, in this study we use the term *father* to refer to a child's biological father.

However, because of demographic changes, including increasing rates of non-marital childbearing, divorce, step-parenting and adoption, the conventional biological definition does not adequately capture the situation for many men who are *doing fathering* today [23]. Scholars have emphasized the need to understand the broader, social definition of being a father, that is, as "a role that is understood and exercised in different ways" [24, p. 14]. The term *fatherhood* is used to refer to the collective social meanings associated with being a father [25, p. 7]. In contrast to the biological concept of father, the social concept of fatherhood is fluid, both over time and between different cultures and social classes. In many traditional African cultures, and increasingly in western societies, the social meanings associated with being a father do not presuppose genetic relatedness [24]. Although we focus on biological fathers in this study, we are interested in the ways in which different men enact the role of father, given the resources and constraints they experience, rather than in the genetic endowments of fathers to their children. Our intention is that the findings of this study should inform future research with biological fathers and with social fathers (i.e.: men who meet the social definition of father towards a child, even though they are not the child's biological father).

The meanings attached to being a father can also be distinguished from the actual parenting practices of fathers, which are collectively referred to as *fathering*. Related to fathering is the concept of *father involvement*, which has been used to define the direct caregiving activities of fathers with children [26, 23, p. 884]. *Care,* as used in this definition, refers to both the “set of activities and resources” given by the carer as as well as “feelings of care....” [27, p. 17-18]

2.1 Theoretical basis for paternal influence on child health

The theoretical construct of primary interest in this study is fathers’ capacity to positively influence their children’s wellbeing. In the following sections we synthesize ideas from three separate conceptual frameworks to explain how this capacity becomes manifested in a variety of different fathering practices, which in turn may influence children’s health. The first framework distinguishes different pathways or “modes” through which fathers may influence the care their children receive. The second framework proposes a causal mechanism for how social and economic characteristics determine children’s risks of mortality in low-to-middle-income settings. The third framework applies a systems ecological lens to organize the various factors which influence the amount and nature of fathers’ involvement in children’s care. Although we draw ideas from multiple conceptual models, throughout we refer to this collection of conceptual material as a singular “model”. Central to our thinking is the idea that the nature of a man’s fathering will depend on his motivation, but also on his skill at recognizing and managing his child’s needs and, crucially, on the family and societal context [26]. Skill and context can be considered as resources that fathers mobilize in order to realize their desires for child wellbeing. Considering the influences on fathering as a system is important because access to resources is not uniform across or within societies. Therefore, similar motivation for child wellbeing may manifest in different patterns of fathering depending on the individual’s situation.

2.1.1 Conceptualizing the modes of paternal influence on child health

To explore fathers’ influences on children’s health, it is necessary to consider the various ways for fathers to be involved in their children’s lives. These different types of involvement have been referred to as “modes of paternal influence” [28]. Fathers may be directly involved in caregiving activities with children. In addition, fathers may indirectly influence children’s care through their economic provisioning and by providing support to mothers and other caregivers [28, 29]. We describe these modes of influence in more detail below.

Direct caregiving activities, defined as ‘father’s involvement’ [26], have received considerable attention in research on children’s psychological development. To increase the conceptual clarity and comparability of early research in this area, Lamb *et al.* proposed a model comprised of three distinct domains of father involvement: *engagement*, *accessibility* and *responsibility* [26]. *Engagement* is defined as direct interaction with a child, for example during caregiving activities and play. *Accessibility* includes being available to and supervising the child but involves less direct interaction. *Responsibility* is taking a primary role in recognizing and making arrangements for a child’s needs, for example, organizing to attend health clinics for immunizations. Early uses of the father involvement construct focused on the amount of time fathers directed to each domain of involvement and did not consider the actual content of caregiving activities. However, in more recent applications of this model, researchers have evaluated fathers' amounts of involvement in specific care activities expected to be beneficial to children [30]. This revised construct has been labelled 'positive father involvement' [30]. There has been relatively little research into the importance of fathers' direct caregiving activities for child health. Possibly this is because caregiving is traditionally considered to be the responsibility of mothers, leading many to assume that fathers' contributions in this domain will be of secondary importance [28, p. 7-8].

Economic provisioning (or breadwinning) features prominently in popular perceptions of 'good' fathering (in South Africa as well as in North America) [31, 32]. It includes ensuring that children's needs for nutritious food, clean drinking water and adequate clothing and shelter are met, and is thus an important means for fathers to promote good child health. Nevertheless, there is frequently a trade off between fathers' levels of economic provisioning and the amount of time they spend in direct child care activities.

Fathers may also contribute indirectly to their children's wellbeing by *supporting mothers or other caregivers*. Support may be emotional or practical, such as giving information or advice, caring for other children, or doing household chores [28]. In terms of child health outcomes, support from fathers may be particularly beneficial in helping to establish an environment conducive for mothers to practice health-promoting care behaviours like breastfeeding [33] and by enabling mothers to cope with emotionally upsetting life experiences, which might otherwise increase the risk of adverse birth outcomes [34] or interfere with maternal-infant bonding [35, 36].

2.1.2 Distal and proximal influences on child health in South Africa

In this section we describe a conceptual framework that integrates perspectives from biomedical and social science research to organize the major determinants of child morbidity and mortality in low- and middle-income countries [37]. We draw on this framework to identify child health determinants over which fathers may have some control via the modes of paternal influence described above. The framework also allows us to identify competing determinants that need to be accounted for in trying to isolate the effect of father's influences.

Consistent with findings from biomedical research, the framework identifies illness and malnutrition, operating in synergy, as the direct causes of most child deaths. Furthermore, the framework emphasizes that children's susceptibility to illness and their chances of recovering good health are related to other individual-level biological characteristics as well as to characteristics of the social, economic, and cultural contexts. The causal foundation of the framework, as described by Mosley and Chen, is that "all social and economic determinants of child mortality necessarily operate through a common set of biological mechanisms, or proximate determinants, to exert an impact on mortality" [37, p. 25]. The proximate biological determinants they identified were:

- *maternal factors*, such as age, parity and birth interval;
- *environmental exposure* to infectious organisms through ingestion, inhalation, and insect vectors;

- *nutrient deficiency*;
- *injury*; and
- *personal illness control*, which includes measures to prevent illness and therapeutic measures to restore health [37].

Millard extended the concept of proximal determinants to include child care practices and other behaviours (for example, food preparation practices) that influence children's risk of experiencing illness and malnutrition [38].

The more distal, socioeconomic determinants of child health identified by these authors include individual characteristics of children's parents (such as knowledge and attitudes); household characteristics (including income and wealth, and division of labour and decision-making power); and features of the natural environment and the social, cultural, political and economic contexts in which families are located [37].

Fathers may influence their children's health by intervening directly on the proximal determinants. For example, through involvement in direct caregiving, as well as by supporting other caregivers, fathers could promote care behaviours which reduce children's exposure to infectious organisms and reduce their risk of injury. Alternatively, fathers may make contributions at the level of the socioeconomic determinants to improve their children's health. For example, by helping to provide adequate food, water, shelter and transport, fathers could reduce children's exposure to infectious organisms, reduce their risk of malnutrition and improve their access both preventative and therapeutic health care services.

However, fathers require access to resources to effectively intervene on the determinants of child health. In their framework, Mosley and Chen identified parental knowledge and skill and household income as examples of important resources. Other theorists in economics and sociology have identified different types of family or household resources that are important for child wellbeing. For example, Becker's time allocation (or household production) model [39] views families as units of production, capable of acting rationally to maximize their production of desired outcomes (reviewed by Ribar [40, p. 4-6], and Haveman and Wolfe [41, p. 1832-4]). Decision-makers in the family decide how much of family members' time will be allocated to generating economic resources and how these resources will be allocated to purchasing goods and services. To some extent, family members can substitute purchased goods and services in place of contributions of their time in order to achieve desired outcomes. Importantly, these decisions are constrained by the total quantity of family members' time, and by the wages and prices available to them, neither of which are constant across families. We apply this model to suggest hypotheses about parents' decision-making in relation to their children's physical wellbeing, given the resources available to them. For example, parents choose between whether to allocate time to breastfeeding or to substitute this with purchased infant formula. Holding prices and wages constant, mothers in households with fewer adult members (and, therefore, overall less time) may experience greater pressure to allocate time toward wage labour and away from breastfeeding. In contrast, given similar amounts of time, mothers in households with access to lower wages or higher formula prices, would be predicted to be more likely to breastfeed.

We also acknowledge some important limitations of the time allocation model identified by feminist scholars: first, there may be conflict between household members over the prioritization of different outcomes, and, second, power over the allocation of household resources is usually not shared equally among household members [42]. In addition, male and female parents may vary in how they make use of similar resources in securing child health. Research in South Africa suggests that the greater financial autonomy women enjoy in female-headed households may allow them to make food purchasing decisions that are more sensitive to children's needs than would be made in similar male-headed households [43, p. 21]. Because access to resources is strongly influenced by gender, male and female parents may be able to mobilize different types of resources in differing amounts [28]. For these reasons, it is important to consider the nature of the relationships among household members as well as how access to resources is shaped by wider gender relations. These influence each parent's 'bargaining power' in decisions about how household resources will be allocated [42].

While Becker's model focuses on time and economic resources, Coleman describes the importance of human and social capital in children's development [44, p. S109-13]. *Human capital* includes parents' knowledge and skill in caring for children, which, in turn, influence their health-related behaviours and care practices. In contrast, *social capital* derives from social structures that function as resources for individuals. These include the relations between family members [44, p. S110]. For example, according to the patrilineal system of descent common among the African cultural groups of South Africa, acknowledged paternity confers on children recognition as a member of their father's clan (or kin network) [45]. Structured relations among clan members include reciprocal obligations to provide care for children and assistance in times of need [45, 46].

Considering the types of resources that parents require to influence their children's wellbeing, as well as how access to these resources is shaped by social structures such as race, gender and social class [38], is important for comparing father's influence in different household and societal contexts. This understanding is critical for studying child health in the South African context, where the former Apartheid political system enforced a grossly unequal distribution of resources and where large inequities are still evident, despite radical legal reforms post-Apartheid. In addition, some biological determinants of child health will be out of parents' control. Examining interactions between context and individual behavioural and biological characteristics can help to elucidate the complex mechanisms producing positive child health outcomes.

2.1.3 A systemic ecological model of fathering and child health

To conclude our review of theoretical literature on father's influences on child health, we expand on the idea that both fathering and child health are shaped by a complex system of factors, spanning from the level of individual children and fathers up to the level of societies. We suggest that a number of the factors identified as determinants of child health in Mosley and Chen's model also influence fathering, meaning that it is important to consider these factors either as potential confounders or as modifiers of father's influence on child health.

Doherty *et al.* proposed a 'systemic ecological' model of the influences on fathering [47]. This model is useful for our purposes because it is intended to be general enough to describe factors influencing the practices of fathers who live with their children and those who live apart (hereafter referred to as co-resident and non-co-resident fathers, respectively). In addition, it depicts fathering as a dynamic process involving individual, inter-personal, and contextual factors. The central portion of the model is the child-father-mother triad, in which individual characteristics of each member as well as characteristics of the relationships between them are emphasized.

- *Father characteristics* include knowledge and skill, commitment, psychological wellbeing, residential status, employment characteristics, and identification with the father role.
- *Mother characteristics* include attitudes toward and expectations of the father, support of the father, and employment characteristics.
- *Child characteristics* include sex, age, developmental status, temperament and behavioural difficulties.
- *Father-mother relationship characteristics* include marital status, dual vs. single earner, relationship commitment, co-operation, mutual support, and conflict.

The model also highlights the importance of the contextual environment in which the triad is embedded. *Contextual characteristics* influencing fathering include institutional practices, employment opportunities and other economic factors, race-related resources and challenges, cultural expectations, and social support.

It is worth identifying factors in this general model that may be of particular importance for fathering in South Africa due to the cultural, economic and political history of the country. The particular way these factors intersect in South Africa may be somewhat unique. Nevertheless, there are clear similarities with other Southern African countries and even with the situations of African Americans in the United States [48].

First, a large proportion of South African children and fathers live apart. Between 2002 and 2013 the percentage of children under 5 years old who were residing with their biological father declined from 43% to 39% (Calculated by the author from South African General Household Survey data [49]). Factors contributing to residential separation include labour migration, cultural traditions related to household formation, and declining marriage rates.

Temporary migration for work is a long-established livelihood strategy in South Africa. During the Colonial and Apartheid eras, increasing numbers of Black South Africans were drawn into wage labour in cities and industrial centres [50]. A goal of the Apartheid government was to reserve well-resourced areas of the country for Whites, while ensuring access to a steady supply of cheap Black labour. To this end, they forcibly removed Blacks to resource-poor “homelands” in rural areas of the country and established laws (known as “pass laws”) which prevented Blacks from living in “White areas” except where they were employed [50]. Together with short-term labour contracts, these government policies resulted in a pattern of cyclical labour migration between permanent family homes in rural areas and temporary accommodation near urban places of work [51]. Because movement was made so difficult, most migrants' families remained at rural homes. As a result, Black households were often "stretched" between different physical dwelling places.

The majority of migrant labourers were men [51]. Many retained strong ties with wives and children at their rural homes and visited them during periods between labour contracts [50]. It was also not uncommon for wives to defy pass laws to visit their husbands in cities, in some cases bringing children with them and in others leaving them with relatives [52]. This type of movement of household members between different residences lead researchers to characterize Black South Africans' residential arrangements as "fluid" [53].

Since the formal abolishment of pass laws in 1986, many Black men and women have moved permanently to cities. However temporary labour migration from rural areas has remained common and only recently appears to be declining. In 2008, it was estimated that 22% of rural Black households had one or more member who was an absent migrant worker [54]. This contrasts with estimates around 36% in surveys conducted between 1999 and 2005 [54]. While an increasing proportion of migrant workers are female, still two thirds were male in 2008 [54].

A second important feature of the context of fatherhood in South Africa are cultural norms and ideals related to parenting and the gendered-division of household labour (including care work). These norms inform fathers' own expectations about their responsibilities to their children, as well as the expectations of members of fathers' social networks. These collective expectations may be difficult for individual men to challenge [32].

In the precolonial Southern African family system, power came with age, marriage, and being male [46]. The ideal of fatherhood was linked with becoming the patriarch of one's family. Importantly, families or households were not formed around a conjugal couple, as has been the long-standing tradition in northern western European cultures [45]. Instead, the principal of family formation was *patrilineal descent*, i.e.: descent from the father's lineage [45]. People sharing a common lineage were regarded as members of an extended family, or kin group. Marriage and payment of *lobolo* (bridewealth) resulted a woman's subsequent children becoming members of her husband's lineage [45]. Children born to unmarried mothers could either be accepted into the maternal grandfather's kin group, or the father's family could acknowledge them by paying 'damages' to the mother's family [45, 55]. Caring and providing for children was seen as a collective responsibility of the kin [56, 46]. Customarily, direct caregiving was the responsibility of mothers and female family members [46]. Fathers were expected to be primary providers, but they were also expected to be involved in teaching children and in making decisions related to their wellbeing [46].

It has been proposed that labour migration and degrading government policies undermined traditional African ideals of fatherhood [56, 46]. During Apartheid, fathers who were migrant labourers would rarely be able to spend time with their children. This may have lead their material provisioning role to assume primacy [46]. Beginning during Apartheid, the increasing entry of women into paid labour has been seen as a further threat to traditional patriarchal fatherhood norms [56, 57]. Finally, it is argued that many young men in cities began to rebel against older ideals of masculinity, which esteemed childrearing and maturity. New ideals of masculine conduct placed greater emphasis on toughness, independence and opposition [56]. Possibly these new ideals were mutually reinforcing with the increasingly violent political protests of the 1960s and '70s [46]. Contemporary rigid gender norms that emphasize the role of men as economic providers and equate caregiving with femininity, provide little impetus for men to take on non-traditional child care roles. These gender norms may even result in a lack of social recognition and support for the contributions made by men in caregiving roles [32].

Also related to the undermining of traditional gender norms and cultural practices of household formation is the dramatic decline in marriage rates among Black Africans, particularly those living in urban areas [58, 59]. For example, a 2006 study found that, among women 40-45 years old living in urban and peri-urban areas, 50% had never married, compared to 42% of their rural counterparts [58]. Co-habitation of non-marital couples has become more common, particularly among people in urban areas, but is still relatively rare [59]. For example, in the same study in 2006, less than half of all women in regular, non-marital relationships were residing with their partners [58].

Many Black South Africans still report positive attitudes towards marriage [59]. However, some researchers have suggested that enduring effects of Apartheid policies on African family life, together with rising unemployment overall and proportionally more women in the paid workforce, have resulted in many young people choosing to remain single [60, 43]. For women, in a society where men are no longer necessary nor often sufficient for financial stability, remaining single may be seen as an attractive way of avoiding patriarchal practices of men [60, 43]. Similarly, for men, unstable economic conditions may be a barrier to raising money for lobolo. Additionally, marriage itself may seem a less viable strategy for attaining the masculine ideals of previous generations [56]. Other young people may be delaying marriage until they have completed school and attained stable employment [61]. For example, among urban Black South Africans, those who are unemployed are less likely to be married [59]. For many, these necessary conditions for marriage occur relatively late in life, if at all. For the above reasons, a large proportion of South African children are born to unmarried, non-cohabiting parents [62].

A third important feature of the fathering context in South Africa is the high rate of unemployment. In 2013, the national unemployment rate was 25% [63]. One third of unemployed people in the country had been without work for longer than a year. Importantly, unemployment is concentrated among Black and Coloured[1] people with limited formal education who are in the age range where childrearing typically begins [63]. Limited employment opportunities and lack of income undermine fathers' ability to provide financially for their children [47, p. 286]. As mentioned above, they can also reduce parents' chances of marrying and establishing an independent dwelling together, thereby further influencing their children's material living conditions. There is also evidence that unemployment negatively impacts other aspects of fathers' parenting and the quality of the co-parental relationship. Psychological distress resulting from job loss [65] and perceived failure to live up to the socially ascribed 'provider' role [32] may cause some men to 'abandon' their other care responsibilities (*Steering by the stars: Being young in South Africa* (2002), as quoted in [66, p. 79]). Other men may respond by becoming abusive [67, p. 103-4].

[1]Coloureds are people "of mixed European ('white') and African ('black') or Asian ancestry, as officially defined by the South African government from 1950 to 1991." [64] During Apartheid, as with Black people, Coloureds were subjected to strictly segregated occupational opportunities and were forcibly relocated to less desirable areas.

The final feature we emphasize is that HIV-infection is widespread in South Africa and most prevalent among women and men in their child-conceiving years. In 2012, the prevalence of HIV infection nationally was 12%. However, among Black African females 20-34 years old, HIV prevalence was 32% and, among Black African males 25-49 years old, it was 26% [68]. Little is currently known about the roles and responsibilities of fathers in HIV-affected families [20]. Nevertheless, HIV-infection is expected to influence parenting in a variety of ways. HIV illness strains the economic, psychological and physical resources parents need to be able to provide good quality care to children [69, 70, 71].

Since the initiation of a public antiretroviral-provision program in 2003, access to treatment has increased dramatically [68, 72]. However, it is estimated that approximately half of adults eligible for ARVs are not receiving them [72]. Coverage is also lower among men than women [68]. As such, adult HIV morbidity is still an important problem.

Caring for HIV-infected children also requires significant added emotional, financial, and time resources [73]. Current strategies for preventing mother-to-child transmission of HIV mean that even uninfected infants of infected parents have additional care needs, including avoiding early mixing of breast- and formula-feeding and giving ARV prophylaxis throughout breastfeeding [74]. HIV-infection may also negatively impact the co-parental relationship and is associated with increased risk of relationship dissolution [75].

2.2 Empirical evidence for paternal influence on child health

The question of what influence fathers have on their children's wellbeing has produced a long history of empirical research. Our aim here is to synthesize findings for the effects of fathering on the physical health outcomes of young children. We include evidence from two reasonably distinct domains of research: one examining the child health consequences of residential separation of fathers and children (commonly referred to as *father absence*), and the other examining the effects of *father involvement*. For the purposes of this review, we define father involvement broadly as including direct involvement in child nurturance as well as providing for children's material needs and giving emotional and practical support to mothers. Typically co-residence is not considered to be a component of father involvement, *per se*. This is because research evidence suggests that it is fathers' positive contributions to children, rather than their mere physical presence, that is important for child wellbeing. However, residential arrangements are one factor influencing fathering [47]. Because of the high rates of residential separation in South Africa and because of the very limited data on fathering, we propose that considering residential arrangements does provide insight into the ways that fathers can influence their children's health. However, we emphasize that there is ample research demonstrating that non-resident fathers can be beneficially involved in their children's lives. (In this sense, the term 'father absence' is misleading.) Indeed, while father-child co-residence may have an important influence on aspects of fathering that are contingent on physical proximity, it may have relatively little influence on other aspects. For example, co-residence has been shown to be a poor predictor of whether fathers provide financial support for their children in South Africa [76]. Therefore, throughout this review we have attempted to complement studies of father absence with relevant studies of father involvement, wherever evidence is available. In so doing, we aim to identify potential father involvement mechanisms by which residential separation may manifest in differences in child health.

The majority of studies of father absence and involvement have been conducted in the United States (US) and Western Europe where several decades of rising rates of divorce and extramarital childbearing have resulted in increasing percentages of children living in 'single-mother households' [77, p. 5]. Researchers' interest in the issue of father absence has, in part, been driven by concern over whether these demographic changes are having a negative influence on child wellbeing. Over the same period, expectations for fathers to take a greater share of the responsibility for child nurturing have increasingly permeated dominant fatherhood ideals [31]. Father involvement research has attempted to document whether fathers' actual parenting practices have kept pace with these evolving ideals, and what the consequences have been for children (as well as for mothers and fathers themselves) [78].

While similar demographic changes have occurred in South Africa [79, 58], important contextual differences may limit the transferability of research findings from Western countries. For example, labour migration is a common and conceptually distinct reason for South African fathers to spend extended periods away from their children's households [48, p. 259]. In addition, only a minority of South African children live in truly 'single-parent' households [80, p. 1022-3]. Many children with absent fathers reside together with their mothers and other maternal relatives [81, p. 17]. Furthermore, cultural expectations which emphasize men's responsibility for financial provisioning and cast child nurturing as 'women's work' may deter many men from becoming highly involved in routine child care [32, 82].

To summarize, research from high income countries suggest that father absence is associated with poorer academic achievement, behavioural competence and psychological wellbeing, social relations, and economic security [83, 77, 84]. In contrast, greater father involvement predicts better outcomes in many of the same domains of child wellbeing [85]. There is more empirical support for the effects of paternal engagement in direct caregiving than for other types of involvement [21]. However, the existing evidence is not sufficiently rich to identify which specific aspects of engagement most effectively promote beneficial outcomes [21, p. 157]. Studies of non-resident fathers' involvement, suggest that payment of child support and practicing authoritative parenting (i.e.: parenting characterized by a mixture of supportiveness and non-coercive control) are associated with improved academic outcomes and fewer behavioural and psychological problems [86]. However, high frequency of contact with non-resident fathers is not consistently associated with child wellbeing [86].

Studies of the relationship between fathering and children's physical health outcomes are rarer. Nevertheless, there is some evidence that young children with absent fathers tend to have higher risks of being diagnosed with, and of being hospitalized for, physical illnesses [87, 88], and of experiencing accidental injuries [87]. In contrast, young children whose fathers are more engaged in routine care activities tend to experience fewer injuries [89]. Experiencing parental divorce or living in a 'single-mother household' during childhood has also been found to predict poorer health in adulthood [90].

A frequent criticism of father absence research is that the observed associations may be due to the effects of factors that 'select' children into father-absent households rather than to any negative effect of father's absence itself. For example, parents' pre-separation characteristics like low socioeconomic status, high levels of relationship conflict, and mental illness all make separation more likely and are also, on average, associated with poorer outcomes for children [77, p. 16]. Studies of father involvement are also subject to potential selection bias and confounding effects. In addition, highly detailed studies of involvement have typically been based on small, non-random (often culturally and socioeconomically homogenous) samples, potentially limiting the generalizability of the findings [91, p. 24]. Nevertheless, studies rigorously designed to reduce potential selection bias and control for confounding still suggest father absence can be detrimental for children [84], and that higher levels of involvement are beneficial [21]. Furthermore, recent, large-scale, population-based studies of father involvement in the United States are beginning to reveal patterns of fathering among low-income and minority groups [92], and confirm the positive influence of father involvement on child development in these populations [93].

While considerable interest has been expressed for better engaging men in child health programs and policies in lower-resource countries, evidence is still quite limited as to the influence that fathers have on child health in these contexts and the ways in which men can be most beneficially engaged [20]. A particular challenge for researchers working in these countries is the almost complete lack of detailed data on fathering [94, 48]. In addition, many of the studies that have been conducted suffer from the methodological limitations mentioned above.

Nevertheless, there is a small body of literature documenting the child-health correlates of father-child residential arrangements and of fathers' involvement in low- and middle-income countries. We review the findings below. We have chosen to restrict our review to studies of physical health outcomes because persistently high rates of child morbidity and mortality in South Africa (as well as the inequitable distribution of these risks by race and social class) mean that, in this and similar settings, there is an imperative to better understand the factors influencing children's physical health[2].

We did not conduct a formal systematic review because we were interested in bringing together literature from two quite distinct areas of study (1. Research on father-child co-residence, and 2. Research on father's involvement in child care). We were concerned that a narrowly focused review might prevent us from identifying overlaps between the two sets of literature.

To identify research on the child-health effects of residing with a father, we searched the Medline database using the terms listed in table 2.1 on the following page. In line with Mosley and Chen's model, we sought to identify studies that included any of the following child health outcomes: breastfeeding or receipt of immunizations (i.e.: proximal determinants); diarrhoeal or respiratory illnesses; malnutrition; or mortality. In addition, studies needed to include a measure of father-child residential arrangements or a related characteristic of the household context (specifically: parents' marital status, or presence of additional relatives) as a predictor of child health outcomes. We included the additional household contextual characteristics because they may influence the nature and consequences of fathers' parenting, as described in section 2.1.3 above. We refer to these characteristics collectively as measures of *household structure*. In addition, we searched the Medline database for articles referencing Mosley and Chen's

[2]Morbidities, including malnutrition and infection, are important causes of impaired child development in low- and middle-income countries [95]. Therefore, the evidence addressed in this review is also relevant for understanding potential mechanisms by which fathers may contribute to developmental outcomes in later childhood and adolescence.

Table 2.1: Terms used to search the Medline database for studies of the child-health effects of residing with a father

SEARCH TERMS 1. (household or family) and structure in: A 2. father and (co-resident or co-residence or coresident or coresidence or non-resident or non-residence or non-co-resident or non-co-residence or non-coresident or non-coresidence or absent or absence) in: A 3. single and mother in: A 4. Immunization or Vaccination in: B 5. breastfeeding in: A or Breast Feeding in: B 6. Diarrhea, Infantile or Diarrhea in: B 7. Respiratory Tract Infections in: B 8. Child, Preschool in: B 9. Infant in: B A = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, or unique identifier B = Medical Subject Heading
SEARCH STRATEGY: (1 or 2 or 3) and (4 or 5 or 6 or 7) and (8 or 9)

model.

We screened the complete search results for English-language articles that presented analyses of data from low- or middle-income countries and presented a measure of association (relative risk, risk difference, odds ratio, or hazards ratio) between one or more characteristics of household structure and one or more of the child health outcomes of interest. We also scanned reference lists of included articles for additional articles meeting our criteria.

We did not use a formal protocol for evaluating the quality of evidence for each association. However, we describe whether studies were cross-sectional or longitudinal and whether they controlled for household socioeconomic status, which was determined *a priori* to be an important potential confounding factor.

Because there is limited research from low- and middle-income countries focusing specifically on fathers' parenting practices, we used relatively general search terms to identify relevant studies. We searched the EBSCO databases for the terms listed in table 2.2 on the next page. We included primary research articles which investigated linkages between fathers' conduct and any of the child health outcomes described above.

We have organized the review by type of child health outcome examined: proximal determinants, illnesses, malnutrition, and child mortality. Within each category of outcomes, we first synthesize evidence for the influence of *household structure*. Where available, we then present evidence for the influence of fathers' involvement.

Table 2.2: Terms used to search the ESBCO databases for studies of the child-health effects of father's parenting practices

DATABASES SEARCHED: Medline Biomed Central EconLit PsychArticles Humanities database Family studies Women studies Anthropology Nursing
SEARCH TERMS: 1. (father and involvement) or (father's and involvement) or (fathers' and involvement) or fatherhood or fathering or father or fathers or father's or fathers' in: A 2. Africa in: A 3. (child and wellbeing) or (child and health) in: A A = Keywords
SEARCH STRATEGY: 1 or 2 or 3

Proximal biological and behavioural determinants

Differences in the following proximal determinants have been studied in relation to household structure: birth weight, breastfeeding, and immunization. We identified only a single study, in South Africa, which specifically explored the effect of fathers' residential arrangements. This study found that co-residence of fathers with mothers during pregnancy is associated with modestly, but statistically significant, higher birth weights [96].

A larger number of investigators focused on parents' marital status. Mothers who are married or have co-resident non-marital partners were found to give birth to significantly heavier babies than unpartnered women (South Africa) [96]. Similarly, mothers with co-resident spouses were significantly more likely to be fully breastfeeding[3] their babies between birth and six months, and also significantly more likely to breast feed at all between birth and 12 months (Philippines) [97]. In addition, compared to children whose mothers were divorced or had never married, children with (monogamously) married mothers were found to have significantly higher probability of completing the polio immunization schedule (Kenya [98]), and higher probability of receiving all routine immunizations (Trinidad and Tobago [99]; Jamaica [99]; Kenya [100]).

Other studies examined the association between immunization completeness and living in extended households (where children reside with their parent(s) and other adult relatives). These studies suggest that, after controlling for household socioeconomic status, there is no significant difference in the

[3] Full breastfeeding is defined as feeding breast milk in combination with only non-nutritive quantities of other liquids [97].

probability of being fully immunized for children living in two-parent households compared to those in extended households (Niger, urban Nigeria, Trinidad and Tobago, and Jamaica) [99, 100]. Children in nuclear households in rural Nigeria are the exception, having been found to have lower probability of being completely immunized than their counterparts living in households which include their parents' siblings [100]. However, the fact that the nuclear household category in this analysis included both single-parent and two-parent households makes the findings difficult to compare to those of other studies reviewed.

Researchers have also documented that women who receive support from a male partner tend to have better antenatal care outcomes and breastfeeding practices. In sub-Saharan Africa, much of this research has focused on correlates of uptake and adherence to interventions to prevent vertical (i.e.: mother-to-child) transmission of HIV. While this research typically does not conceptualize of support from male partners as a type of fathering, the findings clearly contribute to our understanding of potential modes of positive paternal influence. For example, participation of male partners in antenatal HIV counselling and testing (HCT) is associated with a higher probability for HIV-infected women to receive antiretroviral prophylaxis during delivery [101, 102], better adherence to exclusive formula feeding or breastfeeding [101], and significantly reduced risks of vertical HIV transmission and infant mortality during the first year of life [16]. Receiving HIV test results and post-test counselling together as a couple, compared to individually, is associated with an even greater increased probability of using antiretroviral prophylaxis during delivery [102].

A limitation of these studies is that they do not provide insight into the components of father involvement that produce the observed benefits. Antenatal HCT sessions include information about preventing HIV vertical transmission. Therefore some of the beneficial effect observed could have been achieved through better informed fathers being able to provide more encouragement and decision-making support to mothers. However, participation of male partners in couples HCT interventions is voluntary and uptake is generally very low. Therefore selection bias may explain some of the findings. Couples agreeing to participate in HCT may be in more secure, communicative relationships. In these types of relationships, fathers may generally be more supportive of their partners and more positively involved in caring for children [47]. It could be these (unmeasured) beneficial relationship characteristics, more so than couples HCT, that explain the positive outcomes observed.

Qualitative research on the infant-feeding experiences of HIV-infected mothers in South Africa provides more detailed insight into beneficial fathering. These studies have consistently found that dissent by fathers is a significant barrier preventing some women from adhering to infant feeding recommendations [103, 104]. The corollary is that some fathers are an important source of emotional support to mothers, particularly if they are aware of the mother's HIV-status. In situations where economic constraints influence infant feeding considerations, fathers may be able to support optimal infant feeding practices by providing material support to mothers, for example in the form of infant formula for HIV-infected women practicing exclusive formula-feeding [105, p. 106-7].

Illnesses

We identified three studies comparing risk of illness between children living in different household structures. Interestingly, using different approaches, all three studies examined the effect of father's absence due to migrant labour. It is also noteworthy that all three studies were restricted to households in rural areas.

One study, using longitudinal data from Mexico, examined the effects of married fathers' absence due to migrant labour on their children's risks of experiencing any illness and diarrheal illness [106]. It found that father's absence is associated with a significantly higher probability of both categories of illness, with the effect being stronger for diarrhoea. Notably, the detrimental effects were observed both in models that adjusted for a small set of observed indicators of household SES, and in child fixed effects models, which account for unmeasured time-invariant differences between children and households. This suggests that the findings are not the result of confounding by pre-migration household socioeconomic conditions.

The remaining two studies, from Kenya and Ghana, were cross-sectional and compared children living in male-headed households to those living in *de facto* female-headed household (defined as households in which the self-declared male heads are absent for at least 6 months of the year) [107, 108]. Migrant labour is identified as an important reason for the absence of male household heads in these countries. In contrast to the study in Mexico, both African studies reported no significant difference in illness prevalence between children living in *de facto* female-headed household and those in male-headed households. The categories of illnesses examined were: any illness, diarrhoeal illness and malaria. Neither set of analyses controlled for potential confounding (in one case because of small sample size, and, in the other, because childhood illness was not the primary outcome of interest). The design limitations of these two studies means that their results should be interpreted cautiously. However, it is also important to consider that differences in social, cultural and economic context could explain the difference between these findings and those from Mexico.

We did not identify any studies of the influence of fathers' involvement on the incidence of childhood illnesses. However studies of the dynamics of household treatment decision-making indicate that fathers do have a role in influencing the outcomes of illness in Africa. Studies from Kenya and Senegal have found that, although mothers are frequently the first to recognize illnesses, they rarely make treatment decisions alone [109, 110, 111]. Usually, care decisions involve the mother obtaining financial assistance or advice from another household member, with fathers being the most common sources of both types of support. Fathers appear to be particularly important in paying for treatments for childhood illnesses [109, 110, 112, 111] Compared to mothers, fathers tend to be more likely to pay for more costly treatments, including pharmaceutical therapies and visits to health facilities [110, 112]. An important reason for this pattern may be that men are able to draw upon patriarchal cultural and societal norms to assert power over the allocation of household resources [109, 111]. The expectation is that mothers will consult with husbands and elders around childhood treatment decisions. However, in reality, fathers' involvement in treatment decisions appears to depend on the type of illness, the cost of treatments being considered, and the nature of the relationships among family members [109].

Even though parents of uninsured children are meant to be exempt from paying for child health services accessed through public primary- and district-level facilities in South Africa, a considerable minority are still inappropriately made to pay for these services [113]. In addition, transport costs can be a significant barrier to accessing care, particularly for individuals in poor, rural households [113]. For these reasons, financial contributions from fathers may be important in determining whether and how quickly South African children receive medical care.

Malnutrition

Malnutrition appears to have received more research attention in relation to household structure than the other outcomes reviewed here. However, as with the other outcomes reviewed, it is uncommon for investigators to have specifically focused on fathers. Only one study, from South Africa, examined co-residential relationships of children with fathers. It found that neither residing with a father at the time of the survey, nor the percentage of life spent residing with a father were associated with any change in children's likelihood of malnutrition [114]. Living with both parents also showed no significant association, whereas residing with a mother (vs. not) was associated with a significant reduction in children's likelihood of malnutrition. Similarly, a study from The Gambia, which examined parental mortality, found that having a living mother was associated with children having significantly higher weight (adjusted for age and height). In contrast, having a living father was associated with no significant difference in child weight [115]. A limitation of both studies is that they were not able to assess for confounding by household socioeconomic characteristics.

A larger number of studies compared children based on whether their mothers' partners were household residents[4]. Findings from these studies are mixed, with some suggesting that the absence of a partner is associated with a tendency for children to be more malnourished [116, 117], whereas others find no difference [118, 108] or that the opposite is true [107]. One factor that may contribute to these contradictory findings is whether investigators compared children of married to unmarried mothers, or restricted their comparisons to children of different groups of married mothers. Analyses restricted to children of married mothers tend to find that whether the mother has a resident or a non-resident husband is not associated with a change in her child's probability of malnutrition. In contrast, analyses that include children of both married and unmarried women generally suggest that children of married mothers have the lowest probability of malnutrition [98], but children whose mothers have co-resident, non-marital partners may also have lower probability of malnutrition than those whose mothers have a non-resident partner or no partner [116].

Studies in South Africa and Vietnam have examined associations between father's involvement and child malnutrition. In South Africa, receiving financial support from a father was associated with significantly reduced probability of malnutrition [114]. Due to small sample size, these analyses were not stratified by father-child co-residence status. However, in itself, residing together was not found to

[4] The relationship between mother's partner and child is not described in these studies. For the purpose of this review we treat the partner as the child's father, but we recognize that the definition of father involves more than the man's relationship to the mother.

be associated with probability of malnutrition. In Thailand, children whose fathers were involved in taking them for immunizations and in caring for them when sick had lower probability of malnutrition [119]. In contrast, neither the amount of time fathers spent in routine child care activities (e.g.: feeding, playing, bathing) nor the amount of time spent in household chores were consistently associated with malnutrition. These analyses were restricted to children with co-resident fathers, potentially implying that the findings are not generalizable to children with non-resident fathers.

Observations from two studies of household structure provide additional insight into involvement of non-resident fathers. A study using data from Kenya and Ghana, showed that households with absent husbands were not inevitably economically disadvantaged compared to households with resident husbands [107, p. 683-4]. This could be because the former receive remittance income from husbands who are migrant labourers. Because this study found no difference in malnutrition risk between households with and without resident fathers, this observation could provide support for the importance of fathers' economic provisioning in preventing child malnutrition.

A separate study in Kenya, comparing nutritional outcomes of children of married mothers with resident versus non-resident husbands, included a detailed examination of household agricultural characteristics, and division of farming and financial decision-making between wife and husband [108]. The findings suggest quite different patterns in the division of decision-making and allocation of resources in the two types of households. For example, non-resident husbands tended to retain more control over family income but less control over farming decisions than did resident husbands. The authors propose that differences in resource allocation and decision-making control reflect strategies of household members to cope with their particular residential arrangements. These strategies appear to result in children in both household types having similar caloric intake and similar probability of malnutrition, albeit in an area with relatively high rates of malnutrition overall.

Mortality

Two studies (South Africa, The Gambia) estimated whether the death of a parent was associated with a change in children's mortality risk. The study in South Africa also distinguished between father-child *residential connections* (whether they live in the same dwelling) and father-child *social connections* (whether the father is recognized to be a member of the child's "household"[5]). This study compared mortality risks among children who physically resided with their fathers, children who were part of the same household as their fathers but did not reside together, and children whose fathers were not members of their households. Other studies compared child mortality risks by sex of household head and by mother's marital status using data from a number of low- and middle-income countries.

Father's death was not significantly associated with children's risk of mortality [81, 120]. However, children whose fathers were members of their household had a lower mortality risk than children whose fathers were not [81]. In addition, among children whose fathers were members of their household,

[5]"Household" was defined differently in this study than in most other studies reviewed. In typical household surveys, households are composed of co-residing individuals. Whereas, in this study, households were defined "based on respondents' own perception that they belong to a social group which has a distinct identity and a recognized head of household." [81, p. 8]

having always resided together was associated with a significantly lower probability of mortality than having never resided together. Female, compared to male, household headship was not associated with child mortality [118]. In about half of the countries examined, children of mothers who were continuously married to the same partner had significantly lower odds of mortality than children whose mothers had never been married, were formerly married, or had remarried during the child's life [121].

We did not identify any studies examining aspects of fathers' involvement in relation to child mortality.

Summary

Overall, it is relatively clear that fathers can influence the health of young children in low- and middle-income countries. However, the evidence is mixed as to whether residing with a father improves child health. Furthermore, studies of health-decision making suggest that, while fathers have the potential to promote beneficial health outcomes for women and children, the fact that fathers tend to have more power than mothers in household decision-making (particularly in allocating financial resources) can be harmful, leading to unnecessary delays in accessing health care [109]. This review highlights some gaps in the existing knowledge base and some important considerations for future research.

First, relatively few studies of family structure have directly examined father-child residential arrangements. Given the present rarity of detailed data on fathering in low-resource countries, using readily available residential status data from population-level household surveys will likely continue as a preliminary approach to learning more about fathers' influences on child health. However, using variables like mother's marital status and household head's sex as proxies for the residential status of fathers does not seem suitable. Although these household characteristics are inter-related, they measure distinct aspects of a complex set of domestic arrangements. For example, the definition of household headship may differ between studies, and is frequently subjective [122]. In addition, the wide range of residential arrangements in South Africa means that the sex of the household head may not be at all related to the residential status of a given child's father. Declining marriage rates, modestly increasing rates of cohabitation, and the high frequency of marital partners residing apart all mean that mother's marital status is also an inadequate proxy for father's co-residence status [79, 58]. The findings reviewed here suggest that these different dimensions of household structure may not show similar associations with child health outcomes. However, few analyses have simultaneously examined different dimensions of family structure or explored interactions between them.

Second, the majority of studies of father-child residential arrangements have examined only one or two child health outcomes. None used the same dataset to study associations between household structure and both illnesses and proximal behavioural outcomes intended to prevent illness. Doing so would allow us to suggest potential mechanisms by which family structure influences child health.

Third, considering historical and social context improves the interpretability of (sometimes contradictory) findings. The analyses of child malnutrition in rural Kenya and Ghana are good examples: by understanding that migrant labour is a common reason for husbands to spend extended periods away from wives and children, a father's absence can be acknowledged as a rational strategy for families to deal with poor economic conditions. While many studies highlight the importance of considering the influence of social context on family structure effects, none have attempted to estimate the magnitude of contextual variation in their effect estimates or to identify specific contextual factors which contribute to this variation.

Fourth, the few existing studies of fathering in lower-resource settings have tended to focus on a single type of involvement; some focus solely on financial provision or financial decision-making, others on support of mothers, and a limited number on direct engagement in child care. We did not identify any studies that included measures on all three of these types of involvement. Future research in this area would benefit from applying broader conceptualizations of fathering and from using more comparable measurement instruments. Doing so would allow us to develop a more comprehensive understanding of the nature of men's involvement in families. Researchers could then begin to identify the antecedents and child health consequences of different patterns of involvement. Such an understanding would better position us to design interventions to engage men as partners for achieving positive health outcomes for children. A potential challenge is that most of the conceptual work on fathering has been informed by research involving North American and European fathers. Whether this work provides an appropriate model for studying the parenting practices of South African fathers has not been evaluated.

Chapter 3

Methods: Research Objective 1

The first objective of this study was to determine whether South African children who reside with their biological fathers tend to have better health outcomes than those whose fathers reside elsewhere. Although there are no large datasets with an explicit focus on fathering in South Africa, data are available from a number of nationally representative household surveys. These surveys generally collect information about relationships among household occupants, making it possible to determine whether fathers were residing in the household at the time of the survey. Some of these surveys also include measures of children's health status. We used data from one of the latter surveys, the 1998 South African Demographic and Health Survey (SADHS), to address research objective 1. In addition, we aggregated 1996 South African census data to construct measurements of different neighbourhood characteristics for the households surveyed in the SADHS. In the following sub-sections (3.1 and 3.2) we describe the data collected during the SADHS and the 1996 Census, respectively. In sub-sections 3.3 and 3.4, we describe the variables used in our analyses and our steps in selecting the analytic sub-sample. We end this chapter in sub-section 3.5 with a description of our analytic approach and the specific statistical methods used to address research questions 1a-e.

3.1 1998 South African Demographic and Health Survey

The SADHS was a collaborative project of the South African National Department of Health, the South African Medical Research Council and the United States Agency for International Development. It was conducted as part of an international program aimed at collecting comparable, nationally-representative data on population and health indicators for a number of countries. In many countries these surveys have been repeated periodically to allow for comparisons to be made over time. In South Africa, two Demographic and Health Surveys have been completed, in 1998 and 2003. Because the 2003 data were not publicly available, we limited our analyses to the 1998 data. We obtained these data through the MeasureDHS website [123]. Although they are over 15 years old, these data are valuable for investigating factors that influence children's health, particularly those that remain stable over time. They include detailed information about a range of child health indicators and a variety of demographic and socioeconomic characteristics related to children's health and health services utilization. In addition, the sample is representative of almost the complete population of children under 5 at the time of the survey (with the exception of children born to women younger than 15 or older than 45 at the time of the survey, who were not asked questions about their childbearing histories). Below we will briefly describe the sampling strategy and questionnaires used for the SADHS. More detailed descriptions are provided in

Appendices A and F of the full survey report [6].

Sampling

In the SADHS, households were sampled using a stratified, two-stage cluster sampling approach. An aim of the survey was to provide reliable statistics separately for rural and urban areas in eight of the nine Provinces. In the ninth Province, the Eastern Cape, it was desired that separate estimates could be produced for each of five health regions. Consequently, the first-stage sample was stratified into urban and rural areas of each Province, or into urban and rural areas of each health region in the Eastern Cape. Figure 3.1 (page 27) shows a map of South Africa. On the map, rural census Enumeration Areas (EAs) are coloured dark grey, and urban EAs are coloured white.

In the first stage, a sample of EAs was systematically drawn from the list prepared for the 1996 national census. The probability an EA was selected was proportional to the number of households it contained. In the second stage, households were randomly sampled from lists of households in each EA, or from maps. Ten households were sampled from each urban EA and 20 from each rural EA. At each sampled household, field workers completed a single "household questionnaire". They also attempted to complete a "women's questionnaire" with all female household occupants aged 15-49 years.

In total, 972 EAs and 12 860 households were sampled. Data collection was not completed in three EAs, and data from another three EAs were lost, resulting in data being available for 966 EAs. Of the sampled households, 95.2% were successfully interviewed. Among those households that were found to be occupied, the response rate was 97%. These households were comprised of a total of 12 327 female members eligible to complete the women's questionnaire, of whom 95% were successfully interviewed. Consequently the overall response rate for the women's questionnaire (calculated as the product of the household response rate and the women's questionnaire response rate) was 92.3%.

Sample weights, provided with the dataset, can be used to adjust statistics from the sample so that they are representative of the South African population at the time of the survey [124]. Except where indicated, all of the descriptive statistics presented in the results section have been adjusted using the sample weights.

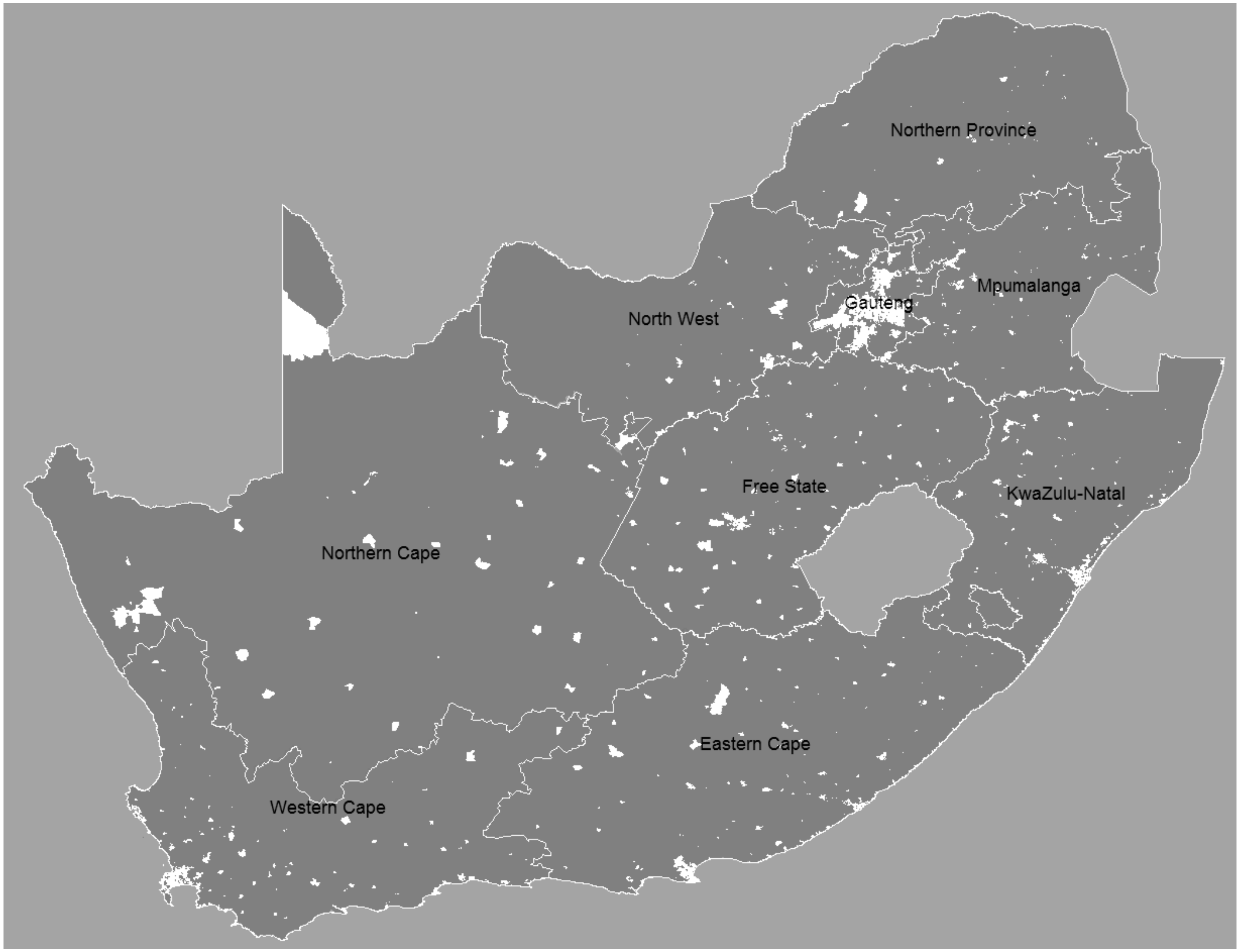


Figure 3.1: Map of South Africa showing the locations of rural (dark grey) and urban (white) 1996 census Enumeration Areas in each province.

Questionnaires

The SADHS data used in these analyses were collected using two separate questionnaires. First, a single household questionnaire was completed for each household. This questionnaire included a roster of usual members of and visitors to the household. For each person in the roster, their relationship to the household head, and limited demographic, educational and employment information were ascertained. For each person younger than 15 years, questions were asked about whether her/his biological mother and father were still living, and whether each was a member of the household. In addition, the household questionnaire included questions about household services (including access to electricity, source of drinking water, and type of toilet facility), whether the household members owned each item in a list of durable assets (including a television, automobile, and livestock), and an assessment by the interviewer of which materials were used in constructing the walls and floor of the household structure. The respondent for the household questionnaire could be "any adult member of the household who [was] capable of providing information needed" to complete the questionnaire [125].

Second, a woman's questionnaire was completed with each female household member aged 15 to 49 years identified in the household roster. This questionnaire included a fertility and marital history, detailed educational attainment and employment questions, and questions about health knowledge, beliefs and attitudes. Using a birth roster, this questionnaire documented the date of all of the respondent's childbirths. For each living child under five years of age, details about the child's delivery, immunization history, and recent health status were ascertained.

As a consequence of the two-stage sampling strategy and data collection using these two questionnaires, units of observation in the SADHS dataset are organized into four nested levels[6]: at the top are EAs within which are nested a number of sampled households. In each household there are potentially multiple women, each of whom could potentially have a number of children. Data were collected for a total of 5066 children born in the five years preceding the survey. Of these, 4797 were alive at the time of the survey.

The complete data collected using these questionnaires are supplied in seven different datasets. For the analyses described here, we drew variables from the following two datasets:

- the "*Household member recode*" dataset, which has a separate record for every member in the sampled households, and includes sociodemographic variables for each individual and characteristics of the household in which they live; and

- the "*Children's recode*" dataset, which has a separate record for each child born to the interviewed women. This large dataset includes variables specific to each child as well as variables specific to the mother (i.e.: values are the same for all children born to the same mother) and some variables specific to the household (i.e.: values are the same for all children residing in the same household.)

We describe how we linked records across these datasets in sub-section 3.4 on page 40.

[6] Nested means that each lower-level unit is found in just one higher-level unit

3.2 1996 South African census

The 1996 South African census was conducted from October to November and aimed to collect information about all persons living in the country on the night of the 9-10th October [126, 127]. To enable enumeration, the country was divided into approximately 86000 EAs, each comprised of 100-250 households, and demarcated so as to align with municipal boundaries [128]. Enumerators visited every household in the country (as well as institutions and hostels) to collect information about the occupants.

For the present analyses, we were interested in combining information from the 1996 census with that from the SADHS because, while the SADHS collected detailed information on households and the women and children living in them, the amount of information collected about EAs was very limited. Conversely, the information collected during the census on (nearly) every household and individual in the country could be used to construct measures of a variety of characteristics of EAs by aggregating relevant information across all of the households or individuals comprising them. Because the list of EAs designed for the 1996 Census was used as the sampling frame for the first stage of the 1998 SADHS sample, it is relatively simple to link information across these two data sources. This allowed for analyses of whether EA-level variables (such as unemployment rates) modify associations between child-level variables (such as the association between having a co-resident father and having been breastfed for six months or longer). That the census data were collected less than two years before the SADHS data makes it reasonable to assume that EA characteristics estimated from the census would correspond to the time period covered by questions in the SADHS.

A single census questionnaire was completed for each household[7]. The questionnaire consisted of 15 questions about the household (such as the type of dwelling, dwelling ownership, and types of services used by the household) and 50 questions about each household member (including their age, population group[8], educational attainment, employment status, and income) [129]. Household members could choose to complete the questionnaire either by themselves or through a face-to-face interview with an enumerator, with the majority opting for the second option [127]. Separate questionnaires were used for people residing in institutions such as prisons and hospitals, and for homeless people. “The Count and How it was Done” report available through the 1996 Population Census website provides more detailed information about the census methodology [127].

We obtained the *1996 Census Community Profile databases* through the University of Cape Town’s DataFirst service [130]. These databases come bundled within SuperTABLE version 3.6 software (Time-Space Research, Melbourne), which allows the user to produce cross-tabulations among a set of predefined census variables. One of the available variables is “Geographical Area”, which descends to the level of EAs, thereby allowing simple aggregate statistics to be produced for every EA. The cross-tabulation results can be exported as comma-separated text files for manipulation in other statistical

[7]For the 1996 Census, a household was defined as “a single person or a group of people who live together for at least four nights a week, who eat from the same pot and who share resources.” [126]

[8]Population group refers to the official groups designated by the Apartheid government: “Asian/Indian”, “Black”, “Coloured”, and “White”. These do not correspond to specific ethnic groups. However, because of their historical political significance these categories are strongly associated with current socioeconomic status.

software.

It is important to recognize that EAs are demarcated to make census enumeration practical, rather than because they necessarily represent distinct social groupings in the 'real world'. Researchers studying how place of residence influences individuals' health and behaviour frequently do treat units of census geography as being reflective of meaningful social groupings, largely because data are most readily available at these administrative levels of aggregation. However, the particular level of social organization selected for study is important and, therefore, should be justified by theories explaining how characteristics of social environments influence individuals' outcomes [131, 132]. In quantifying and attempting to explain geographic variation in the associations between father's residential status and child health outcomes, we have focused on EAs as the geographic level of interest. This decision was based primarily on the fact of the shared geography of the SADHS and the census, which made EAs the most convenient level at which to link individual-level data to group-level data. In presenting our findings we refer to EAs as "neighbourhoods" because this makes the discussion less abstract. Because of our limited theoretical justification for selecting this geographic level, it is necessary to be cautious when interpreting our effect estimates for neighbourhood-level variables and their interactions with individual-level variables. In particular, associations should not be interpreted as causal. In addition, lack of association at the neighbourhood level does not imply that the construct of interest would have no association at a different geographic level.

3.3 Variables

In the following sections we describe the variables used for our statistical analyses. We first describe the father's co-residence status exposure variable and the four child health outcomes. We then define variables measuring other characteristics of child and mother which may act as potential confounders in our analyses. Next, we describe neighbourhood variables which may modify associations between the exposure and outcomes. In many cases we derived our analytic variables from variables in the SADHS datasets. Often our aim was to reduce the number of levels in complex categorical variables. Occasionally we created a new, more specific variable by combining information from a small set of related variables. More detail on how each variable was derived is given in Table A.1 in Appendix A.1 (page 208).

Exposure

The *father's co-residence status* exposure variable was binary, coded as "1" if the child's biological father was reported to be a *de jure* member of the child's household, and "0" otherwise. We use the terms "co-resident" and "non-co-resident" rather than the more concise "present" versus "absent", because the latter terms carry connotations about fathers' levels of involvement in child care [24, 76], which cannot be substantiated by the questions asked in the SADHS. Whereas, the terms "co-resident" and "non-co-resident" focus specifically on what has been ascertained in this survey. We only examined biological fathers because the SADHS household questionnaire specifically ascertained whether each child's biological father was a member of her/his household. In contrast, the questionnaire did not ascertain whether any other member(s) of the household act as social father(s) to the child. Given that care of children by members of the extended family is a feature of traditional kinship systems of many African cultural groups in South Africa, it is likely that many children in the SADHS dataset do have a social father. However, the effect on child health of residing with a social father cannot be addressed using this dataset precisely because there is not way to identify who these social fathers are.

Outcomes

Our analyses treated four separate, binary child health-related outcome variables. Each variable was coded "1" if the child had experienced the outcome, and "0" if not. These variables were defined as follows:

1. Was breastfed for six months or longer

A count variable in the SADHS dataset records the child's duration of *any* breastfeeding in months[9]. This information was ascertained by three questions in the SADHS women's questionnaire: Did you ever breastfeed [child's name]?; Are you still breastfeeding [child's name]?; and For how many months did you breastfeed [child's name]? Children still breastfeeding at the time of the survey were assigned a breastfeeding duration equal to their age in months.

Initially we considered using survival methods to analyze children's time to breastfeeding cessation. Comparing the Kaplan-Meier survival curves for children with and without co-resident fathers, we observed a large and reasonably consistent difference in the probability of still breastfeeding between the two groups of children between 2 months and 18 months of age (Appendix A.2 figure A.1 on page 224). Based on this observation, it seemed reasonable to dichotomize the breastfeeding duration data at a point within this age range and model the resulting outcome using logistic regression, rather than to try to fit a more complex survival analysis model to the time-to-event data. We selected six months as the cut-point for the dichotomized variable because the greatest reduction in child mortality risk from breastfeeding appears to be during the first six months of life [133]. In addition, at the time of the SADHS, women were recommended to exclusively breastfeed for 3-4 months duration, and thereafter to continue breastfeeding with complementary foods for two years or more (A. Behr, personal communication. November 25, 2013). Therefore it made sense to examine whether children had been breastfed for at least as long as the period recommended for exclusive breastfeeding.

To derive our binary analytic variable we dichotomized the original count variable. First, we calculated child's age in months as the difference between the interview date and child's birth date (both recorded as century month codes [124, p.5]). We coded children younger than six months old as "not applicable" and excluded them from analyses of this outcome. Among the remaining children, those with breastfeeding durations of six months or longer were coded having had the outcome, and children

[9] Although it may have been informative to analyze data on the duration of *exclusive* breastfeeding, this information was not ascertained in the SADHS.

Table 3.1: South African EPI schedule (1995-1999) and age groups used to derive immunization completeness outcome variable

Immunization doses	Recommended age of receipt	Limits of age group	Implied range in lower limit
Polio(0), BCG	Birth	0 – <3 months	0 – 1 months
Polio(1), DPT(1), HepB(1)	6 weeks	3 – <4 months	2 – 4 months
Polio(2), DPT(2), HepB(2)	10 weeks	4 – <5 months	3 – 5 months
Polio(3), DPT(3), HepB(3)	14 weeks	5 – <11 months	4 – 6 months
Measles	9 months	≥11 months	10 – 12 months

Note: EPI=Expanded Programme on Immunization; BCG=Bacillus Calmette-Guérin; DPT=Diphtheria, Pertussis, Tetanus; HepB=Hepatitis B, (#)=Dose number for multi-dose vaccines

who were never breastfed or had breastfeeding durations of less than six months were coded not having had the outcome.

2. Was completely immunized for her/his age group

A series of nine variables in the SADHS dataset indicate whether children received each dose of the routine childhood immunizations recommended by the South African Expanded Programme on Immunization (EPI-SA): Polio, Diptheria-Pertussis-Tetanus, and Measles[10]. Based on the EPI-SA schedule in place from 1995 to 1999 [134], we identified five age groups in which children immunized according to schedule ought to have received distinct combinations of immunization doses (depicted in Table 3.1 on page 32)[11]. Column three of Table 3.1 gives the limits used in calculating age groups. Column four gives the implied ranges in the lower age group cut-offs, taking into account our uncertainty about children's ages. We selected age groups such that, for each lower limit, the lowest value in our range of uncertainty is just greater than the recommended age of receipt for the batch of immunization doses that define that age group. In other words, all children within a particular age group should have had adequate opportunity to receive all of the immunization doses appropriate for their age group. Children who had received all of the immunization doses appropriate for their age group were coded as having had the outcome, and all others were coded as not having had the outcome[12].

[10] Hepatitis B was added to the South African EPI in 1995 (whereas, all other dose recommendations in Table 3.1 were in place prior to 1995), therefore four-year-old children in the 1998 SADHS dataset may not have had the opportunity to receive this vaccine. In addition, according to the 1998 SADHS full report, "...hepatitis B vaccination had not been adopted as a standard for the whole country at the time of the survey...." [6, p. 121] For these reasons, we did not consider Hepatitis B doses when deriving our immunization completeness outcome variable.

[11] Children's birth dates and interview dates are recorded to the nearest month in the SADHS dataset. Therefore there is uncertainty of ±1 month in calculating children's ages, making it necessary to use generous lower limits for the age windows.

[12] We treated the following levels of the original variables as equivalent indicators that a particular vaccine dose had been received: 1=yes, vaccination date on card; 2=yes, reported by mother, 3=yes; vaccination marked on card (but date missing). The purpose of doing this was to avoid excluding from our analyses the 4% of children whose health cards were reported missing, and the 22% whose health cards were not seen by interviewers.

3. Had symptoms of ARI in the two weeks before the survey

This outcome was ascertained by asking the mother the following two questions: Has [child's name] been ill or feverish with a cough at any time in the last 2 weeks?; and When [child's name] was ill with a cough, did he/she breathe with difficulty or faster than usual with short, fast breaths?

Only if a mother answered "Yes" to both of these questions was a child coded as having had the outcome. This is consistent with the standard case definition for estimating period prevalence of acute respiratory infection using DHS data [6].

4. Had diarrhoea in the two weeks before the survey

This variable comes directly from the SADHS dataset and was ascertained by asking the mother: Has [child's name] had diarrhoea in the last 2 weeks? If a mother answered "Yes" to this question the child was coded as having had the outcome, and not if the she answered "No". Although mothers were asked additional information about diarrhoeal episodes (i.e.: number of stools on the worst day of the episode, and whether the stools were bloody), this information was not considered in our outcome definition. This is consistent with the standard case definition for estimating period prevalence of diarrhoea using DHS data [6].

Additional household structure variables examined as effect modifiers of father's co-residence status

We examined whether two additional dimensions of household structure modified the association between father's co-residence status and child health outcomes: i) whether the child's mother was in a marital union, and ii) whether there were additional adult relatives residing in the household.

The first characteristic is measured by a dichotomous variable indicating whether a child's mother was married at the time of the survey. We derived this variable from the mother's "current marital status" variable by collapsing the following categories to form a "currently unmarried" reference group: never married, living like married, widowed, separated, and divorced. To test for effect modification of father's co-residence status by whether the mother was currently married we included in our regression models an interaction term involving these two variables[13].

The second characteristic was ascertained using information about the relationship of household occupants to the household head in each child's household. We were particularly interested in comparing children with co-resident fathers to those with non-co-resident fathers, with the latter group stratified by whether they lived with other adult relatives. We classified household members >17 years old as adults, based on evidence from the 2000 South African Time Use Survey showing that 20-39 year olds spend considerably more time engaged in economic work and in household maintenance (which includes care

[13]The identity of the mother's husband was not ascertained in the SADHS. Therefore we were not able to determine specifically whether the child's mother was married to her/his biological father. We assumed that, where the mother was married and the biological father was co-resident, the parents were in a marital union. Where the mother was married and the biological father was non-co-resident, the mother's husband could be the biological father or someone else. This needs to be kept in mind when interpreting the regression coefficient for the interaction term.

work) than 10-19 year olds[135, p. 38]. We were also interested in whether the gender of the co-resident relatives was important. To make these comparisons, we constructed a 4-category extended household structure variable distinguishing children with:

- Two co-resident biological parents ($\pm$ other adult co-resident relatives)
- Co-resident mother, non-co-resident father, $\geqslant$1 adult male co-resident relative
- Co-resident mother, non-co-resident father, $\geqslant$1 adult female co-resident relative, no adult male co-resident relatives
- Co-resident mother, non-co-resident father, no other adult co-resident relatives

For analyses involving this variable we included children whose biological father was dead because the the co-residence status of biological fathers was no longer our sole focus. To examine the effect of this variable we used it in place of the father's co-residence status variable in regression models, and left all other covariates unchanged.

Potential confounders

To estimate unbiased associations between paternal co-residence and each child health outcome requires identifying and statistically controlling for the effects of potential confounding variables. Following the general criteria recommended in epidemiology, we identified potential confounding variables as characteristics that are: a) putative causes of the outcome, and b) expected to be associated with (but not caused by) father's co-residence status [136, p. 154-7].

Mosley and Chen's and Millard's models of the socioeconomic determinants of child mortality guided our consideration of putative causes of the four child health outcomes. To understand how other investigators had operationalized the determinants identified in these theoretical models, we reviewed literature concerning neighbourhood and household socioeconomic influences on child health in low-income countries [137, 138, 99, 139, 140, 141, 142, 106, 143]. Many of these studies used data from household surveys similar to the SADHS. To avoid missing determinants that are more specific to each outcome, we also made reference to studies and reviews of the main predictors of breastfeeding initiation and duration [144, 33], immunization uptake [145, 146, 147], acute respiratory infection [148], and diarrhoeal illness [149, 150, 151, 152, 153, 154]. Most, but not all, of these latter articles were specific to low-income countries.

To identify characteristics associated with fathers' probability of residing with their children, we referred to other South African research on this issue as well as Fein and colleagues' categorization of the determinants of marriage and co-habitation [155]. We reviewed this literature previously in the section describing a systemic ecological model of the influences on fathering (section 2.1.3 on page 10).

Based on our review of the above literature and results of exploratory regression models (described in section 3.5), we included the following child and maternal covariates in regression models for all four outcomes. We describe neighbourhood covariates separately in the subsequent section (page 38).

Child's characteristics:

- **Birth order and preceding birth interval** - A 7-level categorical variable derived by combining information about the number of children the mother gave birth to prior to the index child's[14] birth and the time in months between the index child's birth and the birth of her/his next oldest sibling. Categories were: 1 = *First born*; 2 = *2nd-4th born, birth interval <24 months*; 3 = *2nd-4th born, birth interval 24-47 months*; 4 = *2nd-4th born, birth interval >47 months*; 5 = *5th+ born, birth interval <24 months*; 6 = *5th+ born, birth interval 24-47 months*; 7 = *5th+ born, birth interval >47 months*. Birth order and birth interval are "maternal factors" identified in Mosley and Chen's model, with lower birth order and shorter preceding birth interval previously shown to be associated with increased mortality risk for the index child [142, 156]. Higher parity and short birth intervals are also associated with more constrained household economic resources [157], which negatively predicts union formation and positively predicts union instability.

- **Place of delivery** - A 3-level categorical variable identifying the location where the mother delivered the index child. Categories were: 1 = *Home*; 2 = *Public medical facility*; 3 = *Private medical facility*. This variable was derived by collapsing the sub-categories in the original SADHS variable into the "major categories" defined in the dataset documentation [124]. Children reported to have been born in an "Other" place of delivery (*n*=35) were treated as having missing data for this variable. Place of delivery is a proxy for the "environmental contamination" and "personal illness control" categories in Mosley and Chen's model, in that pathogen exposure and availability of medical interventions differ between home and medical facility birth environments. Delivering in a private medical facility would be more likely among women with greater income or wealth at the time of the child's birth, which, in turn, my positively predict being in a marital union. Whereas, lower income women would be more likely to deliver at home or in a public medical facility, because user fees for maternity care at public facilities in South Africa were removed in 1995 [7, p. 835].

- **Antenatal care provider** - A 3-level categorical variable identifying the person who provided antenatal care to the mother during the pregnancy with the index child. Categories were: 1 = *Nurse/midwife (with or without a doctor)*; 2 = *Doctor only*; 3 = *Traditional birth attendant, other care provider or no care*. This variable is related to the mother's access to health services, her socioeconomic status during the pregnancy and her health care beliefs, all of which feature in models of the determinants of child mortality. Traditional health beliefs may co-occur with more traditional beliefs favouring marriage. Whereas lower personal income as well as living in a poorer-resourced area may be negatively associated with marriage/cohabiting and positively associated with cohabiting union disruption, for example from men's entry into migrant labour. In South Africa antenatal care from government primary health clinics is usually provided by nurse midwives. We assumed that women who received antenatal care from a doctor only are likely

[14] By "index child" we are referring to a child who is the unit of analysis in our models, i.e.: a child meeting the inclusion criteria and for whom exposure, outcome, and covariate information were available.

to have purchased this care privately. Also note, there is not a professional 'Traditional Birth Attendant' designation in South Africa. Traditionally, women would deliver alone or attended by a family member. We assumed that women who sought care from a traditional birth attendant or other care provider or who did not have any antenatal care were more likely to have experienced barriers to accessing medical facilities or were following specific beliefs that disfavoured medical care.

- **Whether the mother wanted the pregnancy with the index child at the time she became pregnant** - This variable was used directly as provided in the SADHS dataset. Response options for the timing when the mother wanted to become pregnant were: 1 = *Then*; 2 = *Later*; 3 = *Did not want any more children*. Women reporting unintended pregnancies are less likely to receive adequate antenatal care, and children born of unintended pregnancies have lower probability of receiving routine childhood immunizations and increased probability of dying during the neonatal period [158]. Unintended pregnancy is also associated with decreased union stability. In addition, pregnancies occurring outside of a union (which may relate to whether the pregnancy is wanted) influence subsequent marriage and cohabiting union formation.

Mother's characteristics

- **Mother's population group** - A dichotomous variable (0 = *Black*; 1 = *Non-black*) derived by combining the "Asian/Indian", "Coloured" and "White" population groups to form the "Non-Black" category. During Apartheid, discriminatory laws controlled non-White population groups' rights to own property, job availability, wage levels, access and quality of services like education and health care, as well as power and perceived status in society. As a consequence, population group is persistently and strongly associated with socioeconomic status. Higher socioeconomic status is expected to improve children's health outcomes and parent's opportunities for marriage and/or cohabitation.

- **Mother's highest completed level of education** - A 3-level categorical variable (1 = *No education or incomplete primary*; 2 = *Complete primary or incomplete secondary*; 3 = *Complete secondary or higher*) derived by collapsing adjacent pairs of categories in the original six-level variable. Educational attainment is an important "socioeconomic determinant" in Mosley and Chen's model, with higher maternal educational attainment having been found to be associated with lower risk of various negative child health outcomes [142, 157]. Research shows that a majority of Black South African women share the belief that marriage should come after completion of education [159, 61], suggesting that lower educational attainment may be associated with lower probability of being in a marital union.

- **Mother's age at index child's birth** - A count variable derived by calculating the difference in years between the index child's date of birth and mother's date of birth. Mother's age is an important influence on children's health outcomes, being related to knowledge and experience, and economic resources. Increasing age is also associated with increased likelihood of marriage and cohabitation [59].

- **Mother's age at first child birth** - A 3-level categorical variable (1 = *<18 years old*; 2 = *18-29 years old*; 3 = *>29 years old*) derived from the continuous "age at first birth" variable in the SADHS dataset. Early childbearing is associated with increased probability of low birth weight and infant mortality [160]. It is also associated with poorer economic outcomes for the mother (school drop-out and household poverty) [161], which are, in turn, associated with poorer child health outcomes. Early, non-marital pregnancy also reduces subsequent marriage prospects, although it may promote cohabitation.

For models of breastfeeding duration and immunization completeness we also adjusted for a 4-level categorical variable measuring **whether the mother spent her childhood in a rural or urban area and whether she had migrated between childhood and the time of the survey**. This variable was derived by by creating a category for each combination of the levels of two dichotomous variables in the SADHS dataset: mother's childhood place of residence (with "City" and "Town" categories treated together as "Urban" vs. "Countryside"), and type of place of residence at the time of the interview ("Urban" vs. "Rural")[15]. This variable is intended to capture some of the influence of mother's place of upbringing on her later-life socioeconomic status and on her attitudes and beliefs. We are also interested in capturing the effects of urbanization, which has been an important demographic change in South Africa, especially since the end of Apartheid-era pass laws. Research suggests that moving to an urban environment exposes women to better educational and employment opportunities and may reduce the social pressures to conform to traditional marriage norms [162, p. 93-4]. Urban women may be more likely than rural women to live independently from, or in a cohabiting but non-marital union with, their children's fathers [52]. They may also have improved access to resources for keeping their children healthy. Alternatively, women may migrate with their partners to urban centres, avoiding the common pattern of migrant labour-induced familial/spousal separation.

For models of immunization completeness, recent ARI and recent diarrhoea, we also adjusted for a count variable measuring the **child's age** in months, which was derived as the difference between the date of the interview and the child's date of birth. Children's risk of respiratory and diarrhoeal infection declines with age [148, 153]. Children are also less likely to receive vaccine doses that are scheduled for receipt at older ages [163]. Therefore, as children age, they are less likely to have received all immunizations appropriate for their age-group. Finally, we anticipated that the probability of having a co-resident father might vary as children age.

Finally, for models of recent ARI and recent diarrhoea we also adjusted for a dichotomous variable measuring **child's sex** (0 = *Female*; 1 = *Male*), and a 3-level categorical variable measuring the **season during which the interview was conducted** (1 = *Summer [January-March]*; 2 = *Autumn [April-May]*; 3 = *Winter [June-September]*). Male children have a higher incidence of diarrhoeal disease than females, and possibly a slightly higher incidence of respiratory illness [164, 148]. Female sex of first-born

[15] For the purposes of this variable, "migration" means having moved from a rural childhood place of residence to an urban place of residence by the time of the survey, or *vice versa*

children has been found to be associated with reduced marriage quality [155, p. 13], while male children in the United States are more likely than females to have co-resident fathers [165]. We included season as a covariate in the models for the recent illness outcomes because incidence rates of respiratory and diarrhoeal infections vary by season [148, 153] and because paternal non-co-residence associated with migrant labour may also vary by season.

Of note, we did not include sex as a covariate in the immunization completeness models. Although studies of childhood immunization coverage in India have found that boys are more likely than girls to be completely immunized [166], studies in African settings have not reported gender-differences in immunization coverage [167].

Neighbourhood-level variables

Fathers' parenting practices have been found to be sensitive to societal context [168, p. 50][47, p. 285][26, p. 889]. As discussed in the literature review (Section 2.1.3 on page 10), employment availability and gender norms are two important features of the context of fatherhood in South Africa, which may modify the effect of residing with a father on children's health outcomes. Direct measures of employment availability and gender norms are not available for the neighbourhoods in the SADHS dataset. However, by aggregating 1996 census data from individuals and households comprising the neighbourhoods, we may be able to obtain indirect measures of the characteristics of interest. We hypothesize that variables measuring aspects of neighbourhood social context may explain neighbourhood-level variation in co-resident father effects on children's health outcomes. We explored the following variables for this purpose:

1. **A dichotomous variable distinguishing urban from rural neighbourhoods**

2. **Unemployment rate among adult male residents** - A continuous variable calculated as the number of male EA residents 15 years old or older who were "unemployed, looking for work" expressed as a percentage of all male EA residents 15 years old or older who were either employed or unemployed, as per the "expanded definition" of unemployment used by Statistics South Africa [126, p. 2].

3. **Percentage of households having a female head** - A continuous variable calculated as the percentage of households in the EA who reported having a female household head.

4. **Percentage of households having an annual income <R6000**[16] - A continuous variable calculated as the percentage of households in the EA with derived annual household incomes in the "R2401-6000" range or lower. The chosen income cutoff roughly corresponds to the the upper limit for the lowest quintile of household incomes nationally, as calculated in the 1995 South African Income and Expenditure Survey [169, p. 28].

[16] R6000 was equivalent to approximately $1900 CAD at the average exchange rate for the 1996 calendar year.

5. **Percentage of female residents having completed high school education or higher** - A continuous variable calculated as the percentage of female EA residents 20 years old or older who had completed high school, including those with any level of post-high school education.

6. **Ratio of percentage female to percentage male residents having completed high school education or higher** - A continuous variable calculated as the percentage of female EA residents 20 years old or older who had completed high school divided by the percentage of male EA residents 20 years old or older who had completed high school.

Employment availability and cultural norms are expected to vary between urban and rural neighbourhoods. Employment opportunities are expected to be more limited in rural neighbourhoods, neighbourhoods with higher rates of male unemployment, and neighbourhoods with greater percentages of low-income households. Higher percentages of female headed households may indicate neighbourhoods with higher numbers of absent male migrant labourers.

Choosing to leave a neighbourhood offering limited opportunities to provide financially for one's children may reflect a responsible fathering decision and may benefit children's health. In addition, if economic marginalization makes men less able to meet their fathering responsibilities, even when they physically reside with their children, having a co-resident father in these neighbourhoods may, on average, be of limited benefit to children. Furthermore, we expect that neighbourhoods with better employment opportunities and fewer low-income households would tend to have better access to good-quality public infrastructure and services[17]. Through their access to services, parents in these neighbourhoods may be more able to ensure positive health outcomes for their children. We hypothesize that in neighbourhoods with less unemployment and lower percentages of low-income households, having a co-resident father will be more strongly associated with positive child health outcomes.

With respect to cultural norms, in neighbourhoods that empower women and emphasize greater gender equality, men and women may have more space to negotiate their obligations and responsibilities to one another and to their children. Neighbourhoods with more permissive gender norms are likely to display higher absolute and relative (compared to men) percentages of women having completed high school. Urban neighbourhoods and those with greater percentages of female households heads may also have less traditional norms. In such neighbourhoods, fathers may become more involved in the intimate care of their children [52, p. 77, 83]. In addition, women may be able to negotiate more control over decision-making related to their children's care [43, 60]. For these reasons, having a co-resident father may be more beneficial in these contexts.

[17] Exploratory analyses support this assumption: using data from all neighbourhoods in the 1996 census dataset (results not shown), we found the percentage of households with incomes <R6000 to be modestly negatively correlated with the following five indicators of neighbourhood access to public services: percentage of households with water piped into dwelling or site, percentage of households having a flush or chemical toilet, percentage of households using electricity for lighting, percentage of households with a telephone in the dwelling, and percentage of households having refuse disposal services provided by the local authority (Spearman's rank correlation coefficients between -0.32 and -0.40).

Additional variables used to describe the analytic sample

Household socioeconomic status is another important potential confounder in these analyses because it is intimately associated with household structure and affects child health through a number of pathways. Investigators using household survey data often operationalize household socioeconomic status using a combination of measures of household members' educational attainments and employment statuses, and household income, expenditure or wealth. The SADHS dataset includes household wealth variables, but these cross-sectional measures only reflect the situation at the time of the survey. Because father's co-residence status (also measured only at the time of the survey) could be a cause or a consequence of household socioeconomic status, adjusting for the latter could bias the co-resident father regression coefficient estimates (as a result of controlling for variables that mediate some of the effect of father's co-residence on child health)[18] [83, p. 358][77, p. 33][40, p. 12-13]. For this reason we do not adjust for these variables in our regression models but we do include them in the table of descriptive statistics (Table 4.1). The two socioeconomic status variables we present are: (i) a dichotomous variable measuring whether the **mother was working at the time of the survey** (0 = *No*; 1 = *Yes*); (ii) and a 5-level categorical variable measuring the **quintile of household wealth**, which was derived from a series of questions about household dwelling structure and ownership of durable assets, as described previously [170].

In our descriptive statistics tables we also included an extra 9-level categorical variable measuring the **Province** in which the neighbourhood is located. This variable is of interest because it likely influences both father's co-residence and children's health outcomes. Vastly differing employment opportunities and lasting effects of the Apartheid government's displacement of African people to rural "homelands" in some Provinces likely contribute to between-Province differences in the percentage of children with co-resident fathers. Differences in Provincial public infrastructure and health system functioning likely contribute to variations in children's health outcomes. However, we did not include the Province variable in our regression models for the following reasons: a) we found it to be highly correlated with some of the individual-level potential confounders, and b) there are relatively few neighbourhoods per Province in our analytic sample. Both lead to large uncertainty in coefficient estimates from models which include Province as a covariate.

3.4 Inclusion and exclusion criteria and data linkage

To be eligible for inclusion in our analyses children had to be alive at the time of the survey and residing with their mother. A total of 4,437 children in the child recode dataset met these criteria.

To estimate associations between having a co-resident father (recorded for each child in the house-

[18] Ideally we would adjust for household socioeconomic status at conception or during pregnancy. Not only does this precede father's co-residence status at the time of the survey, pregnancy is also likely to be a critical period in the processes leading to whether parents co-reside [155]. Unfortunately, household socioeconomic status during pregnancy was not directly assessed in the SADHS. We assume that mother's population group and educational attainment, as well as antenatal care provider and place of delivery will indirectly measure socioeconomic status during pregnancy. This is part of our rationale for adjusting for these variables.

hold member dataset) and children's health outcomes (recorded for each child in the child dataset) it was necessary to link each child's record across the child and household member datasets. Optimally a *unique child identifier* that is common to both datasets would be used to link children's records. This would ensure accuracy of the linked data. Unfortunately the SADHS datasets do not include a unique identifier for children. An alternative is to link pairs of records by matching their values on a set of variables present in both datasets. There are five variables common to the child and household member datasets: a unique number for each EA, a unique number for each household, a unique identifier for each woman selected to complete the women's questionnaire (referred to subsequently as mother's identifier), and the sex and age (in years) of each child. We tested two alternative matching strategies. One strategy was more conservative in that only those records matching on all five common variables were linked. However, a concern with the conservative strategy is that it would fail to link records of children whose ages and/or sexes were accidentally recorded differently in the household member and child datasets.[19] To overcome this limitation, the alternative strategy allowed records to be linked if they matched on only three or four of the five common variables, provided each record could only be matched to one record in the other dataset. At a minimum, linked records had to match on EA number, household number, and mother's identifier. In other words, we assumed that if each dataset contained only a single record for a child under 5 years old residing with the same uniquely identified mother that those records could be linked, even if the child's age and/or sex variables did not match. We provide a detailed description of the two linking strategies and flow diagrams comparing them in Appendix A.3 on page 225.

We compared the datasets generated by the two linking strategies by assessing for differences in the distributions of the exposure, outcomes and covariates of interest in each dataset. Because we found no significant differences between the two datasets in the distributions of these variables, we used the dataset produced by the less conservative strategy for our analyses. The latter dataset was comprised of linked records for 4010 children (90.4% of the 4,437 who met our inclusion criteria).

To produce the final analytic sub-sample, we excluded 48 children because either child or mother was recorded as a visitor to the household or because both the child's and mother's values of the household resident status variable were missing. We excluded a further 152 children whose biological father was dead at the time of the survey. Although it would be valuable to examine the health outcomes of children whose fathers have died, the factors leading to, and consequences of, fathers' deaths may be distinct from those leading living fathers to reside apart from their children. As such, treating children with dead fathers as equivalent to children with living, non-co-resident fathers in our analyses could bias our estimates of the effect of co-residing with a father. In addition, there were too few children in this

[19] Children's data in the household member dataset were collected using the household questionnaire, which could have been completed by any adult household member, not necessarily a close relative of the child. In contrast, data in the child dataset were reported by the child's mother. In the former dataset children's ages were collected simply by asking how old children were at the time of the survey, possibly allowing ages to be rounded up or down at the discretion of the respondent. Whereas, in the child dataset, mothers reported the year and month of their children's births, from which age in completed years was calculated. Because of this difference in the way children's ages were obtained, it is plausible for the same child to have their age recorded differently in the two datasets. However, we would expect most discrepancies to be of only one year. In the dataset produced by our second linking strategy 91% of records having a mis-match on the child's age were discrepant by only one year.

group to treat them as a separate group during analysis. For these reasons we excluded them from our dataset. This leaves a total of 3,810 children in the analytic sub-sample, 85.9% of the total number of children in the SADHS who met our inclusion criteria.

Finally, we linked records of children in the analytic dataset to corresponding records for the neighbourhoods where they live. The latter records were included in a dataset of neighbourhood variables that we derived using 1996 SA census data (described in Table A.1 on page 208). The linkage involved matching records using a unique EA identifier. Each EA in the 1996 census is identified by a unique 7-digit identifier. The same identifier for EAs in the SADHS dataset was obtained by multiplying the 3-digit "district ID" variable by 10000 and added the 4-digit "EA number" (S.O. Manda, personal communication, April 17, 2012). We failed to link the records of 39 children in the analytic sample (1% of the total) because their EA identifier did not have a match in the census dataset. These children were from 10 EAs in the SADHS dataset. Exploratory analyses showed that two of the EAs were in the Western Cape (one urban, one rural), one was in a rural area of the Eastern Cape, and the remaining seven were in urban areas of Gauteng (results not shown). We excluded these 39 children with missing neighbourhood-level data from all of our analyses.

3.5 Statistical analysis

The following sections describe our approach to preparing initial descriptive statistics and to fitting a series of multilevel regression models to address research questions 1a-e (Chapter 1).

Descriptive data analysis

For all outcome, exposure, and potential confounding variables we prepared descriptive statistics with the aims of understanding: a) the distribution of each variable in the analytic sample, and b) the proportion of missing responses. We examined categorical variables using single-variable frequency tables. For continuous variables, we calculated the percentages of records having missing data and prepared histograms of the valid response data. We calculated the following measures of central tendency and spread for each continuous variable: means and standard deviations for approximately normally-distributed variables, and medians and interquartile ranges for non-normal variables. Assessment of normality was based on visual inspection of histograms.

As a first step in determining whether the associations hypothesized from the conceptual model and literature review were supported by the data, we examined associations among pairs of variables using contingency tables for categorical variables; Pearson and Spearman correlation statistics for continuous variables; and, for pairs of continuous and categorical variables, means, medians, standard deviations, and interquartile ranges of the continuous variables within each stratum of the categorical variables. In the results chapter (Table 4.1 on page 50), we present population-weighted descriptive statistics for the complete analytic sub-sample and for strata of children with and without co-resident fathers. For population weighting we used the person weights provided with the SADHS datasets.

To describe the multilevel structure of the analytic sub-sample, we prepared frequency distributions of the counts of children per mother, household and neighbourhood. As a gross assessment of whether the risk of each outcome is unevenly distributed across neighbourhoods, we prepared frequency distributions for counts of each outcome per neighbourhood. Using these distributions, we can examine whether outcomes appear to be ’concentrated’ in a subset of neighbourhoods.

Multilevel regression modelling

Answering our research questions requires us to be able to isolate individual and neighbourhood sources of variation in the observed child health outcomes. Multilevel modelling is a powerful method for doing this. The feature which distinguishes multilevel models from ordinary regression models is their ability to model variation among lower-level units simultaneously with variation across higher-level units [171, p. 251]. Given the aims of this study, multilevel modelling afford the following advantages:

- It allowed us to model neighbourhood-level variation in the regression intercept via treating the intercept as a random variable. This has two advantages. First, ordinary regression assumes that each child has an independent probability of having the outcome. The complex sampling design used in the SADHS produces data that likely violate this assumption because children who were living in the same neighbourhood may have been more alike one another in their probability of having the outcome than children who were living in different neighbourhoods. Modelling group-level variation in the intercept allowed for outcomes of individuals in the same group to be correlated, thereby relaxing the independence assumption. The second advantage of including intercepts that vary by group was that they “absorbed” unexplained variation in the individual-level model that could be explained by group membership. In this way, varying intercepts accounted for the effect of unmeasured group-level confounding variables.

- We were able to model group-level variation in the regression co-efficient for the father’s co-residence status variable. This allowed us to estimate the magnitude of variation across neighbourhoods in the effect of having a co-resident father, and to explore the degree to which various neighbourhood-level covariates explained this variation.

The SADHS data are arranged in four nested levels: children > mothers > households > neighbourhoods. However, the sample sizes at the "mother" and "household" levels were too small in the hierarchical structure to facilitate useful inference at these levels of clustering. This can be seen in that fact that the majority of mothers and households have only a single eligible child (figure 4.1 on page 55). Therefore, for the analysis of this data we developed two-level (random intercept and coefficient) models with children nested under neighbourhood. We utilized maternal and household characteristics as individual level data.

Our analyses proceeded in four stages. First, we estimated unadjusted odds ratios (ORs) for the association between covariates of interest and each child health outcome. These ORs were estimated using generalized linear models (GLMs), each with a single predictor variable. In the second stage we fit a series of GLMs with father’s co-residence status and different sets of potential confounders. These models allowed us to assess the effect of confounder adjustment on the regression coefficient for father's co-residence status. We also simultaneously modelled groups of potential confounders appearing to measure related characteristics (for example mother's educational attainment and self-reported literacy). We reviewed the estimated correlation matrices of these models to identify covariates showing multicollinearity. Last, we tested interaction terms between father's co-residence status and child's age and mother's population group. Using the Wald test, these interaction terms were not found to be significant at the 5% level and so were not included in subsequent models.

For the final individual-level models, we based our selection of potential confounders predominantly on the findings of our literature search for variables having demonstrated associations with exposure and outcome, and on our assessments for multicollinearity, rather than on the basis of statistical significance. Once we had decided on the final set of covariates for each adjusted model, we prepared analytic datasets having complete data for all included variables. The total number of records in these datasets varies by outcome because of missing responses for the outcome variables themselves and because of differences in the covariates included in the full models. We then refit the unadjusted models using the complete case datasets.

Each GLM expresses the expected value, or mean, of the outcome variable as a linear combination of explanatory variables and associated regression parameters (intercepts and slopes) [172, 173, 171]. A *link function* is used to connect the mean of the outcome to the linear predictor [172]. All four outcomes in this study are binary (i.e.: for each child, the outcome, *y,* can only take on a value of 1=yes or 0=no). We assumed that the outcomes follow a Bernoulli distribution, a special case of the binomial distribution in which there is a single trial (i.e.: each child has only a single opportunity to have the outcome). To accommodate the binary outcomes, we used a log-odds or *logit* link function.

Therefore, we modelled the log-odds of π_{ij}, the probability that the outcome occurs for the i^{th} child in the j^{th} neighbourhood, as:

$$\operatorname{logit}(\pi_{ij}) = \log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_1 x_{1ij} + X_{ij}B \tag{3.1}$$

In the above equation, β_0 is the intercept and β_1 is the effect for the co-resident father variable, x_{1ij}. The matrix X_{ij} is composed of children's values for all additional covariates in the model. Column vector B contains the regression coefficients for the additional covariates.

In the third stage of our analysis, we constructed multilevel generalized linear models, in which we allowed some of the regression coefficients to vary by neighbourhood. The simplest multilevel model involves an intercept that varies by neighbourhood and is otherwise identical to equation 3.1. This model can be written as:

$$\begin{aligned} &\operatorname{logit}(\pi_{ij}) = \beta_{0j} + \beta_1 x_{1ij} + X_{ij}B, \text{ for } i = 1,...,n \text{ and } j = 1,...,J \\ &\beta_{0j} = \beta_0 + u_{0j} \\ &u_{0j} \sim \mathrm{N}\left(0, \sigma^2_{u0}\right) \end{aligned} \tag{3.2}$$

where β_{0j} is the intercept, which varies by neighbourhood (as indicated by the subscript j). In multilevel models, the varying regression coefficients are modelled using a separate *neighbourhood-level* model which is fit simultaneously with the *individual-level* model[20] [171, p. 251]. In the simple 2-level model shown above, the varying intercepts are modelled using a linear regression with an intercept, β_0, and a residual term, u_{0j}. In this regression, β_0 is the average of the neighbourhood intercepts, while the residual can be thought of as measuring each neighbourhood's deviation from the average intercept. The neighbourhood-specific deviations were assumed to be normally distributed around a mean of zero with a variance of σ^2_{u0}, which is estimated from the data.

We used varying intercept models to explore the influence of unmeasured neighbourhood confounders on the coefficient for father's co-residence status. We also explored the effect of including an interaction term involving father's co-residence status and mother's marital status. Finally, we replaced the father's co-residence status variable with the four-level household structure variable, to assess whether living with additional relatives modified the effect of having a non-resident father.

In model 3.2, the regression coefficient for the co-resident father predictor variable is fixed, i.e.: its value is assumed not to vary by neighbourhood. To relax this assumption, we can extend model 3.2 by allowing the co-resident father coefficient to also vary by neighbourhood:

$$
\begin{aligned}
&\operatorname{logit}(\pi_{ij}) = \beta_{0j} + \beta_{1j}x_{1ij} + X_{ij}B \\
&\beta_{0j} = \beta_0 + u_{0j} \\
&\beta_{1j} = \beta_1 + u_{1j} \\
&\begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim \mathrm{MVN}(0, \Omega) \\
&\Omega = \begin{pmatrix} \sigma^2_{u0} & \rho\sigma_{u0}\sigma_{u1} \\ \rho\sigma_{u0}\sigma_{u1} & \sigma^2_{u1} \end{pmatrix}
\end{aligned}
\tag{3.3}
$$

Similarly to the neighbourhood intercepts, the neighbourhood slopes are modelled using a linear regression without predictors. The intercept, β_1, is equal to the mean slope across all neighbourhoods, and u_{1j} is the neighbourhood-specific deviation from the mean slope. We assumed that the deviations for the intercepts and slopes followed a joint multivariate normal distribution having mean zero and covariance matrix, Ω, estimated from the data. The diagonal components of the covariance matrix are the variance terms for the varying intercepts and slopes, σ^2_{u0} and σ^2_{u1}, respectively. The off-diagonal components, $\rho\sigma_{u0}\sigma_{u1}$, are equal to the covariance between the varying intercepts and slopes. The assumption of a joint distribution allows for the varying intercepts and slopes to be correlated. We calculated the correlation, ρ, by dividing the covariance by the product of the intercept and slope standard deviations.

In the final step of our analyses, we included neighbourhood-level covariates. To do this, we included the neighbourhood covariates as predictors in the linear regression models for the varying inter-

[20]By *individual-level* we are referring to units at the lowest level of clustering, i.e.: children in this case.

cepts and slopes. Below we present an example model that includes a neighbourhood-level covariate, z_1, which, for illustration, could be the percentage of households with an annual income <R6000:

$$
\begin{aligned}
&\operatorname{logit}(\pi_{ij}) = \beta_{0j} + \beta_{1j}x_{1ij} + X_{ij}B \\
&\beta_{0j} = \beta_0 + u_{00j} + u_{01}z_{1j} \\
&\beta_{1j} = \beta_1 + u_{10j} + u_{11}z_{1j} \\
&\begin{pmatrix} u_{00j} \\ u_{01j} \end{pmatrix} \sim \operatorname{MVN}(0, \Omega) \\
&\Omega = \begin{pmatrix} \sigma_{u0}^2 & \rho\sigma_{u0}\sigma_{u1} \\ \rho\sigma_{u0}\sigma_{u1} & \sigma_{u1}^2 \end{pmatrix}
\end{aligned}
\tag{3.4}
$$

In this model, z_{1j} is the percentage of low-income households in neighbourhood j. In the regression for the varying intercepts, β_0 is the neighbourhood-average intercept and u_{01} is the coefficient for the low-income household covariate, which does not vary by neighbourhood. Similarly, in the regression for the varying slopes, β_1 is the neighbourhood-average slope and u_{11} is the fixed coefficient for the low-income household covariate. The neighbourhood-specific deviation terms are given as u_{00j} and u_{10j}. If the covariates explain any of the deviation of the neighbourhood intercepts and slopes about their respective means, we should see a corresponding decrease in the estimated variance parameters σ_{u0}^2 and σ_{u1}^2.

In the model for the neighbourhood intercepts, the regression coefficient, u_{01}, is the change in the intercept observed when comparing neighbourhoods that differ by one standard deviation in their value of the neighbourhood covariate. In the model for the neighbourhood slopes, the coefficient, u_{11}, can be interpreted in two ways. Similarly to the term in the model for the intercepts, it can be interpreted as the change in the slope observed in comparing neighbourhoods that differ by one standard deviation in their value of the covariate. Alternatively, it can be interpreted as the coefficient for an interaction involving the value of the father's co-residence status variable for child i and the value of the covariate for the neighbourhood where child i lives [171, p. 282-3]. The latter interpretation is more easily seen by substituting line 3 of model 3.4 into line 1. By either interpretation, the magnitude of this term indicates whether the effect of having a co-resident father is modified by neighbourhood context.

Model estimation

The varying coefficients in multilevel models make these models difficult to solve mathematically. However, model parameters can be estimated using procedures that maximize approximations to the likelihood or using Bayesian Markov Chain Monte Carlo (MCMC) techniques [174, p. 128-31]. Residual pseudo-likelihood is a simple and widely available method for estimating parameters of multilevel models [174, p. 130]. However, this method has been found to produce biased estimates of the variance parameters for varying intercepts and slopes in models involving binary outcomes [175]. Two other estimation procedures, Laplace Approximation and Gauss-Hermite Quadrature, are more accurate than pseudo-likelihood but less able to fit complex models, such as ones including multiple random coefficients. MCMC is both accurate and able to fit complex models, however it is time-consuming and brings the conceptual change of working within a Bayesian inferential framework [174, 176, p. 130].

Prior to selecting a method for our regression analyses, we applied the four estimation procedures described above to fit a test model. The test model outcome was a binary indicator for whether children had ever been breastfed and the model included a single predictor (the co-resident father variable) and varying intercepts at household- and neighbourhood-levels. Using default settings, the Gauss-Hermite Quadrature method did not converge, so we were only able to compare the estimates from pseudo-likelihood, Laplace, and MCMC methods (results not shown). The co-resident father co-efficient estimates were reasonably similar across the three methods. Whereas the estimated variance parameters for the group-level intercepts were quite different. Given the ability to handle complex models and the accuracy of the parameter estimates, we chose to use MCMC for our analyses.

Using a Bayesian approach, parameters are estimated using the likelihood function for the observed data, conditional on the unknown parameters, in combination with prior information about plausible parameter values [177, p. 46]. The plausible values are specified using a *prior distribution*. Model parameters are conceptualized as random variables having probability distributions. After the model is fit, the parameter probability distributions are called *posterior distributions*. MCMC methods can be used to estimate the posterior distributions. These methods work by iteratively sampling from the joint posterior distribution of the model parameters. The serially correlated random sample values are called ‘chains’. After a sufficient number of samples have been drawn, and assuming the chains have converged (i.e.: further sampling will not dramatically change the estimates), it is possible to calculate summary statistics for each of the model parameters (e.g.: means and 95% credible intervals). By default, WinBUGS implements MCMC methods using a Gibbs sampling algorithm or a Metropolis-within-Gibbs algorithm for more complex conditional posterior distributions [178]. These algorithms are described elsewhere (for example [177]).

Statistical software, MCMC settings, and specification of prior distributions

We used SAS version 9.3 to perform dataset manipulation (merging of records across datasets, derivation of variables, selection of the analytic sub-sample) and to calculate descriptive statistics. We used WinBUGS version 1.4.3 (Imperial College and MRC, United Kingdom) to implement Bayesian Markov Chain Monte Carlo methods for estimating our regression parameters. We used an open source statistical software package, R (version 2.14.1, The R foundation for Statistical Computing), and a complementary user interface, RStudio (version 0.97.551, RStudio, Inc.), to prepare the datasets from SAS for use in WinBUGS. Specifically, we used the *writeDatafileR* function to output datasets in array format [179].

The MCMC implementation was carried out with weakly- or non-informative priors so that parameter (posterior density) estimation was driven predominantly by the data. The estimates produced using this approach are typically similar to those from maximum likelihood-type methods [177, p. 46]. For all non-varying regression coefficients we used normal prior distributions with mean of 0 and standard deviation of 100. To allow for correlation between the varying intercepts and slopes we modelled them using a multivariate normal prior and an inverse-Wishart hyperprior with 2 degrees of freedom for the covariance matrix. We tested models involving independent normal distribution priors for the neighbourhood intercepts and slopes, with uniform hyperpriors for the standard deviation parameters ranging from 0 to 100. We also tested a scaled inverse-Wishart hyperprior with 3 degrees of freedom for the covariance matrix of the intercepts and slopes as recommended by Gelman and Hill [171, p. 376-7]. These test models showed poor chain mixing for the neighbourhood slopes standard deviation parameter.

In all MCMC runs, we used three chains. We determined whether chains had converged in two ways: a) by visually inspecting the chain sampling histories for good mixing, and b) by using 'BGR diagrams' (prepared automatically by WinBUGS), which compare within-chain to between-chain variability across increasing fractions of the total simulation run [178]. We identified convergence in the diagrams as an R value < 1.1 and reasonably stationary values for the estimates of between chain and within chain variability.

Our models appeared to converge within 2000 sampling iterations, so, by default, we discarded the first 2000 iterations when calculating chain statistics. We began monitoring the deviance information criterion following the first 2000 iterations. In the remaining iterations, we set thin to 10 (i.e.: we stored every 10th sample). This level of thinning appeared to produce low auto-correlation between samples for most parameters. We found that running 7000 iterations per chain (i.e.: a total of 15000 samples after discarding the first 2000 from each chain) produced reasonably smooth posterior density plots, so we used this as our default run length. In our results tables we report means and 95% credible intervals for the posterior densities.

Chapter 4

Results: Effects of Father's Co-residence Status on Child Health Outcomes

4.1 Description of the analytic sub-sample

A total of 3810 children contributed data to these analyses. Of these children, 43% had co-resident fathers and 56% had non-co-resident fathers (the remaining 1% had missing values for father's co-residence status). The top panel of Table 4.1 on the next page shows the numbers of mothers, households and neighbourhoods from which these children came, and the average number of children per higher-level unit. The average household and mother contributed a single child to the analysis, indicating that most children under 5 years old in South Africa did not reside with another child in this age-group. Interestingly, the average number of children per neighbourhood was higher for children with non-co-resident fathers (3.5) than for children with co-resident fathers (2.4). Another way to explore the multi-level structure of the dataset is to look at the frequency distribution of counts of children per mother, per household, or per neighbourhood. Figure 4.1 on page 55 visually depicts these frequency distributions for the total analytic sub-sample. Approximately 15% of mothers and 20% of households in the sample had more than a single child. Conversely, 81% of neighbourhoods in the sample had more than one resident child and 48% had more than three resident children. Only about 5% of neighbourhoods had more than 10 resident children.

Table 4.1: Descriptive statistics for outcomes and potential confounding variables in the complete sample of children and separately for strata of children with and without co-resident fathers, 1998 SADHS.

	All children, N=3810	**Children with non-co-resident fathers**, *n*=2141	**Children with co-resident fathers**, *n*=1638
CLUSTERING	*n* (Ratio)	*n* (Ratio)	*n* (Ratio)
Mothers	3271 (1.2)	1887 (1.1)	1355 (1.2)
Households	3023 (1.3)	1701 (1.3)	1343 (1.2)
Neighbourhoods	862 (4.4)	615 (3.5)	676 (2.4)
OUTCOMES	*n (%)*	*n (%)*	*n (%)*
Breastfed 6 months or longer			
No	958 (25.3)	450 (20.8)	498 (30.4)
Yes	2329 (60.8)	1381 (64.5)	930 (56.2)
Don't know	22 (0.5)	11 (0.4)	10 (0.7)
Missing	50 (1.5)	29 (1.5)	20 (1.6)
N/A (<6 months old)	451 (11.9)	270 (12.8)	180 (11.2)
Completely immunized			
No	1251 (31.6)	722 (32.2)	515 (30.4)
Yes	2435 (64.9)	1359 (64.5)	1061 (65.7)
Don't know	118 (3.3)	57 (3.0)	59 (3.7)
Missing	6 (0.2)	3 (0.2)	3 (0.2)
Recent ARI			
No	3028 (77.8)	1708 (78.5)	1296 (77.0)
Yes	743 (21.0)	412 (20.5)	326 (21.6)
Don't know	17 (0.5)	6 (0.2)	10 (0.8)
Missing	22 (0.7)	15 (0.8)	6 (0.6)
Recent Diarrhoea			
No	3255 (85.2)	1815 (84.5)	1416 (86.3)
Yes	526 (13.9)	309 (14.6)	211 (12.7)
Don't know	5 (0.2)	3 (0.2)	2 (0.2)
Missing	24 (0.7)	14 (0.6)	9 (0.8)

Continued on next page

	All children, N=3810	**Children with non-co-resident fathers**, *n*=2141	**Children with co-resident fathers**, *n*=1638
POTENTIAL CONFOUNDERS	*n (%)*	*n (%)*	*n (%)*
Preceding birth interval & birth order			
1st born	1232 (32.4)	897 (43.0)	315 (19.4)
<24 months, 2-4th born	232 (6.3)	110 (5.1)	122 (7.8)
24-47 months, 2-4th born	671 (17.9)	336 (15.4)	334 (21.2)
>47 months, 2-4th born	1016 (26.9)	477 (22.2)	530 (32.2)
<24 months, 5+ born	96 (2.4)	47 (2.1)	49 (2.8)
24-47 months, 5+ born	304 (7.4)	141 (6.0)	162 (9.2)
>47 months, 5+ born	254 (6.6)	131 (6.1)	123 (7.3)
Missing	5 (0.1)	2 (0.1)	3 (0.2)
Place of delivery			
Home	610 (14.0)	380 (16.1)	228 (11.6)
Public Medical	2862 (75.3)	1682 (79.5)	1155 (70.2)
Private Medical	303 (9.7)	57 (3.2)	244 (17.3)
Missing	35 (1.0)	22 (1.1)	11 (0.9)
Antenatal care provider			
Nurse/mid-wife (+/- doctor)	3005 (77.2)	1850 (85.9)	1133 (67.2)
Doctor only	629 (18.3)	210 (10.7)	412 (27.0)
TBA, Other, No antenatal care	140 (3.4)	66 (2.5)	73 (4.5)
Missing	36 (1.1)	15 (0.8)	20 (1.4)
When mother wanted child's birth			
At that time	1810 (47.9)	771 (36.0)	1028 (62.3)
Later	1307 (34.7)	928 (44.9)	366 (22.4)
No more	683 (17.2)	435 (18.8)	242 (15.1)
Missing	10 (0.3)	7 (0.3)	2 (0.2)
Child's sex			
Female	1917 (50.9)	1071 (50.6)	806 (51.7)
Male	1893 (49.1)	1070 (49.4)	832 (48.3)
Child's age in months, *Median (IQR)*	27 (30)	24 (30)	29 (31)

Continued on next page

	All children, N=3810	**Children with non-co-resident fathers**, *n*=2141	**Children with co-resident fathers**, *n*=1638
Season			
Summer	2169 (58.8)	1234 (61.9)	912 (54.8)
Autumn	1315 (31.0)	769 (31.6)	541 (30.7)
Winter	326 (10.2)	138 (6.5)	185 (14.6)
Mother's population group			
Black	3010 (81.2)	1862 (90.1)	1123 (70.6)
Non-Black[21]	780 (18.3)	270 (9.4)	504 (28.8)
Coloured	*499 (10.0)*	*253 (8.8)*	*242 (11.3)*
White	*190 (5.9)*	*11 (0.4)*	*179 (12.5)*
Asian/Indian	*91 (2.5)*	*6 (0.3)*	*83 (5.0)*
Missing	20 (0.5)	*9 (0.4)*	*11 (0.6)*
Mother's highest completed education level			
Less than primary	1028 (26.4)	558 (26.0)	463 (26.8)
Primary or incomplete secondary	1991 (51.1)	1203 (54.4)	772 (47.1)
Secondary or higher	791 (22.5)	380 (19.5)	403 (26.0)
Mother's childhood place of residence and whether she migrated			
Rural area, did not migrate	1907 (46.3)	1252 (56.6)	649 (35.1)
Urban area, did not migrate	1164 (33.7)	515 (25.8)	632 (42.2)
Rural area, migrated to urban	520 (15.3)	250 (12.5)	265 (18.5)
Urban area, migrated rural	170 (3.6)	95 (3.8)	73 (3.4)
Missing	49 (1.1)	29 (1.3)	19 (0.8)
Mother's age at first child birth			
<18 years	959 (25.1)	592 (27.8)	361 (22.0)
18-29 years	2739 (71.7)	1501 (69.7)	1214 (74.0)
>29 years	112 (3.2)	48 (2.4)	63 (4.0)
Mother's age at index child's birth; *Median (IQR)*	26 (11)	24 (10)	28 (9)

Continued on next page

[21] We use a binary population group variable in our regression analyses. The "non-Black" category was created by collapsing the Coloured, White, and Asian/Indian categories. Statistics for the sub-categories are shown here for descriptive purposes.

	All children, N=3810	**Children with non-co-resident fathers**, n=2141	**Children with co-resident fathers**, n=1638
Type of neighbourhood			
Urban	1702 (49.3)	773 (38.7)	907 (61.0)
Rural	2108 (50.7)	1368 (61.3)	731 (39.0)
ADDITIONAL VARIABLES	*(%)*	*n (%)*	*n (%)*
Mother's current marital status			
Married	1855 (48.4)	534 (22.8)	1318 (79.5)
Unmarried	1955 (51.6)	1607 (77.2)	320 (20.5)
Never married	*1314 (33.4)*	*1279 (60.2)*	*12 (1.0)*
Living like married	*440 (12.9)*	*140 (8.3)*	*300 (18.8)*
Widowed	*20 (0.4)*	*19 (0.8)*	*1 (0.0)*
Divorced	*47 (1.4)*	*43 (2.3)*	*2 (0.2)*
Separated	*134 (3.4)*	*126 (5.7)*	*5 (0.4)*
Mother worked in last 7 days			
No	2789 (72.5)	1677 (77.7)	1089 (66.4)
Yes	1005 (27.0)	453 (21.7)	545 (33.3)
Missing	16 (0.5)	11 (0.7)	4 (0.2)
Household wealth score (quintile)			
1 (Lowest)	990 (22.7)	690 (28.7)	297 (16.0)
2	887 (24.1)	555 (28.0)	327 (19.8)
3	765 (19.8)	425 (20.4)	332 (19.3)
4	658 (17.8)	352 (16.6)	295 (18.6)
5 (Highest)	510 (15.5)	119 (6.4)	387 (26.2)

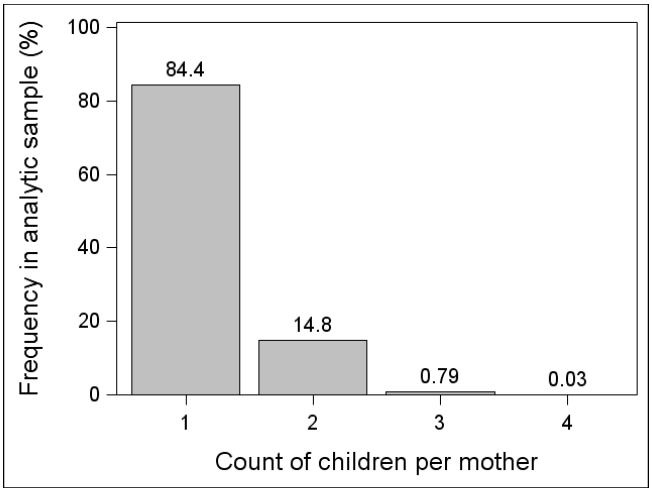
Continued on next page

	All children, N=3810	**Children with non-co-resident fathers**, *n*=2141	**Children with co-resident fathers**, *n*=1638
Province			
Western Cape	266 (9.1)	108 (7.0)	154 (11.6)
Eastern Cape	973 (14.3)	640 (17.2)	331 (11.1)
Northern Cape	344 (2.2)	176 (2.1)	164 92.4)
Free State	243 (5.3)	104 (4.3)	139 (6.7)
KwaZulu Natal	532 (20.7)	282 (22.3)	246 (19.1)
North West	282 (7.3)	159 (7.7)	120 (6.9)
Gauteng	288 (18.5)	98 (11.7)	179 (25.3)
Mpumalanga	400 (7.6)	243 (8.5)	156 (6.7)
Northern Province (Limpopo)	482 (14.9)	331 (19.2)	149 (10.1)

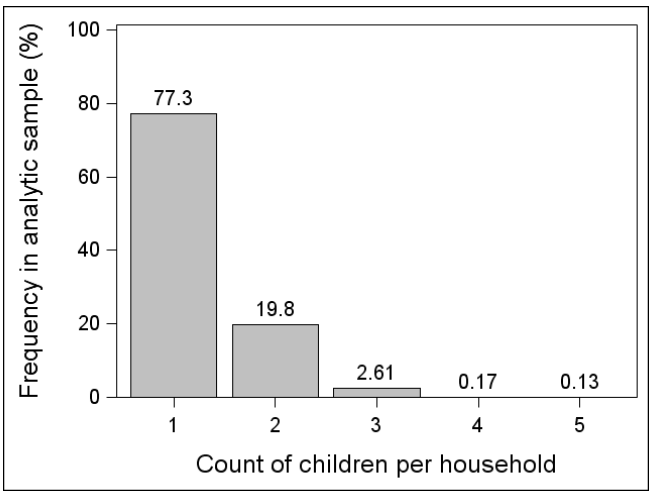
Note: Ratio=Ratio of children to each higher level unit; ARI=Acute Respiratory Infection; IQR=InterQuartile Range; TBA=Traditional Birth Attendant. Percentages, medians and IQRs are weighted to represent the 1998 South African population. Counts are unweighted.

The second panel of Table 4.1 shows the prevalence of each outcome in the complete analytic sample and separately for children with and without co-resident fathers. The third panel shows the frequency distributions (or measures of central tendency and spread) of potential confounding variables. The confounders are arranged from child- to neighbourhood-level. However, so that comparisons can be made across strata of the child-level exposure variable, all of the descriptive statistics have been calculated at the child-level (for example, 'type of neighbourhood' reflects the percentage of children living in urban neighbourhoods as opposed to the percentage of neighbourhoods that are urban). Medians and interquartile ranges for the five neighbourhood variables derived from 1996 census data are shown separately in Table 4.6 on page 69.

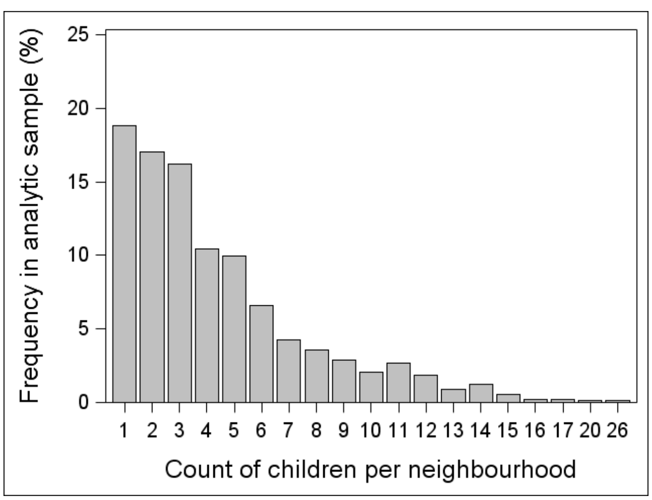
The descriptive statistics show a clear tendency for women in the sample to have had relatively low parity and long birth intervals. This is consistent with our observation that few children co-resided with other children in the under-5 age-group. This makes it difficult to use descriptive statistics to evaluate whether children living in the same household were more similar to one another in their experience of the exposure and outcomes than they were to children in other households. Clustering can be more easily examined for children living in the same neighbourhood. We found that 50% of neighbourhoods had a mixture of children with and without co-resident fathers. Whereas, in 22% of neighbourhoods there were only children with non-co-resident fathers, and in 29% there were only children with co-resident fathers. We also found that 65% of children who were breastfed for six months or longer lived in just 33% of neighbourhoods. Similarly, 65% of children who are completely immunized lived in 35% of neighbourhoods. For the illness outcomes, 59% of all children who had a recent ARI were concentrated in the 20% of neighbourhoods where two or more children had this outcome. While 50%



(a)



(b)



(c)

Figure 4.1: Bar graphs representing the distribution of children in the complete analytic sub-sample across mothers (a), households (b) and neighbourhoods (c).

of children who had recent diarrhoea lived in the 15% of neighbourhoods where two or more children had this outcome. These statistics suggests that the probability of living with a father and the probability of experiencing each health outcome was not evenly distributed across South African neighbourhoods.

It is clear that, compared to children with non-co-resident fathers, fewer children with co-resident fathers were breastfed for six months or longer. In contrast, there were no differences between children with and without co-resident fathers in the probability of having experienced each of the other three outcomes. This is surprising given that the groups had clearly different distributions of potential confounders. For example, a slightly greater percentage of children with non-co-resident fathers were delivered at home, while a dramatically greater percentage of children with co-resident fathers were delivered in private medical facilities. These differences in birth environment might be expected to manifest in different rates of immunization completeness because BCG and polio vaccines are given at birth. Conversely, children with co-resident fathers tended to be older than those with non-co-resident fathers. Therefore, we may expect a greater percentage of the latter group to be completely immunized because fewer would have had the opportunity to miss a vaccine dose. Possibly the reason there is no unadjusted association between father's co-residence status and immunization completeness is because there is confounding in both positive and negative directions, leading to a net null effect.

Another interesting observation is that children with co-resident fathers tended to be their mother's second born child or higher, while a much larger percentage of children with non-co-resident fathers were first borns. We might expect that having more siblings would increase children's exposure to infectious organisms, manifesting in the group of children with co-resident fathers having higher prevalences of ARI and diarrhoea. On the other hand, a far greater percentage of children with non-co-resident fathers lived in rural neighbourhoods. Children in rural neighbourhoods tend to have greater risks for diarrhoeal and respiratory illnesses because of poorer access to sanitation and running water and because of higher levels of indoor air pollution from cooking fuels [2, p. 35]. Again these opposing confounding effects may result in net null unadjusted associations between father's co-residence status and recent ARI or diarrhoeal illness.

Examining indicators of household socioeconomic status (antenatal care provider and place of delivery, mother's population group and educational attainment, household wealth index and type of neighbourhood) it is clear that children with co-resident fathers tended to come from higher socioeconomic status households. However, it is interesting to note that this group does not seem to be a purely 'high status' group. For example, receipt of antenatal care from a non-medical provider (or receiving no care), though rare in absolute terms, were twice as common for children with co-resident fathers than for those with non-co-resident fathers. Similarly, although having a mother who completed high school was more common among children with co-resident fathers, the percentage whose mothers had less than primary-level education was equal in the two exposure groups. The potential confounding effects of these variables on the co-resident father-child health outcome associations can be more readily appreciated by comparing adjusted to unadjusted odds ratios, presented in the following section.

4.2 Findings from multilevel regressions

Principal analyses of father's co-residence status and child health outcomes

In this section we present results of regressions of each child health outcome on father's co-residence status. In the top panel of Table 4.2 on page 59, odds ratios (ORs) and 95% Credible Intervals (CIs)[22] are from ordinary logistic regression models, without confounder adjustment. The remainder of the results in Table 4.2 are from multilevel logistic regressions, which include neighbourhood-level varying intercepts and co-resident father varying slopes and adjust for all potential confounders listed. Point and interval estimates for the parameters of the neighbourhood varying coefficients are presented in the bottom panel of the table. Tables A.2-A.5 (Appendix A.4) present findings of complementary regression models which do not model neighbourhood variation in the co-resident father slope or which, additionally, model household variation in the intercept. Note that, in models with varying slopes, the co-resident father regression co-efficient is conditional on neighbourhood membership. The interpretation thus becomes: the average expected change in the odds of having the outcome associated with having a co-resident father, *comparing otherwise similar children living in the same neighbourhood*.

For models of breastfeeding duration, complete case data were available for 3126 children (93.1% of children at least six months old in analytic sub-sample). 3499 children (91.8% of analytic sub-sample) contributed data to models of immunization completeness. For the models of recent ARI, complete case data were available for 3633 children (95.4% of analytic sub-sample) and, for recent diarrhoea, complete case data were available for 3642 children (95.6% of analytic sub-sample).

Consistent with the descriptive statistics in the preceding section, without adjustment for potential confounding, having a co-resident father was associated with 39% lower odds of having been breastfed for six months or longer. In contrast, the OR estimate from the full model is completely attenuated. This finding suggests that, for otherwise similar children living in the same neighbourhood, having a co-resident father was not associated with having been breastfed for six months or longer.

Also consistent with the descriptive statistics, the unadjusted regression results suggest having a co-resident father was not significantly associated with having been completely immunized or with having had a recent illness. The multilevel models suggest similar results hold after controlling for potential confounding and neighbourhood membership.

Referring to the bottom panel of the table, we observe relatively large standard deviations (SDs) for the neighbourhood varying coefficients in all four models. The credible intervals give the range of most likely values for these parameters. These ranges are all reasonably large, but suggest that it is very unlikely that any of the varying coefficient parameters is zero (which would imply no neighbourhood-level variation). The varying slopes SDs for the immunization completeness and recent diarrhoea outcomes are of similar magnitude (SD: 0.59, 95% CI: 0.35 - 0.91; and SD: 0.57, 95% CI: 0.33 - 0.91, respectively). Whereas the varying slopes SD is noticeably larger in the model for recent ARI, though the associated CI is very wide (SD: 1.10, 95% CI: 0.63 - 1.53).

[22] A Credible Interval is interpreted similarly to a Confidence Interval in frequentist statistics. The 95% credible interval gives the range of values which are 95% likely to include the true value of the parameter of interest.

The SD estimates are on the logit scale. To interpret the magnitude of variation on the odds ratio scale we can calculate the interval that would be expect to include odds ratios from 95% of neighbourhoods in South Africa. In contrast to the 95% CIs (which reflect uncertainty in the parameter estimates) the following 95% OR intervals reflect the extent of variation observed in the co-resident father effect estimate across children living in different neighbourhoods. For the breastfeeding outcome the range of odds ratios expected to be observed in 95% of South African neighbourhoods was 0.24 - 4.56. Similarly, for immunization completeness and recent diarrhoea the 95% OR ranges were 0.38 - 3.90 and 0.38 - 3.58, respectively. For ARI the range was considerably wider than for the other outcomes because of the larger slopes SD (95% OR range: 0.14 - 10.40). The OR point estimates suggest that, on average, having a co-resident father was not associated with any of the child health outcomes. However, all of the above 95% intervals include very large and very small OR values. This indicates that in a percentage of neighbourhoods having a co-resident father was associated with increased odds of the child health outcomes and in other neighbourhoods having a co-resident father was associated with reduced odds of the outcomes.

There appeared to be little to no correlation between the varying intercepts and slopes in models for breastfeeding, immunization and diarrhoea. In contrast, in the ARI model the correlation was estimated to be reasonably large and negative (ρ: -0.43, 95% CI: -0.74 – 0.03). This could indicate that there were important covariates not accounted for in the model, which influence both neighbourhood intercepts and slopes, causing them to be correlated.

Table 4.2: Odds ratios (ORs) and 95% Credible Intervals (CIs) estimated from multilevel logistic regressions for four child health outcomes; children aged 0-4 years in the 1998 SADHS.

	Breastfed $\geq$6 months		Completely immunized		Recent ARI		Recent diarrhoea	
	Est.	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**
UNADJUSTED								
Co-resident father	0.61	(0.52 - 0.71)	1.11	(0.96 - 1.27)	1.04	(0.88 - 1.22)	0.88	(0.73 - 1.07)
VARYING INTERCEPT, VARYING SLOPE								
Co-resident father	0.99	(0.78 - 1.25)	1.17	(0.95 - 1.43)	1.09	(0.81 - 1.42)	1.12	(0.83 - 1.45)
Birth order & preceding birth interval								
1st born	0.68	(0.49 - 0.91)	1.09	(0.82 - 1.41)	1.18	(0.85 - 1.60)	1.31	(0.89 - 1.84)
2-4 born, <24 months	0.95	(0.59 - 1.46)	1.07	(0.72 - 1.54)	1.41	(0.89 - 2.11)	1.33	(0.79 - 2.09)
2-4 born, 24-47 months	REF		REF		REF		REF	
2-4 born, >47 months	0.89	(0.65 - 1.19)	0.97	(0.74 - 1.25)	1.29	(0.94 - 1.73)	1.31	(0.91 - 1.83)
5+ born, <24 months	0.64	(0.32 - 1.19)	0.58	(0.32 - 0.98)	1.67	(0.81 - 3.00)	2.16	(1.01 - 3.99)
5+ born, 24-47 months	1.11	(0.65 - 1.77)	0.82	(0.54 - 1.20)	1.26	(0.77 - 1.94)	1.41	(0.84 - 2.25)
5+ born, >47 months	1.18	(0.66 - 1.96)	1.02	(0.64 - 1.55)	1.62	(0.96 - 2.62)	2.06	(1.16 - 3.39)

Continued on next page

	Breastfed ≥6 months		Completely immunized		Recent ARI		Recent diarrhoea	
	Est.	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**
Place of delivery								
Public medical facility	REF		REF		REF		REF	
Home	1.31	(0.95 - 1.77)	0.60	(0.47 - 0.76)	1.03	(0.77 - 1.34)	1.41	(1.05 - 1.86)
Private medical facility	0.68	(0.45 - 0.98)	0.89	(0.60 - 1.27)	0.80	(0.51 - 1.20)	0.60	(0.32 - 1.00)
Antenatal care provider								
Nurse/ midwife (+/- doctor)	REF		REF		REF		REF	
Doctor	0.64	(0.48 - 0.84)	0.81	(0.61 - 1.05)	1.03	(0.75 - 1.36)	1.10	(0.77 - 1.52)
TBA, Other, no care	0.95	(0.54 - 1.56)	0.66	(0.42 - 0.99)	0.69	(0.38 - 1.11)	0.52	(0.25 - 0.90)
Time mother wanted pregnancy								
Then	REF		REF		REF		REF	
Later	1.20	(0.95 - 1.50)	1.12	(0.92 - 1.36)	1.04	(0.83 - 1.29)	1.35	(1.04 - 1.71)
No more	0.99	(0.74 - 1.30)	0.86	(0.68 - 1.09)	1.11	(0.84 - 1.44)	1.51	(1.11 - 2.00)
Child's sex								
Female					REF		REF	
Male					0.99	(0.82 - 1.18)	1.35	(1.10 - 1.66)
1 SD increase in child's age (months)			0.69	(0.63 - 0.75)	0.79	(0.72 - 0.87)	0.59	(0.52 - 0.65)

Continued on next page

	Breastfed ≥6 months		Completely immunized		Recent ARI		Recent diarrhoea	
	Est.	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**
Season								
Summer					REF		REF	
Autumn					1.03	(0.80 - 1.30)	0.99	(0.77 - 1.27)
Winter					1.37	(0.91 - 1.99)	0.59	(0.34 - 0.92)
Mother's population group								
Black/African	REF		REF		REF		REF	
Non-Black/African	0.46	(0.34 - 0.60)	1.66	(1.25 - 2.17)	1.13	(0.84 - 1.50)	0.86	(0.60 - 1.18)
Mother's highest completed education level								
Less than primary	1.44	(1.10 - 1.86)	0.77	(0.62 - 0.94)	0.85	(0.66 - 1.07)	1.18	(0.90 - 1.51)
Primary or incomplete secondary	REF		REF		REF		REF	
Secondary or higher	0.87	(0.67 - 1.11)	1.08	(0.84 - 1.36)	0.84	(0.64 - 1.09)	0.87	(0.63 - 1.17)
Mother's childhood residence & migration status								
Rural area, did not migrate	REF		REF					
Urban area, did not migrate	0.53	(0.39 - 0.69)	1.21	(0.93 - 1.56)				
Rural area, migrated urban	0.74	(0.53 - 1.03)	1.08	(0.80 - 1.43)				
Urban area, migrated rural	0.77	(0.48 - 1.18)	1.75	(1.09 - 2.69)				

Continued on next page

	Breastfed ≥6 months		Completely immunized		Recent ARI		Recent diarrhoea	
	Est.	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**
Mother's age at first child birth								
<18	1.15	(0.89 - 1.47)	0.91	(0.74 - 1.12)	1.16	(0.91 - 1.44)	1.09	(0.83 - 1.38)
18-29	REF		REF		REF		REF	
>29	0.67	(0.35 - 1.18)	0.90	(0.50 - 1.51)	0.72	(0.34 - 1.33)	0.85	(0.35 - 1.66)
1 SD increase in mother's age at index child's birth	0.91	(0.77 - 1.07)	1.10	(0.95 - 1.27)	0.92	(0.77 - 1.08)	0.90	(0.74 - 1.08)
Varying coefficients								
SD Neighbourhood intercepts	0.77	(0.57 - 0.99)	0.76	(0.58 - 0.95)	0.78	(0.56 - 1.02)	0.56	(0.38 - 0.77)
SD Neighbourhood slopes	0.74	(0.43 - 1.13)	0.59	(0.35 - 0.91)	1.10	(0.63 - 1.53)	0.57	(0.33 - 0.91)
Correlation between varying coefficients	0.29	(-0.26 - 0.74)	0.01	(-0.50 - 0.56)	-0.43	(-0.74 - 0.03)	0.00	(-0.58 - 0.56)

Note: ARI=Acute Respiratory Infection; Est.=Estimate; REF=Reference category; TBA=Traditional Birth Attendant; SD=Standard Deviation.

Interactions between father's co-residence status and other dimensions of household structure

In this section we present results of analyses examining whether other dimensions of household structure were interacting with father's co-residence status in their association with each child health outcome.

First, we considered mother's marital status as a potential effect modifier, grossly distinguishing between married and currently unmarried mothers. The latter category includes never married and formerly married women. We treated children with currently unmarried mothers and non-co-resident fathers as the reference group. Note that the OR comparing children with married mothers and co-resident fathers to the reference group was calculated as the exponentiated linear combination of the coefficients for father's co-residence status, mother's marital status, and the interaction term.

There were modest differences in the ratio of odds ratios within each category of mother's marital status for the immunization, ARI and diarrhoea outcomes (Table 4.3 on the next page). However, the 95% CI estimate for the interaction term in all four models included the null (results not shown). Father's co-residence status was not associated with immunization completeness among children of currently unmarried mothers. Whereas, among children with married mothers, residing with a father was associated with a modest, but non-significant, increased odds of being completely immunized. There was also a non-significant trend for residing with a father to be associated with increased odds of both types of illness, but only among children with currently unmarried mothers.

Table 4.3: Adjusted Odds Ratios (ORs) and 95% Credible Intervals (CIs) for interactions between father's co-residence status and mother's marital status estimated using multilevel logistic regressions with intercepts varying by neighbourhood. Counts and population-weighted percentages in each group are also shown; children aged 0-4 years, 1998 SADHS.

		Breastfed ≥6 months		**Completely immunized**		**Recent ARI**		**Recent diarrhoea**	
	n (%)	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Currently unmarried, not co-residing	1607 (41.7)	REF		REF		REF		REF	
Currently unmarried, co-residing	320 (9.4)	1.07	(0.71 - 1.57)	0.96	(0.68 - 1.31)	1.44	(1.02 - 1.98)	1.45	(0.97 - 2.07)
Married, not co-residing	534 (12.3)	0.70	(0.49 - 0.97)	0.96	(0.71 - 1.25)	1.05	(0.76 - 1.40)	1.33	(0.92 - 1.84)
Married, co-residing	1318 (36.6)	0.73	(0.56 - 0.94)	1.15	(0.91 - 1.43)	1.12	(0.87 - 1.42)	1.32	(0.98 - 1.74)

Note: ARI=Acute Respiratory Infection

Second, we examined whether living with other adult relatives affected the outcomes of children whose fathers were non-co-resident as compared to those of children with co-resident fathers. (Complete descriptive statistics and regression results from these analyses are presented in Tables A.6 and A.7, Appendix A.5)

Among children with non-co-resident fathers, approximately half had co-resident male relatives, one quarter had co-resident female relatives (but no co-resident male relatives) and the remaining one quarter had no additional co-resident relatives[23] (Table 4.4 on the following page). Only a minority of children with co-resident fathers had additional co-resident relatives of either sex. In contrast, the majority of children with non-resident fathers and co-resident male relatives also had co-resident female relatives. These types of households tended to have a greater number of adult members than the three other household types.

To relate these household types to the preceding analyses involving mother's marital status, notice that almost half of mothers who were the lone adult in their children's households were married, while about one quarter had never been married. This could reflect that more lone mother households in South Africa arise because of married couples residing in separate dwellings than through non-marital childbearing. (Formal divorce appeared to be a very uncommon cause of lone mother households.) It appears that the majority of children who were born outside of marriage and were living with their mothers also had other adult relatives residing with them.

Examining the unadjusted OR estimates in the upper panel of table 4.5 it appears that, in comparison to living with a co-resident father, living in any other household structure was associated with greater odds of having been breastfed for at least six months. However, similarly to what we observed in the principal analyses, adjusting for potential confounders completely attenuated these associations. Children living with single mothers appeared to be less likely to be completely immunized than children with two co-resident parents, even after adjusting for potential confounding (OR: 0.79, 95% CI: 0.61 - 1.00). In contrast, children with additional co-resident relatives had similar odds of being completely immunized to children with co-resident fathers. All children with non-co-resident fathers showed a trend towards lower odds of recent ARI and diarrhoea compared to children with co-resident fathers, regardless of whether they had additional co-resident relatives. However, the 95% CIs included the null in all cases.

[23] Recall that all children included in these analyses live with their mothers.

Table 4.4: Population-weighted descriptive statistics comparing children with co-resident fathers to those with non-co-resident fathers, the latter stratified by whether they reside with other adult relatives; children aged 0-4 years, 1998 SADHS.

		Non-co-resident father		
	Co-resident father	**$\geqslant$ 1 male relative**	**Female relatives only**	**Mother only**
n (%)	1638 (43.9)	1156 (27.8)	572 (13.7)	543 (13.1)
Median number *de jure* adult household members (IQR)	2 (1)	4 (2)	2 (1)	1 (0)
Number co-resident adult female relatives				
0	76.9	16.3	0.0	100.0
1	16.4	39.9	63.6	0.0
2+	6.4	43.7	36.4	0.0
Missing	0.2	0.0	0.0	0.0
Number co-resident adult male relatives				
0	81.4	0.0	100.0	100.0
1	13.1	60.7	0.0	0.0
2+	5.3	39.3	0.0	0.0
Missing	0.2	0.0	0.0	0.0
Mother's current marital status				
Married	79.5	12.3	14.6	48.6
Unmarried	20.5	87.7	85.4	51.4
Never married	*1.0*	*71.6*	*69.4*	*24.2*
Living like married	*18.8*	*5.9*	*8.7*	*10.8*
Widowed	*0.0*	*2.1*	*1.6*	*5.2*
Divorced	*0.2*	*1.6*	*2.1*	*4.0*
Separated	*0.4*	*6.5*	*3.5*	*7.2*

Note: IQR=InterQuartile Range.

Table 4.5: Odds Ratios (ORs) and 95% Credible Intervals (CIs) comparing children with different combinations of co-resident relatives estimated by ordinary logistic regressions (unadjusted) or multilevel logistic regressions with neighbourhood-level varying intercepts (adjusted); children aged 0-4 years, 1998 SADHS.

	Breastfed >= 6 months		**Completely immunized**		**Recent ARI**		**Recent diarrhoea**	
	OR	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
UNADJUSTED								
Co-resident father	REF		REF		REF		REF	
$\geqslant$ 1 male relative	1.52	(1.26 - 1.81)	1.01	(0.85 - 1.19)	0.99	(0.81 - 1.19)	1.17	(0.93 - 1.44)
Female relatives only	1.63	(1.28 - 2.06)	0.88	(0.71 - 1.08)	0.98	(0.76 - 1.24)	1.24	(0.92 - 1.61)
Mother only	1.84	(1.44 - 2.35)	0.67	(0.54 - 0.82)	0.84	(0.64 - 1.08)	1.02	(0.76 - 1.35)
ADJUSTED, VARYING INTERCEPTS								
Co-resident father	REF		REF		REF		REF	
$\geqslant$ 1 male relative	1.12	(0.86 - 1.42)	0.92	(0.73 - 1.14)	0.85	(0.67 - 1.07)	0.83	(0.63 - 1.07)
Female relatives only	1.03	(0.74 - 1.40)	0.89	(0.68 - 1.14)	0.86	(0.64 - 1.14)	0.85	(0.61 - 1.15)
Mother only	1.08	(0.79 - 1.45)	0.79	(0.61 - 1.00)	0.82	(0.60 - 1.09)	0.84	(0.60 - 1.14)
SD neighbourhood intercepts	0.93	(0.75 - 1.11)	0.80	(0.65 - 0.94)	0.73	(0.56 - 0.90)	0.56	(0.37 - 0.74)

Note: ARI=Acute Respiratory Infection; REF=Reference category; SD=Standard Deviation.

4.3 Explaining variation in neighbourhood coefficients

In this section we present descriptive statistics for the neighbourhood-level covariates derived from 1996 census data. We then present findings of analyses assessing the degree to which each neighbourhood covariate accounted for variation in the neighbourhood intercepts and co-resident father slopes.

There were clear differences between the typical neighbourhood characteristics of children who had co-resident fathers and those whose fathers were non-co-resident (Table 4.6). The former group tended to live in neighbourhoods where a greater percentage of female residents had completed high school. Interestingly, the IQR for the percentage of women having completed high school was higher for children whose fathers were co-resident than for children whose fathers were non-co-resident (IQR 22.7 vs 10.7). Children with co-resident fathers also tended to live in neighbourhoods with lower percentages of female-headed households, lower rates of male unemployment, and lower concentrations of low-income households.

Table 4.7 on page 71 is a compilation of findings from seven multilevel models for each outcome. The first panel presents a subset of results from the 'Varying intercept, varying slope models' first presented Table 4.2 (reproduced here for ease of comparison). Each subsequent panel presents the results of a model which includes a single neighbourhood covariate as a predictor in the models for the varying intercepts and slopes (and is otherwise identical to the 'Varying intercept, varying slope model'). The neighbourhood covariates are indicated in bold font in the first column of Table 4.7 on page 71. The estimate for the neighbourhood covariate is the (exponentiated) regression coefficient from the model of the neighbourhood intercepts. The 'interaction' estimate is the (exponentiated) regression coefficient from the model of the random slopes.

Examining the OR estimates for each neighbourhood covariate, we observed few ORs with 95% CIs that exclude the null. Two exceptions were the ORs for a) the rate of unemployment among male neighbourhood residents, and b) the percentage of female residents with completed high school education or higher in models for the immunization outcome. These ORs are interpreted as the expected ratio of the odds of being completely immunized comparing otherwise similar children who live in neighbourhoods that differ by 1 SD on the characteristic of interest. For example, comparing otherwise similar children, each 17.9% increase in the neighbourhood percentage of female residents who completed high school was associated with an 18% increase in the odds of being completely immunized. Conversely, a 26.5% increase in the unemployment rate for male neighbourhood residents was associated with a 14% decline in the odds of having been completely immunized, all other characteristics being equal. Including any of these covariates in the model for the neighbourhood intercepts resulted in only a small reduction in the estimated SD of the intercepts about their mean.

Next we examine the estimated ORs for the interaction terms. In these models, the OR for the co-resident father variable is interpreted as the expected ratio of the odds of having the outcome comparing a child who had a co-resident father to *an otherwise similar child in the same neighbourhood* who had a non-co-resident father, *where the value of the neighbourhood-level predictor in question was at*

Table 4.6: Medians (*M*) and InterQuartile Ranges (*IQR*) for neighbourhood contextual variables derived from 1996 SA Census data. Statistics are presented for the complete analytic sample of children from the 1998 SADHS and separately for strata of children with and without co-resident fathers

	All children N=3810		**Children with non-co-resident fathers** n=2134		**Children with co-resident fathers** n=1646	
	M	*IQR*	*M*	*IQR*	*M*	*IQR*
% Female residents completed high school	10.7	(15.3)	8.7	(10.7)	13.8	(22.7)
Ratio female-to-male residents completed high school	0.9	(0.5)	0.9	(0.6)	0.9	(0.5)
% Households having a female head	40.7	(28.6)	46.7	(27.5)	31.5	(26.7)
% Male residents unemployed	37.6	(39.4)	44.7	(36.6)	25.9	(37.5)
% Households with annual income < R6000	38.4	(44.6)	45.2	(42.8)	28.8	(41.2)
Missing data; n (%)	*39*	*(1.0)*		*(1.2)*		*(0.5)*

the reference level[24]. On the other hand, the OR for the interaction term is the expected combined effect of having a co-resident father and a 1SD increase in the value of the neighbourhood covariate, *comparing otherwise similar children, living in otherwise similar neighbourhoods (i.e.: neighbourhoods having the same value of the random slope).* Few of the ORs were significant. The largest interactions were for the urban neighbourhood indicator in the model of immunization completeness, and for the percentage of female residents with completed high school education in the model for recent ARI. The interaction for the urban neighbourhood indicator suggested that, comparing otherwise similar children in a rural neighbourhood, father's co-residence status was not associated with a change in odds of being completely immunized. Whereas, comparing otherwise similar children in an urban neighbourhood, co-residing with a father was associated with about 50% higher odds of being completely immunized. For the ARI outcome, as the neighbourhood percentage of female high school graduates increased, the association between having a co-resident father and having had a recent ARI became more strongly positive. Similarly to the case for the varying intercepts, none of the covariates appeared to significantly explain the variation in the neighbourhood-specific effects of having a co-resident father from their overall mean value.

[24]The reference level for the urban neighbourhood indicator variable is rural. For all other neighbourhood covariates, the reference level is the mean across all neighbourhoods in the analytic sample.

Table 4.7: Odds Ratios (95% credible intervals) for neighbourhood covariates in models for neighbourhood varying intercepts and co-resident father slopes estimated using multilevel logistic regression. Standard Deviations (95% credible intervals) for the varying coefficients are also shown.

	Breastfed ≥6 months		**Completely immunized**		**Recent ARI**		**Recent diarrhoea**	
	Est.	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**
Co-resident father	0.99	(0.78 - 1.25)	1.17	(0.95 - 1.43)	1.09	(0.81 - 1.42)	1.12	(0.83 - 1.45)
SD neighbourhood intercepts	0.77	(0.57 - 0.99)	0.76	(0.58 - 0.95)	0.78	(0.56 - 1.02)	0.56	(0.38 - 0.77)
SD neighbourhood slopes	0.74	(0.43 - 1.13)	0.59	(0.35 - 0.91)	1.10	(0.63 - 1.53)	0.57	(0.33 - 0.91)
Co-resident father	0.90	(0.63 - 1.24)	0.95	(0.74 - 1.22)	0.99	(0.68 - 1.39)	1.24	(0.86 - 1.70)
Urban neighbourhood[25]	N/A		N/A		0.88	(0.64 - 1.19)	0.95	(0.69 - 1.28)
Interaction	1.24	(0.79 - 1.86)	1.66	(1.13 - 2.37)	1.26	(0.79 - 1.91)	0.84	(0.52 - 1.28)
SD neighbourhood intercepts	0.78	(0.57 - 1.00)	0.75	(0.58 - 0.94)	0.79	(0.56 - 1.02)	0.57	(0.38 - 0.78)
SD neighbourhood slopes	0.73	(0.42 - 1.11)	0.58	(0.35 - 0.89)	1.10	(0.64 - 1.53)	0.58	(0.34 - 0.93)
Co-resident father	1.01	(0.77 - 1.29)	1.12	(0.90 - 1.38)	1.13	(0.84 - 1.47)	1.06	(0.78 - 1.40)
% male residents unemployed	1.03	(0.88 - 1.20)	0.86	(0.75 - 0.98)	1.08	(0.93 - 1.25)	0.89	(0.77 - 1.03)
Interaction	1.07	(0.86 - 1.34)	0.99	(0.83 - 1.19)	0.89	(0.71 - 1.10)	1.10	(0.88 - 1.36)
SD neighbourhood intercepts	0.76	(0.56 - 0.98)	0.74	(0.56 - 0.93)	0.78	(0.56 - 1.02)	0.57	(0.38 - 0.79)
SD neighbourhood slopes	0.75	(0.45 - 1.13)	0.60	(0.36 - 0.90)	1.10	(0.66 - 1.53)	0.60	(0.34 - 0.95)

Continued on next page

[25] Because we used the 'type of neighbourhood' variable to derive the individual-level variable indicating whether the mother migrated since childhood, these variables are perfectly correlated and it is not possible to include them together in our models. In consequence, in models of the breastfeeding and immunization outcomes, we do not estimate the main effect of type of neighbourhood on the outcome (as aspects of this effect are being reflected in the effects of having migrated versus continuously resided in the same type of area since childhood). However, we do estimate the effect of the interaction between type of neighbourhood and father's co-residence status.

	Breastfed ≥6 months		Completely immunized		Recent ARI		Recent diarrhoea	
	Est.	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**
Co-resident father	1.00	(0.77 - 1.27)	1.18	(0.96 - 1.46)	1.09	(0.81 - 1.43)	1.12	(0.83 - 1.49)
% households having a female head	1.04	(0.89 - 1.22)	1.02	(0.88 - 1.16)	1.02	(0.87 - 1.18)	1.02	(0.87 - 1.18)
Interaction	1.03	(0.83 - 1.27)	0.93	(0.77 - 1.10)	0.96	(0.77 - 1.18)	0.97	(0.78 - 1.20)
SD neighbourhood intercepts	0.77	(0.56 - 0.98)	0.76	(0.59 - 0.95)	0.79	(0.57 - 1.02)	0.57	(0.38 - 0.79)
SD neighbourhood slopes	0.74	(0.43 - 1.13)	0.59	(0.36 - 0.90)	1.11	(0.65 - 1.55)	0.59	(0.34 - 0.94)
Co-resident father	1.00	(0.78 - 1.27)	1.16	(0.94 - 1.43)	1.13	(0.84 - 1.48)	1.06	(0.78 - 1.41)
% households with annual income < R6000	1.11	(0.94 - 1.30)	0.94	(0.81 - 1.09)	1.15	(0.99 - 1.33)	0.98	(0.84 - 1.14)
Interaction	0.92	(0.74 - 1.14)	1.02	(0.85 - 1.22)	0.93	(0.74 - 1.15)	1.21	(0.96 - 1.50)
SD neighbourhood intercepts	0.78	(0.57 - 1.00)	0.76	(0.58 - 0.94)	0.78	(0.55 - 1.02)	0.57	(0.38 - 0.79)
SD neighbourhood slopes	0.71	(0.40 - 1.11)	0.59	(0.35 - 0.91)	1.11	(0.65 - 1.55)	0.59	(0.34 - 0.93)
Co-resident father	1.03	(0.80 - 1.30)	1.15	(0.92 - 1.41)	1.14	(0.85 - 1.51)	1.08	(0.80 - 1.40)
% female residents with high school education or higher	0.88	(0.75 - 1.03)	1.18	(1.03 - 1.35)	0.91	(0.78 - 1.06)	1.01	(0.86 - 1.19)
Interaction	1.15	(0.92 - 1.43)	0.99	(0.83 - 1.19)	1.25	(0.99 - 1.55)	0.90	(0.71 - 1.14)
SD neighbourhood intercepts	0.78	(0.57 - 1.00)	0.73	(0.56 - 0.92)	0.77	(0.54 - 1.01)	0.57	(0.39 - 0.78)
SD neighbourhood slopes	0.72	(0.42 - 1.10)	0.59	(0.34 - 0.91)	1.07	(0.61 - 1.50)	0.59	(0.34 - 0.95)

Continued on next page

	Breastfed ≥6 months		Completely immunized		Recent ARI		Recent diarrhoea	
	Est.	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**	**Est.**	**(95% CI)**
Co-resident father	0.99	(0.77 - 1.26)	1.17	(0.94 - 1.43)	1.08	(0.80 - 1.40)	1.13	(0.84 - 1.49)
Female-to-male ratio residents with high school education or higher	0.91	(0.80 - 1.03)	0.98	(0.88 - 1.09)	0.93	(0.82 - 1.05)	0.95	(0.83 - 1.07)
Interaction	1.00	(0.82 - 1.21)	1.05	(0.89 - 1.23)	1.15	(0.94 - 1.39)	1.08	(0.88 - 1.30)
SD neighbourhood intercepts	0.76	(0.56 - 0.98)	0.76	(0.59 - 0.95)	0.78	(0.56 - 1.02)	0.57	(0.38 - 0.80)
SD neighbourhood slopes	0.75	(0.43 - 1.15)	0.58	(0.35 - 0.91)	1.09	(0.62 - 1.52)	0.59	(0.35 - 0.95)

Note: ARI=Acute Respiratory Infection; Est.=Estimate of Odds Ratio or Standard Deviation; CI=Credible Interval; SD=Standard Deviation.

Chapter 5

Discussion: Effects of Father's Co-residence Status on Child Health Outcomes

The focus of this project was on the influences that biological fathers can have on their children's health. Although father-child residential arrangements, the focus of the preceding set of analyses, only tells a small part of the story, it does serve to highlight an important feature of the context for fathering in South Africa: the nuclear family form - involving a married or cohabiting couple residing with their offspring - is far from the norm in South Africa (as previously emphasized, see for example [180, 122, p. 60-1]). Less than half of the children in our sample were residing with both parents. Nevertheless, father-child co-residence was considerably more common in our study than in two previous studies of households in rural areas of South Africa. Both of these found less than one third of children were residing with fathers [76, 81]. The difference between their findings and ours may be mainly because paternal co-residence appears to be more common in urban than rural areas. That our findings are reflective of the situation nationally is supported by the fact that 46% of 0-4 year old children were estimated to be residing with both biological parents in the 2002 South African General Household Survey, similar to the 43% in our analytic sample (*calculated by the authors using Statistics South Africa data* [49]).

In our study, children with non-co-resident fathers were found to be living in a variety of household structures, only one quarter of which could be considered truly 'single-mother households'. Many previous investigations of household structure effects on child health focus on a single dimension of household structure, such as mother's marital status or female household headship. The complexity of household structures we observed in this dataset leads us to suggest that simultaneously considering multiple dimensions of household structure may produce more meaningful results, especially when fathers are a focus of the investigation.

With this set of analyses, we sought to address three questions. First, we asked whether children who reside with both biological parents would tend to have better health-related outcomes than children who reside with mothers but not fathers. Second, we assessed whether the (lack of) association between father's co-residence status and children's health outcomes was modified by either a) mother's marital status, or b) co-residence status of other adult family members. Third, we estimated the magnitude of neighbourhood-level variation in the association between residing with a father and children's health outcomes, and explored whether neighbourhood contextual variables constructed from census data could explain variation in the co-resident father effect estimates. In the sections that follow, we discuss our findings to each question as well as some important limitations of our analyses.

5.1 Do children who reside with their biological father tend to have better health outcomes?

We did not find evidence to support this hypothesis. The lack of association with father's co-residence status was consistent for all of the child health-related outcomes we examined. In general, controlling for potential confounders did not change the conclusions of unadjusted analyses. Breastfeeding duration was the exception: the unadjusted effect estimate suggested that children with co-resident fathers tended to be less likely to be breastfed for six months or longer; whereas, the adjusted estimate suggested no difference between the two groups of children. It is difficult, using the cross-sectional measures available in the SADHS dataset, to control for socioeconomic conditions preceding the observed living arrangements. Nevertheless, we were careful to control for indicators of socioeconomic status that were unlikely to result from father's co-residence status at the time of the survey. As such, our adjusted regression findings support the conclusion that the tendency for children in two-parent households to be breastfed for shorter durations is more likely related to living in higher socioeconomic status households than to co-resident fathers effecting earlier weaning.

Previous research in low- and middle-income countries has found that more educated women, women who are employed and those with higher incomes tend to wean their children earlier [181, 182, 97]. One of these studies also demonstrated that women with co-resident spouses tended to breastfeed for longer durations. The authors explained this association as possibly being because women with absent spouses are "more likely to assume market economic roles, which often are incompatible with breast-feeding." [97, p. 67] Our analyses did not show the same association with father's co-residence status. Possibly because, in our sample, a greater percentage of women who resided with their children's fathers were working. This could relate to confounding by socioeconomic status: more highly educated women tended to be more likely to co-reside with their child's father. Additionally, more highly educated women were more likely to be employed, reducing the chances that they breastfed for extended durations. Possibly, had we been able to adjust for more specific socioeconomic indicators, particularly whether mothers worked prior to children's births, we may have found a stronger positive association between father's co-residence and breastfeeding duration than we did.

5.2 Are the father's co-residence status – child health outcome associations modified by other characteristics of household structure?

Our findings for this question are suggestive but not definitive. In all of our models, effect estimates for the interaction terms were subject to large uncertainty, so need to be interpreted cautiously. However, it is interesting to note that children whose mothers were the only adult members of their households tended to be less likely to be completely immunized than children who resided with both parents. This association persisted even after adjusting for potential confounding variables. However, children who were living with their mothers and one or more additional adult relatives were just as likely to be completely immunized as children living with both biological parents. Whether the additional relatives included one or more males did not appear to be important for this association.

These findings are consistent with predictions of the time allocation model: a greater number of adults in a household means a greater pool of time resources to allocate to the common goal of producing child wellbeing. According to this model, the sex of the adults and their relationship to the child should be unimportant. Routine childhood immunizations had been available in South Africa without cost to parents from the beginning of the time period considered in this study. While this may have reduced the importance of financial cost as a barrier, the opportunity cost of time spent taking children for immunizations may have been more burdensome for mothers who did not have ready access to support from household members, contributing to a lower chance of immunization completeness for their children.

In conflict with the time allocation model, previous research in South Africa has suggested that mothers are more supported in allocating household resources to their children's health in households managed by co-operating female relatives than in households managed by men [43, 60]. Although the information was not available in the SADHS dataset to properly identify households composed of co-operating female relatives, we used the presence of co-resident adult female relatives and the absence of co-resident male relatives as an proxy indicator for these types of households. Our models did not demonstrate higher rates of immunization completeness among children living with only female relatives compared to children living with both biological parents or with their mother and one or more adult male relatives, however, future research into this question would be valuable.

Our model findings for the immunization and recent illness outcomes also suggest that co-residence of fathers tends to be more beneficial when parents are married. For example, among children whose mothers were married, a co-resident father was associated with a higher likelihood of being completely immunized, but not among children whose mothers were unmarried. In addition, children with cohabiting but unmarried parents tended to be more likely to have had a recent respiratory or diarrhoeal illness than children with unmarried mothers and non-resident fathers. But the same does not seem to be true for children with married, co-residing parents. These findings do not fit with predictions of the time allocation model: co-resident fathers, whether married or unmarried, should increase available household resources. Nevertheless, they are consistent with findings of prior research, which often suggests outcomes are poorer among children whose parents are in cohabiting versus marital unions [96, 116]. A possible explanation is that, at least among some segments of South African society, cultural norms favour marriage over cohabitation, as described in the literature review (section 2.1.3). In families and communities with strong traditional values, couples living in non-marital unions may experience social isolation, while their children may lack the benefits of recognized membership in either father's or mother's kin groups. These may result in more negative outcomes for children. However, it appears that attitudes towards cohabitation differ between Black and White South Africans and between urban and rural Black South Africans [59]. Non-marital cohabitation is clearly a complex phenomenon. The health consequences (if any) for children of living with cohabiting as compared to either married or single parents cannot be adequately addressed with the analyses presented here. Temporal trends toward fewer marriages and more cohabiting unions in South Africa indicate this question is deserving of further research attention [79, 58].

5.3 What is the magnitude of neighbourhood-level variation in the co-resident father effect estimates and which contextual characteristics contribute to this variation?

For all outcomes we found reasonably consistently high levels of variation across neighbourhoods in the co-resident father effect estimates. However, the standard deviation parameters for the distributions of these neighbourhood effects were all estimated with large uncertainty. This uncertainty is due to there being few 0-4 year old children per neighbourhood in the SADHS dataset, making it impossible to precisely estimate the within-neighbourhood co-resident father effects. For this reason, our analyses are more useful for describing the magnitude of variation than for making comparisons between neighbourhoods. Our results support the conclusion that, for each outcome, in some neighbourhoods co-resident fathers are, on average, associated with significantly increased odds of the outcome, and in others they are associated with a significant reduction in the odds of the outcome.

In general, our analyses using neighbourhood-level variables did not provide much insight into the factors responsible for variations in the co-resident father effect estimates. We hypothesized that father's co-residence would be more weakly associated with beneficial child health outcomes in poorer neighbourhood and in neighbourhoods with lower levels of employment. We also hypothesized that father's co-residence would be associated with stronger positive effects in more gender-equitable neighbourhood contexts. The only findings to support our hypotheses were: a) the strongly positive association of father's co-residence with immunization completeness in urban neighbourhoods, compared to no association in rural neighbourhoods, and b) the increasingly negative association between father's co-residence and diarrhoea as the percentage of low-income households decreased (although this estimate had large uncertainty). In fact, for the ARI outcome, there is some evidence to contradict our hypotheses: although not statistically significant, the direction of the interaction between father's co-residence status and a) percentage of female residents having completed high school, and b) the ratio of female to male high school graduates suggest that, as these indicators of neighbourhood gender equity increased, having a co-resident father became more strongly positively associated with recent ARI. Even where the cross-level interaction terms were significant, the estimated standard deviation of the neighbourhood co-resident father effect estimates did not noticeably decrease. This implies that the neighbourhood characteristics did not explain much of the variation of the within-neighbourhood co-resident father effects away from the average effect across all neighbourhoods in the sample.

We selected neighbourhood characteristics with reference to a theoretical model of the determinants of positive fathering [47]. This model identifies characteristics of the economic and cultural context as important. At least in some areas of South Africa, the dominant societal expectation of men is to be economic providers for their families [32]. These societal expectations appear to be mirrored in young fathers' expectations of their personal involvement with their children. Despite recognizing other positive types of involvement, their accounts emphasize financial provision as the foremost requirement of being a good father [82]. We had hypothesized that fathers should be able to contribute to improved child health through pathways not limited to economic provision. However, in reality, societal and personal expectations may make financial provision a pre-requisite to other types of positive involvement.

In economic contexts of limited employment for low- and semi-skilled labourers, realizing a stable position as 'breadwinner' may be impossible for many men. Perceived as failures in light of traditional gender norms, unemployed or unstably employed men may be discouraged from supporting their children through alternative (traditionally feminine) caregiving activities [32]. Evidence from the United States shows that in impoverished neighbourhoods, where few men are able to replicate traditional patriarchal models of masculinity, alternative models of masculinity - which celebrate violence and sexual promiscuity and de-emphasize responsibility towards women and children - can become the norm [183, 18].

There are a few possible explanations for why our neighbourhood-level analyses did not produce findings consistent with this previous research. First, the limited number of children per neighbourhood in the dataset resulted in very uncertain neighbourhood-level effect estimates, and prevented us from being able to consider multiple neighbourhood-level variables together in a single model. Second, our area-level variables may have been inadequate for two reasons: 1) EAs may not have been the most relevant geographic level at which to measure all of the theoretical constructs of interest; and 2) indices derived from aggregated census data may not have adequately measured the constructs. Our conceptual framework hypothesizes that the nature and level of fathers' involvement in caring for children are influenced by economic conditions and gender norms (see section 2.1.3). Related to the first point, the influence of economic conditions on the co-resident father – child health associations may have been more apparent at the level of districts, provinces or even countries, because government economic policies are applied at these higher geographic levels [132]. Related to the second point, "norms" are rules of behaviour that are enforced by social sanctions [184, p. 1494]. The immediate community or neighbourhood may well be the most appropriate level at which to study how social norms influence behaviour. However, census data can only give indirect measures of norms. In addition, variables derived from census data could simultaneously be measuring more than one theoretical construct [131]. For example, the percentage of female neighbourhood residents with high school education could be an indicator of both gender norms and of the accessibility of secondary schools. Future studies using more direct measures of the constructs of interest could improve upon our analyses. A final possible explanation for our findings is that our models may not have adequately accounted for individual-level variability in the exposure-outcome associations. This would have made making inference about neighbourhood-level sources of variability challenging. This last point is related to inherent limitations of the exposure and outcome measures, which we discuss in the following section.

5.4 Limitations

The child health outcomes we investigated were a pair of upstream child health-promoting behaviours and a pair of illnesses directly responsible for a large percentage of child deaths in South Africa. Our descriptive statistics showed that children with and without co-resident fathers clearly differed on a number of variables known to influence these health outcomes. In light of differing background circumstances, it is surprising that even our unadjusted analyses did not show clear differences in the outcomes of these two groups of children (save for breastfeeding duration). Previous empirical evidence is not consistent as to whether, and under what circumstances, co-residing with a father is beneficial for young children's health in South Africa (see literature review section 2.2). Our findings contribute to this evidence by suggesting that, all else being equal, merely residing separately from one's biological father does not negatively impact children's outcomes on two critical health-promoting interventions of early life and on a pair of important childhood illnesses. In the preceding sections we have described some nuances to these findings and issues requiring clarification in future research. However, there are important limitations to these analyses which also need to be considered.

The first limitation is related to an inherent challenge with cross-sectional studies: the fact that exposure, outcome and potential confounder data are all ascertained at the same point in time. This usually prevents one from clearly identifying the temporal ordering of the variables and dramatically limits the ability to infer causation from associations in the data. With respect to our research questions, a particular limitation of the SADHS data is that they do not describe children's residential arrangements since birth, only at the time of the survey. Household transitions appear to be a common feature of childhood for many South Africans. Only a small minority of children will have spent all of their lifetime residing with both biological parents (estimated at 8% for children under 5 in a rural area of the KwaZulu-Natal province [81]). The timing at which children experience major household transitions has been found to be important for psychological and academic outcomes, and some negative effects of household disruption have been found to weaken over time [84, 77]. The same may be true for the physical health outcomes studied here. In particular, we might expect that current co-residence with a father would be less relevant for the breastfeeding and immunization outcomes of older children, because, for most, these outcomes would have been completed within the first 1-2 years of life. We tested this possibility by including an interaction between father's co-residence status and child's age in our full regression models, but did not find evidence of interaction for any of the outcomes (results not shown). Nevertheless, future analyses using either longitudinal data on father child co-residence or more detailed retrospective data on the timing of transitions in children's residential arrangements would be beneficial and may produce more definitive conclusions than those of our analyses. Future studies involving more detailed residential data should also attempt to distinguish between the effects of household transitions (for example, migration to a new household, which might be expected to reduce children's health by disrupting their existing linkages with the health care system) and effects due to residing in a given household structure.

A second limitation is that, although maternal recall is a common method of estimating illness period prevalence in household surveys, validation studies have identified some concerns with the accuracy of these data. Maternal recall appears to decline for illnesses having occurred more than 2-3 days before the survey [185]. In addition, recall errors may occur more frequently among less educated mothers [185]. A similar bias has been observed in maternal recall of breastfeeding duration, with misreporting becoming more common with increasing time since breastfeeding cessation, and with more highly educated mothers tending to over-report their breastfeeding durations [186]. Although we controlled for child age and maternal education, differential recall errors for breastfeeding duration and illness episodes could be a source of bias in our effect estimates. Another limitation of examining period prevalence is that diarrhoea and respiratory infection are relatively common childhood illness. As an indication of children's burden of exposure to pathogens it may be more meaningful to examine the number of illnesses episodes experience over a period of time. Alternatively, examining illness duration and severity may give more insight into the quality of care children receive and their capacity to recover from illness. Because of the synergistic relationship between illness and malnutrition, it would also be valuable in future studies of fathering and child health to examine these outcomes together. This was not possible using the 1998 SADHS data because the survey did not include anthropometry for children.

A third limitation is that the SADHS did not collect any additional data about non-co-resident fathers. This prevented us from being able to control for some potentially important confounding factors, such as father's educational attainment. It also prevented us from examining whether the reason for father's absence influenced the effect of co-residence status on children's health outcomes. For example, it may be useful to distinguish between fathers who spent periods away from their children as migrant labourers and those who were permanently residing elsewhere because of no longer having a relationship with the child's mother. This limitation is common to most household survey datasets. We echo other authors in noting that high rates of residential separation makes it essential, in order to adequately study fathering in South Africa, for us to develop study designs which include data collection on both co-resident and non-co-resident fathers [48, p. 258-9].

A final limitation is that defining households based solely on residential criteria limits the value of the SADHS (and similar household surveys) for studying fathers. Russell argues that this approach to delineating households is based on "assumptions about the coherence and stability and exclusiveness of co-residential groups, which ... hold good only under limited cultural and economic conditions." [45, p. 6] She points out that north-western Europeans (and their White descendants in South Africa) follow a kinship tradition based on conjugal ties, whereas southern Africans' kinship traditions are based on "patrilineal or agnatic descent, i.e. descent from father." [45, p. 8] Therefore, in studying the allocation of resources within African domestic groups, including from fathers to children, it may be necessary to consider kinship ties rather than simply co-residential and conjugal affiliations.

Two studies based in rural demographic surveillance sites have improved on the co-residential definition of households in studying children's health outcomes. Investigators on these studies have distinguished between the social and residential connections of household members [81, p. 5]. Their findings support the idea that children who have social connections with their fathers, even when not residing together, do have better health outcomes than children who have no connection to their fathers. (Unfortunately, thus far, these analyses have been limited in the child health outcomes explored.)

In contrast, our reliance on co-residence status means we treated fathers who were socially but not residentially connected to their children as equivalent to those who had no connection at all with their children. To some extent, parent's marital status may reflect fathers' social connections with their children. In this respect, our finding that, among children of married parents, father's co-residence status was associated with no difference in any outcome except immunization completeness would be consistent with the hypothesis that social connections with fathers are more important for child health than residential connections. However, as discussed, parents' marital status is only one dimension of kinship. This is clearly an important area for future investigation.

5.5 Next steps

Ultimately, not having data on father's actual parenting practices prevents us from being able to explain why, for the sample as a whole, residing with a father was not associated with children's health outcomes, while in some neighbourhoods the association was strongly positive and, in others, strongly negative. It is likely, for example, that a non-co-resident father who contributes financially and is involved in making important care decisions would be more beneficial for a child's health than a co-resident but uninvolved father. Similarly, a completely absent father may have less of a detrimental effect on child health than an abusive one. Confounding of the father's co-residence status – child health outcome associations by unmeasured fathering practices could explain why we observed an overall null association but with considerable neighbourhood-level variability.

Fathering data is extremely limited in South Africa. To date, essentially all studies of the relationship between fathering and children's health outcomes have relied on father's household membership (whether residential or social) as a proxy for his contributions to children's care. As we have discussed above, this approach has clear limitations. In the rare cases where data have been collected on South African fathers' actual involvement in caring for children, the focus has been limited to financial contributions. A previous study using these data has demonstrated that co-residence is a poor proxy for financial support: co-resident fathers were found to be no more likely than some non-co-resident fathers to be financially supporting their children [76]. It is likely that co-residence status is also an inadequate proxy for other aspects of father's involvement [48, 20, 94].

In order to facilitate future population-level research, which moves beyond the limited reliance on father's co-residence status as a proxy for his involvement in child care, we conducted a study to assess a comprehensive questionnaire for measuring father involvement in South Africa. We describe the details of this study in the following chapter.

Chapter 6

Methods: Research Objective 2

As discussed in chapter 5, data on fathers' involvement in caring for children is severely limited in South Africa. Richer data on fathers' parenting practices, as well as the antecedents and child health consequences of different patterns of fathering would be valuable for a number of reasons. For example, household surveys that included data on fathering could be used to compare the practices of resident and non-resident fathers. In turn, these comparisons might enable us to explain why in some cases residential separation of fathers and children appears to be harmful, whereas in others it does not. Together with existing research from other settings, such data would allow for cross-cultural comparisons of fathering to be made. Perhaps most important, population-level fathering data could be used to identify which fathering practices are most beneficial for children's wellbeing and inform interventions aimed at promoting positive fathering.

Ideally, efforts to collect population-level fathering data should be informed by preliminary research into approaches for overcoming current theoretical and methodological challenges. The scarcity of previous research on the parenting practices of South African fathers is, itself, a major challenge because it means there are no validated data collection tools and limited data from which to develop and test conceptual models [48]. Research assessing the validity of conceptual models and data collection tools developed for use in other cultural settings could begin to address this challenge.

Another challenge to collecting fathering data in South Africa, particularly using household surveys, is the high percentage of fathers and children who live apart. Methodological strategies to address this challenge might include using secondary respondents, such as mothers, as sources of data on fathers' parenting practices. But the reliability of mothers' reports would also need to be assessed. Alternatively, recruitment and data collection strategies that accommodate both co-resident and non-resident fathers could be developed.

Our second set of research questions (2a-c in Chapter 1) are directed at beginning to overcome the above challenges. This chapter describes the study design and statistical methods used to address these research questions.

6.1 Study design

Setting and sample

Our investigation of fathering was a sub-study of a longitudinal cohort study called the Mother Infant Health Study (MIHS). It involved families living in Kraaifontein, a suburb of Cape Town in the Western Cape Province of South Africa. Kraaifontein is located in a relatively wealthy district of the City of

Cape Town Municipality, but is comprised of census suburbs of which some are the least ‘well off’ in the district (based on an index which combines the percentage of low-income households, percentage of adults with less than high school education, unemployment rate, and percentage of the labour force in unskilled occupations) [187]. While the majority of dwellings are formal, stand-alone houses, there are also some ‘informal settlements’, which consist of high concentrations of dwellings that were “not erected according to approved architectural plans or on planned sites...” [187][127]. In these areas, access to basic services (electricity, potable water, flush or chemical toilets, and refuse removal) is limited [187].

The MIHS consisted of a convenience sample of infants delivered between July 16th, 2012, and June 28th, 2013, at the Kraaifontein Midwife Obstetric Unit. This primary-level health centre manages all low-risk deliveries by women living in the area, excluding those of women who pay to deliver in private hospitals. To be eligible to participate in the MIHS, a mother had to be at least 18 years old, a resident of the clinic catchment area, and not planning to move within one year of enrolment. Infants had to be live-born, singleton births, at least 35 weeks gestational age, weigh at least two kilograms at birth, and could not have any severe congenital abnormalities.

The sample for the Fathering Sub-study included all mothers and infants from the MIHS who completed the first study visit at 2 weeks. The sub-study also included a convenience sample of fathers of infants in the MIHS. For a father to be eligible to participate in the sub-study, the infant’s mother had to consent for us to enrol the father. In addition, the mother had to complete the first study visit. Participation of fathers in the Fathering Sub-study was not required for mothers and infants to continue on either the sub-study or the MIHS.

Recruitment procedures

MIHS

For the MIHS, recruitment staff held regular group information sessions in the antenatal clinic waiting area. These sessions explained the aims of the study and what would be involved in participating. Their purpose was to familiarize pregnant women with the study, should they later be approached for enrolment.

Mothers and infants were enrolled at the time of delivery. Enrolment was offered to all eligible HIV-infected mothers, and to a roughly equal number of HIV-uninfected mothers. The uninfected women were selectively offered enrolment based on their self-identified racial group, with the aim of attaining a similar racial mix in both groups. There are significant racial and geographic socioeconomic inequalities in South Africa. By recruiting participants from a single community, and by balancing the racial mix across groups, we hoped to minimize socioeconomic differences between HIV-infected and HIV-uninfected mothers. In addition, social class has an important influence on father involvement [47]. For the present study, we wished to limit this source of variation.

Fathering sub-study

Based on previous study findings [188] and past experiences of our research study staff, we anticipated relatively few fathers would be present at the clinic during delivery. At enrolment into the MIHS we asked each mother to take an introductory letter to her child's father (Appendix B.1). The letter explained the Fathering sub-study and invited the father to participate. We also collected father's telephone number if mother consented to his participation. We enrolled and consented fathers by telephone when their infants were 2 weeks old. A copy of the informed consent script is shown in Appendix B.2.

Sub-study visits

Sub-study visits were completed when infants were 2-weeks, 16-weeks, and 6-months old. Mothers and infants attended study visits at our research clinic located in a tertiary-level hospital approximately half-an-hour drive away from Kraaifontein. Including travel, they would typically spend the entire morning and early afternoon at study visits. A previous South African study reported many men were unable to participate because of employment obligations [188]. We also expected that many fathers would not be residing with their children, with some of them potentially living in other cities. Therefore, to maximize participation of fathers, we offered them the option to complete sub-study visits by telephone or in-person at the study clinic. At each visit, fathers and mothers completed an approximately 30-minute fathering questionnaire with an interviewer. Fathers and mothers completed different versions of the same questionnaire.

Participants were offered organized study transportation or reimbursement of their travel expenses to and from the study clinic. In addition, mothers were given a R100 (approximately $10 CAD) honorarium for each visit attended. Because many fathers completed the entire study by telephone, we did not give honoraria to any fathers even if they attended in-clinic visits. However, all telephone call charges were covered by the study.

Institutional review and consent

The study protocol was approved by the human research ethics committees at Stellenbosch University (Reference number: S12/01/009) and the University of British Columbia Children's and Women's Health Centre (Reference number: H12-01181). All participating mothers provided written informed consent. Participating fathers gave verbal informed consent over the telephone.

6.2 Fathering questionnaire

We constructed our fathering questionnaire by drawing from a pool of survey questionnaire items originally developed for the Developing a Daddy Survey (DADS) project in the United States [189]. A goal of the DADS project was to develop a common set of theoretically and methodologically rigorous questionnaire items for measuring father's involvement in three national studies. Guided by Lamb and colleagues' framework (described in literature review section 2.1.1), the DADS project developed items intended to measure five modes of paternal influence: *Accessibility, Direct Caregiving*, *Responsibility*, levels of financial contribution toward children's material needs (*Material Provisioning*), and involvement in household chores (*Practical Support for Mother*). For our questionnaire, we selected items that were designed for use with fathers of infants and were meant to be suitable for both co-resident and non-co-resident fathers. The complete list of fathering items included in our adapted questionnaire is presented in Table B.1, Appendix B.3.

In addition to questions about father's involvement, we collected information about potentially important covariates. At each visit, to provide a measure of ongoing interparental relationship quality, we had fathers and mothers complete the 'negotiation' scale of the Revised Conflict Tactics Scales, and a sub-set of items from the 'psychological aggression' and 'physical assault' scales[26] [190]. The questionnaire asked respondents to separately rate the frequency they experienced and perpetrated each act of negotiation or violence in the past three months.

Additionally, at the first visit we collected information (from both fathers and mothers) on father's involvement during the pregnancy, father's demographic and socioeconomic characteristics, number of previous children sired, and characteristics of the mother-father relationship. In order to assess fatherhood beliefs, we also asked mothers and fathers to rate their level of agreement with each of a set of opinions about fathers' responsibilities towards children (questions shown in Table B.2, Appendix B.3). The belief questions were adapted from the DADS questionnaire items with reference to research on fatherhood ideals in South Africa.

At the first visit, mothers reported on their own demographic and socioeconomic characteristics. They also completed a roster for the members of their household, and questions about the structure of their dwelling place and their access to basic services. These questions were adapted from the 1998 South African Demographic and Health Survey household member questionnaire [6]. Finally, fathers were asked questions about how frequently they saw each of their biological parents during childhood, and the quality of their relationship with each parent. These latter questions were drawn from the pool of DADS project items.

The questionnaire was professionally translated from English into isiXhosa and Afrikaans, the two most commonly spoken languages in Kraaifontein. Interviewers administered the questionnaire to participants in their choice of the three languages. Before beginning data collection, the translated questionnaire was back-translated into English by members of the research study staff and reviewed by the principal investigator to ensure that questions retained their original meaning. In addition, we asked the interviewers to give us feedback on the appropriateness of the content of the questionnaire. The interviewers had similar racial and cultural backgrounds to many of the study participants. Interviewers were given another opportunity to suggest changes after completing the questionnaire with the first couple of participants. Before beginning data collection the interviewers agreed that the majority of items on the questionnaire were appropriate. However, some interviewers felt that two *Direct Caregiving* items (singing songs or nursery rhymes to the child, and taking the child for walks) may not be

[26]Our questionnaire included the following two items from the CTS-II psychological aggression scale: "Frequency insulted or swore at [person]", and "Frequency threatened to hit or throw something at [person]"; and the following item from the physical assault scale: "Frequency punched or hit [person] with something that could hurt."

culturally relevant. We decided to retain these items in the questionnaire, but we further consider their appropriateness in a discussion of the questionnaire's Face Validity in Chapter 8. After completing the questionnaire with the first few participants, the interviewers requested that we change the wording of four *Accessibility* items that were difficult for participants to answer. The original questions asked the number of hours fathers spent with the infant on an average work day and on an average non-work day, and the number of hours fathers spent alone with the infant on an average work day and on an average non-work day. We revised these questions to ask whether fathers usually spent an hour or more with the infant in the morning, afternoon and evening on work days and on non-work days, and whether fathers usually spent an hour or more alone with the infant on work days and on non-work days. The revised questions were translated from English into Afrikaans and isiXhosa by study staff members. The revised questionnaire was first used with the 10th mother and the 6th father to complete 2-week visits. Mothers and fathers who had completed the original version of the questionnaire were excluded from analyses involving the revised *Accessibility* items.

For illustration, the final English-language version of the questionnaire administered to fathers at the 2-week study visit is shown in Appendix B.4.

6.3 Statistical methods

6.3.1 Description of the cohort

To characterize families participating in the MIHS, we computed descriptive statistics for sociodemographic data reported by mothers at study enrolment and the first study visit (together referred to as "baseline"). We calculated frequency distributions for categorical variables and medians and interquartile ranges for continuous variables. To compare the characteristics of families with a participating father to those without, we recalculated baseline descriptive statistics stratified by father's participation status. Although the strata are not random samples, we present p-values from bivariate tests of independence as a way of indicating characteristics that contrast strongly between families with and without a participating father. Pearson's chi-squared tests were used to assess independence of father's participation status and categorical baseline variables. Wilcoxon rank-sum tests were used for continuous variables.

6.3.2 Description of fathers' parenting practices

To describe the parenting practices of our cohort of fathers, we calculated the percentage frequency distribution of responses for each fathering questionnaire item. We used response data from mothers at the 2-week study visit because our interest was in describing the reported practices of fathers of all infants in the cohort (whereas, fathers' reports were only available for a subset of infants). We prepared stacked bar charts to visually compare response frequencies across sets of items intended to measure the same mode of paternal influence.

Next, we examined whether the reported fathering practices of our sample were associated with variables identified as determinants of positive fathering in the theoretical framework (Section 2.1.3).

Using questionnaire data given by mothers at their 2-week visits, we prepared cross tabulations between each fathering item and a small number of covariates. These covariates measured individual characteristics of father, mother and child; characteristics of the father-mother relationship; characteristics of the household context; and characteristics of father's involvement during pregnancy. To present these results graphically, we prepared stacked bar graphs showing the frequency distribution of each fathering item grouped into strata specified by level of the covariate. We calculated *gamma* statistics to describe the monotonic trend association between each pair of variables in the cross tabulations. *Gamma* is calculated as the difference between the number of concordant and discordant pairs of observations in the contingency table, divided by the sum of concordant and discordant pairs[27] [191, p. 57-58]. It measures the difference between the probability of concordance and the probability of discordance for a pair of variables. In a cross-tabulation of variables X and Y, a pair of observations is concordant if the observation having the higher value of X also has the higher value of Y. The pair is discordant if the observation having the higher value of X has the lower value of Y. Gamma has a range of -1 to 1, inclusive. A value of 1 indicates a monotonic increasing relationship (i.e.: zero probability of discordance), while -1 indicates a monotonic decreasing relationship (i.e.: zero probability of concordance). The gamma statistic is only suitable for measuring associations between ordinal (including binary) variables. For these analyses we dichotomized all nominal fathering variables, as described in section 6.3.3. In the case of nominal covariates, we calculated associations between the fathering variables and each pair of levels of the covariate. In addition, for all cross tabulations, we calculated Pearson's chi-square tests to identify associations greater than would be expected by chance.

Finally, we assessed whether the frequency fathers were reported to perform each fathering item changed as their children aged. For this analysis we restricted our dataset to data reported by mothers who had completed a fathering questionnaire at all three study visits (i.e.: when infants were 2 weeks, 16 weeks and 6 months old.) We calculated a percentage frequency distribution for each fathering item by study visit. We then prepared stacked bar graphs showing the frequency distribution at each visit side-by-side. As with our other analyses, we present these graphs grouped by the mode of paternal influence each item was intended to measure. Friedman tests [192] were used to evaluate whether, on average, father's ratings on each item differed significantly across study visits. The Friedman test accounts for the non-independence of measurements on the same individuals at different time points.

We also evaluated how representative the mothers included in the latter analysis were of the entire group: using Pearson's chi-square tests for categorical variables and Wilcoxon rank-sum tests for continuous variables, we compared the sociodemographic characteristics of mothers with complete follow-up to all who completed the 2-week visit.

Results of the above descriptive analyses are presented in Sections 7.1 and 7.2 of the following chapter.

[27] For 2 x 2 tables, *Gamma* is equivalent to Yule's Q statistic, which can also be calculated from the odds ratio (OR) as: $Q = {}^{(\mathrm{OR}-1)}/_{(\mathrm{OR}+1)}$ [191, p. 67].

6.3.3 Modelling the fathering questionnaire response data

Reliability is the consistency of repeated measurements [193, p. 3]. It is inversely related to the amount of error in the measurements. In contrast, the *validity* of a measurement is the extent to which it evaluates the construct of interest [194, p. 183]. Reliability is a necessary, but not sufficient, component of validity [193]. Therefore, to establish the validity of measurements from a questionnaire, it is necessary to assess their reliability.

We sought to assess the reliability of the measurements of fathering from our questionnaire in two ways. We assessed the consistency of responses from two different observers (fathers and mothers). These analyses are described in section 6.3.5. We also assessed the consistency of individual observers' responses to related questionnaire items. These items were related in the sense that they were hypothesized to provide measures of a common underlying construct. Although we repeated our measurements of fathering at three study visits, we did not assess the consistency of responses across visits because fathering behaviours have been shown to change as children age [30].

In the following sub-section we describe the theoretical basis of the Item Response Theory method used to evaluate the reliability of conceptually-related questionnaire items. We then present the statistical models used, and our analytic approach.

Theoretical basis of Item Response Theory

We conducted these analyses within a latent variable framework. In other words, we assumed that the observed parenting practices measured by the questionnaire items were manifestations of fathers' levels on a smaller number of unmeasured (i.e.: latent) variables. We hypothesized that each mode of paternal influence described in the theoretical framework (section 2.1.1) would correspond to a distinct latent variable. Thus the hypothesized latent variables would reflect father's level of: *Direct Caregiving*, *Accessibility*, *Responsibility*, *Material Provisioning* and *Practical Support for the Mother*. We also hypothesized that each set of conceptually-related questions would measure just one latent variable. The items hypothesized to measure each mode of paternal influence are identified in Table B.1, Appendix B.3.

Specifically, we tested the fit between the questionnaire data and our hypothesized latent variable structure using a special type of Confirmatory Factor Analysis called Item Response Theory (IRT) modelling. IRT is a theory for "establishing the correspondence between latent variables and their manifestations" [193, p. 4]. Some specific terms used in IRT are defined in table 6.1 on the next page.

IRT models were suitable for our analyses because they are designed to model responses from categorical items, and they are concerned with how individuals having different levels of a latent trait perform differently on a set of items intended to measure the trait [195]. Similarly to Factor Analysis, the latent trait is treated as a continuous variable in IRT models. Parameter estimates from IRT models reflect properties of both the items and the individuals on whom the data were collected. Thereby, IRT modelling allowed us to assess the measurement properties of the fathering questionnaire and to suggest

Table 6.1: Definition of terms commonly used in Item Response Theory

Term	Definition
Trait	The continuous latent construct of interest.§
Item	A measurement instrument (for example, a question on a questionnaire) intended to provide a measure of the latent trait.
Discrimination	A measure of the item's ability to distinguish between individuals having different levels of the trait. Equal to the slope term in a regression of the item responses on the trait.
Item/category boundary location	The point on the latent trait scale at which a person is 50% likely to choose the designated response option or higher. Inversely proportional to the intercept term in a regression of the item responses on the trait.

§In the results chapter we refer to our latent constructs of interest as "modes of paternal influence" or just "modes" rather than "traits". We chose this naming convention because our theoretical model describes fathers' parenting practices as dynamic, not as fixed, inherent traits.

possible improvements. It also allowed us to describe the parenting practices of our sample of fathers in terms of their levels of the latent constructs of interest.

Three assumptions underlie the IRT models we used for our analyses. The first is that responses to each set of related items are a function of just one latent trait. Although multidimensional IRT models are possible, this *unidimensionality assumption* applies to all of the models we used [193, p. 20]. A second assumption is that an item's responses are *conditionally independent* of responses to other items given the respondent's level of the latent trait [193]. This implies that the responses of individuals who share the same level of the trait are uncorrelated [195]. The third assumption is that the data fit the functional form specified by the model. We describe the functional form of our statistical models next.

Statistical models

The general IRT model, which is applicable to dichotomous and ordinal items, can be written in the form of a proportional-odds model [191]. The model expresses the probability that, for a given item i, father j is in response category k or higher, given his score on the latent trait, θ_j:

$$P(y_{ij} \geq k \,|\, \theta_j) = \frac{\exp[\alpha_{ik} + \beta_i \theta_j]}{1 + \exp[\alpha_{ik} + \beta_i \theta_j]} \tag{6.1}$$

Similarly to a regression equation, this model includes (item-specific) slope and intercept parameters, β_j and α_{jk}, respectively. The difference from ordinary regression is that the predictor in this model, θ, is a latent variable. The slope is an indication of how rapidly the response probability changes as the level of the latent trait increases. It is proportional to the strength of association between the item responses and the latent trait. In IRT the slope is also called the *discrimination.* The higher the discrimination the better the item distinguishes fathers with high levels of the latent trait from those with low levels. For dichotomous items there is a single intercept, whereas for ordinal items there is an intercept for each response category but the lowest. The probability of selecting the lowest response category or higher is 100% so that category does not have an associated intercept. For dichotomous items, the above equation corresponds to the 2-Parameter Logistic model and, for ordinal items, to Samejima's Graded Response model [193].

The cumulative probability function in equation 6.1 specifies a logistic (sigmoid) function, with a lower asymptote of 0 and an upper asymptote of 1 [193]. Furthermore, for ordinal items, categories are strictly sequentially ordered and have a common slope. However, the slope is allowed to vary across items. Whether these assumptions are justifiable can partially be judged by assessing the degree of fit between the data and the statistical model. The approaches we used to assess model-data fit are described in the next sub-section.

Classically in IRT the following alternative formulation of the conditional probability expression is used:

$$P(y_{ij} \geq k \,\big|\, \theta_j) = \frac{\exp[a_i(\theta_j - b_{ik})]}{1 + \exp[a_i(\theta_j - b_{ik})]} \tag{6.2}$$

In this formulation, a_i is the item discrimination (equal to β_i in equation 6.1), and b_{ik} is the item (or category boundary) *location*[28]. The location gives the point on the latent trait scale at which a person is 50% likely to choose the designated response option or higher. A smaller, or more negative, value indicates that a lower level of the latent trait is needed for that response (or higher) to be 50% likely. The majority of fathers would be expected to select this category or higher. Whereas, a larger location value means that a higher level of the trait is needed before one is 50% likely to chose that response or higher, and fewer fathers would be expected to do so.

Note that equation 6.1 models the conditional probability boundary between response category k or higher and response category $k-1$ or lower. The plot of this cumulative probability function is called a *Category Characteristic Curve* (or an *Item Characteristic Curve* in the case of a binary item) [193]. For binary items there is only one category boundary, so the probability of being in category 1 or higher versus 0 is equivalent to the probability of being exactly in category 1. In contrast, for ordinal items, the probability of being exactly in a specific category must be calculated by taking the difference between the cumulative probability functions for adjacent response categories [193], i.e.:

$$P^*(y_{ij} = k) = P^*(y_{ij} \geq k) - P^*(y_{ij} \geq k-1)$$

where P^* is the conditional probability given the latent trait. A plot of the above function is called a *Category Response Curve.*

Together with item parameters, IRT models can be used to estimate each father's level of the latent trait. These levels are called *person locations* and they are estimated on the same scale as the item/category boundary locations. We used the *Expected A Posteriori* (EAP) method to estimate person locations [196]. This method uses a Bayesian approach to combine information about a father's position

[28] An item or category boundary location can be calculated from the slope and intercept parameters in equation 6.1 as: $b_{ik} = \frac{-\beta_i}{\alpha_{ik}}$.

on the latent trait from the likelihood function of his observed item responses and from a prior probability distribution reflecting our assumption about the distribution of the trait in the population [193, p. 76]. Typically, a standard normal prior distribution is used [193, p. 76]. By the EAP method, the father's location is calculated as the mean of the estimated posterior probability distribution. Including prior information about what location values are most likely in the population allows location estimates to be calculated for fathers who were in the lowest (or highest) possible response option on every item. Otherwise, the likelihood estimate for these fathers would be infinite [193, p. 75].

From a fitted IRT model it is possible to estimate a *Total Information Function* for the set of items included in the model. Total Information is inversely proportional to the standard error of person location estimates produced by the set of items. In contrast to a single measure of reliability, information varies as a function of the latent trait. In other words, total information is a measure of the precision of the person location estimate at the specified point on the latent trait [193, p. 27]. A benefit of information is that, in contrast to reliability, it does not depend on the characteristics of the questionnaire respondents, only on the characteristics of the items in the questionnaire [193, p. 29]. Total information for a set of items is calculated as the sum of the separate information functions for each item. For ordinal items, item information is the sum of the separate information functions for each response category.

Analytic approach

For all of the analyses described in the current section we used questionnaire data reported by mothers at the 2-week visit. We used mothers' reports because we were interested in modelling the fathering practices of the complete set of fathers, not only those who participated in the study. We used the 2-week visit data because this was the single largest dataset available.

For most Material Provisioning items, we observed few "Mainly mother" and "Mainly someone else" responses. Similarly, for the Responsibility items we observed few "Mainly father" and "Mainly someone else" responses. To make the analyses for these items more informative, we recoded them as binary variables indicating whether the father had a primary-level of involvement in the item versus not. Fathers reported to be mainly involved or involved together with the mother were recoded as having primary involvement. If it was reported that mainly the mother or mainly someone else was responsible for the item, fathers were coded as not having a primary-level of involvement.

For most ordinal items with six response categories, such as items measuring the frequency fathers performed direct caregiving activities, we observed few fathers in the "Rarely", "A few times a month" and "About once a day" response categories. In order to minimize small cell size problems in analyses involving these variables, while also retaining as much information as possible, we recoded these as 4-level ordinal variables. To do so, we collapsed the "Rarely" and "A few times a month" categories and the "A few times a week" and "About once a day" categories, and left the "Not at all" and "More than once a day" categories unchanged.

Our analytic steps were as follows. First, we calculated the correlation between all pairs of fathering items (Spearman rank-correlations for pairs of ordinal items, phi coefficients for pairs of binary items, and rank-biserial correlations for binary-ordinal item pairs). These pairwise associations allowed us to assess whether items within sets were associated as hypothesized, and also whether there were any large associations between items in different sets.

Next, we fit a unidimensional IRT model to each of the five sets of fathering items specified in table B.1 (Appendix B.3). When fitting the Accessibility trait model we excluded items measuring time spent with infants on work days because 10% of fathers were not working at the time of the 2-week study visit. We also excluded an item measuring whether the father spent time with his infant on non-work-day evenings, because it was highly correlated with a similar item measuring time spent together on non-work-day afternoons. Similarly, when fitting the Responsibility trait model, we excluded an item measuring whether the father took the baby to the clinic or doctor because it was highly correlated with the *Talk mother, Important Decisions,* and *Decided Name* items. In addition, we excluded from our IRT analyses items which had large percentages of "Not Applicable" responses. These were comprised of a single item for the Responsibility trait model (*decided when to introduce solid foods*), and two items for the Material Provisioning trait model (*pays for medicines*, and *pays for toys*).

IRT model parameters were first estimated using Weighted Least Squares with mean- and variance-adjusted Chi-square test statistics (WLSMV), as implemented by default in Mplus software version 7.3 [197]. Our initial models had a similar form to that shown in equation 6.1, except that we used a cumulative standard normal distribution (with a probit link) instead of the logistic distribution[29]. From these models we obtained the following commonly-used indices of model fit: chi-square fit statistic and p-value, Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) [198].

We then re-estimated the model parameters using a Maximum Likelihood estimator with standard errors and chi-square test statistic adjusted to be robust to the non-normality of our response data (MLR). Using the MLR estimator we were able to specify the model using a logistic functional form, exactly as in equation 6.1. From these models we obtained chi-square fit statistics and p-values, item parameter estimates (and associated standard errors), and estimates of each father's location on the latent trait. We also obtained estimates of total and item information at a series of points along the latent trait. In the results, we present information graphically in the form of *Information Curves*. We prepared histograms to graphically display the distribution of father's location estimates along each latent trait.

Note that, by default, Mplus estimates item (and category boundary) *thresholds* instead of intercepts. Thresholds are equal to the negative of item intercepts, i.e.: the β_{ik}'s in equation 6.1. Thresholds are therefore proportional to, but not equal to, item locations (b_{ik}'s in equation 6.2). Because standard error estimates calculated in Mplus are on the same scale as the thresholds, we present the thresholds estimates in our results tables. But, because of their more intuitive interpretation, we also describe items in terms of their locations. We calculated item and category boundary locations by dividing each threshold by the associated slope.

As per the standard approach in IRT, we used the estimated distribution of the latent trait in the population to fix the scale of the trait. We set the origin of the latent trait to be equal to the population mean, and the unit of measurement equal to 1 standard deviation [199, p. 280]. Both the item and

[29] The reason for this difference is that the WLSMV estimator in Mplus can only be used with a probit link.

person location estimates were measured on this same scale. For person location estimation, we utilized the default standard normal prior distribution.

Models were taken to have acceptable fit if both chi-square fit test p-values were >0.05 (implying the null hypothesis of perfect fit was not rejected), RMSEA was <0.05, and CFI and TLI were both >0.95 [198, 200]. In addition, for models fit by MLR, we examined tables of bivariate model fit information to check that few standardized residuals had an absolute value >1.96.

We included fathers with missing item response data in our IRT analyses, as per the default in Mplus. With both the MLR and WLSMV estimators, this was accomplished using full information maximum-likelihood parameter estimation, which assumed the missing data were Missing at Random

Last, we estimated the correlation between each pair of latent traits. These correlations were estimated in Mplus by fitting the five separate IRT models described above together in a single model. The result is a structural equation model comprised of five separate measurements models (one for each latent trait) and a structural part specifying that the correlation parameters among the continuous latent traits are to be freely estimated. The parameters of this model were estimated using the WLSMV estimator because it is less computationally intensive than the MLR estimator for models with multiple latent variables. Model fit was assessed using the fit statistics described in the paragraph above. When fitting the model, we requested modification indices to be calculated. Mplus calculates these indices for all parameters in the model that are fixed. Modification indices give the expected drop in the chi-square statistic if the parameter were allowed to be freely estimated [197, p. 726]. In other words, they identify parameter constraints that could be relaxed to improve model-data fit. In our model, the constraints of interest were those specifying zero slopes for items hypothesized not to measure a particular latent trait. We considered removing slope constraints associated with large modification indices in cases where it seemed theoretically reasonable for the item to be measuring the latent trait in question [201].

Results of the IRT analyses are presented in Subsections 7.3.1 and 7.3.2 of the following chapter.

6.3.4 Comparing co-resident and non-co-resident fathers and testing for differential item functioning

To compare the reported parenting practices of co-resident and non-co-resident fathers at 2 weeks, we prepared cross tabulations of the fathering items and a binary variable indicating whether father and infant were living together at the 2-week visit. To present these results graphically, we prepared stacked bar graphs showing the frequency distribution of each fathering item stratified by the co-residence status variable. To assess for confounding caused by no longer being in a relationship with the mother, we conducted the following sensitivity analysis: we excluded fathers who were reportedly "no longer seeing" the mother at the 2-week visit and reran the fathering item by co-residence status cross tabulations. We present the results of the sensitivity analysis graphically, as described above, in Appendix B.8 (Figures B.15 to B.20).

Next, to determine whether residing with the child was associated with having significantly different levels on each latent mode of paternal influence, we constructed a regression of each latent trait on the father's co-residence status variable. In each regression model, the latent trait is measured by its effect on the observed fathering items, exactly as in the IRT models described above. This type of model is called a Multiple Indicators Multiple Causes (MIMIC) model [202]. The coefficient in the regression of the latent trait on the covariate was interpreted similarly to the slope term in an ordinary linear regression. The difference from an ordinary regression is that, in this case, the dependent variable was latent.

Differential Item Functioning (DIF) is when an item has a different relationship with the latent trait for different sub-populations specified by a covariate [203, p. 324]. In this study, we were interested in determining whether our questionnaire could be used to measure the contributions of both co-resident and non-co-resident fathers. Therefore, we assessed whether father's co-residence status was associated with differential functioning of items on the questionnaire. To test for DIF, we extended the MIMIC models described above by including regressions of selected fathering items on the father's co-residence status variable. A statistically significant regression coefficient was interpreted as evidence for DIF. Because the fathering items were all categorical, these regression coefficients were interpreted as log odds ratios. What was being estimated, however, was the *direct effect* of father's co-residence status on the fathering item, after accounting for the *indirect effect* operating through the latent trait. We selected items for DIF testing based on the results of the cross-tabulations described in section 6.3.2, above. We assessed for DIF when the cross-tabulation results suggested an item had a different association with father's co-residence status compared to other items measuring the same latent trait. Parameters in the above models were estimated in Mplus using the MLR estimator.

Results of the MIMIC models are presented in Subsection 7.3.3 of the following chapter.

6.3.5 Agreement between fathers' and mothers' questionnaire responses

The second means of assessing the reliability and validity of the fathering questionnaire data was to compare agreement between the responses of paired fathers and mothers. We recognize that neither parent's responses can be treated as a 'gold standard' because each is likely to be influenced by their personal perceptions about the adequacy of the father's parenting, which are, in turn, likely to be informed by an array of individual, interpersonal, and societal factors. By assessing agreement we can identify individual questions, or sets of related questions, that tend to elicit consistent responses from both parents. We would then have reason to be more confident about the validity of responses for these items. In addition, finding reasonable agreement between fathers' and mothers' questionnaire responses would suggest that mothers could be used as reliable proxies for fathers in future research on fathering. In contrast, we would be less confident in the reliability and validity of items for which the level of father-mother agreement is low because at least one parent's responses must differ from the father's true practices [204].

For these analyses we used mothers' and fathers' responses from the 2-week study visit. Except where described below, mother-father pairs were excluded from the analyses for a given questionnaire item if either parent had a non-valid response for that item (i.e.: a "don't know" or missing response). We analyzed paired responses for all fathering questionnaire items listed in Appendix B.3, except for three items that had large percentages of "not applicable" responses. The excluded items measured whether the father paid for his child's medicines or toys, and whether he had responsibility for deciding when his child would begin eating solid foods. We also analyzed paired responses for a set of variables measuring the father's demographic, socioeconomic and health characteristics, and characteristics of the father's relationship with the mother. We included "Don't know" responses when estimating the proportions of overall agreement for two variables measuring characteristics of father's employment history and a single variable measuring whether the father had ever had an HIV test. For these variables, 5-10% of mothers had "Don't know" responses. Therefore, excluding these mothers could have upwardly biased the estimates of overall agreement. A revision to the questionnaire caused the first 10% of mothers and fathers who completed the questionnaire to have missing data for six Accessibility items measuring whether the father spent an hour or more with the infant at different times of the day. Because it was caused by a questionnaire change, we considered these data to be missing completely at random and, therefore, excluded mother-father pairs with missing data from the analyses involving these six variables.

For each variable we calculated the observed proportion of overall agreement and the proportion of agreement specific to each response category. The latter index gives the conditional probability, given that one randomly selected parent in a pair choses the response category, that the other parent will also do so [204]. We calculated 95% confidence intervals for these raw agreement indices using the non-parametric bootstrap method using 1000 simulated datasets. Only three variables had >5% (but <10%) "Don't know" responses: "Father's educational attainment", "Number of months father worked in past year", "Whether father has ever had a HIV test". Excluding this large percentage of records because of "Don't know" responses could upwardly bias estimates of overall agreement. Therefore, we retained "Don't know" as a valid response option when calculating percentage overall agreement for these three variables.

Next we assessed for marginal homogeneity of father's and mother's responses on each item. The purpose of evaluating for marginal homogeneity was to compare fathers' and mothers' propensities to choose each response category. We used histograms to visually assess for differences in fathers' and mothers' response profiles on each item. To test for departures from marginal homogeneity that were greater than would be expected by chance, we used the McNemar test for binary items and the Bhapkar test for nominal and ordinal items. The Bhapkar test is for marginal homogeneity across all response categories [191, p. 424]. In addition, for ordinal and nominal items, we used the non-parametric bootstrap method to test for significant differences between fathers' and mothers' marginal proportions for each response category individually.

All of the ordinal items in the questionnaire can reasonably be considered to be measuring underlying continuous variables, i.e.: the frequency the father performed a particular parenting practice. During the design of the questionnaire, these underlying variables were divided into discrete response categories. Both the definition of the underlying variable itself and the definition of the threshold between each pair of adjacent response categories are somewhat subjective. Therefore, for each of our ordinal items, two components of disagreement can be distinguished: mothers and fathers may disagree about the definition of the fathering practice being assessed; alternatively, they may disagree about the thresholds between different frequencies of performing the fathering practice [204].

When a pair of ordinal variables are each assumed to measure an underlying continuous trait, the polychoric correlation between them gives an estimate of the correlation between the underlying continuous traits [205]. We estimated the polychoric correlation between mothers' and fathers' responses on each ordinal item. An important assumption of the polychoric correlation is that the underlying traits are normally distributed [205]. We used the likelihood ratio chi-squared test to test whether our paired questionnaire response data fit this assumption. Both the polychoric correlation and likelihood ratio test statistic were calculated using the "polycor" package in R software (version 2.14.1) [206]. In addition, we summed each parents' responses on the sets of items included in the Item Response Theory models (described in the previous section), yielding an "item total score" for each latent mode of paternal influence. These scores reflect mothers' and fathers' ratings of fathers' positions on a continuous variable hypothesized to underly each related set of questionnaire items. Therefore, they offer an alternative approach for estimating the correlation between the continuous traits underlying mothers' and fathers' questionnaire responses. We estimated the strength of association between mothers' and fathers' item total scores using Pearson correlation coefficients.

Next, to evaluate whether mothers and fathers agreed over the response category thresholds for each item, we calculated tests of category threshold equality and tests of overall bias. We tested the null hypothesis of equal response thresholds for mothers and fathers using the method described by Uebersax [204]. To describe this test briefly, consider a cross-tabulation of fathers' and mothers' responses to a hypothetical ordinal item with K response categories. Threshold equality for response category k can be tested by collapsing rows and columns for response categories 1 to k-1 and collapsing rows and columns for response categories k to K, then performing a McNemar test on the resulting 2x2 table. This procedure is repeated for all $K-1$ thresholds.

While tests of threshold equality focus on each category threshold separately, tests for bias evaluate whether, overall, fathers tends to give responses that are higher or lower than mothers' on a given item [204]. Again, the test is performed using a cross-tabulation of fathers' and mothers' responses for each ordinal item. Response frequencies above the main diagonal of the table are summed to give b and response frequencies below the main diagonal are summed to give c. As with the McNemar test, the test statistic is then calculated as:

$$X^2 = \frac{(b-c)^2}{(b+c)}$$

and compared for statistical significance against a chi-squared distribution with one degree of freedom (*Discrete multivariate analysis: theory and practice* (1975) as referenced in [204]).

We did not adjust the type I error rate for multiple comparisons because we were more interested in identifying patterns of agreement for sets of items thought to be measuring the same underlying mode of fathering than in the results of significance tests for individual items.

Finally, because we assumed fathers' and mothers' responses to the fathering items would be, in part, influenced by their fatherhood beliefs we used the same methods described above to calculate agreement on a set of six fatherhood belief questions (Table B.2, Appendix B.3). In contrast to the other items described in this section, these items asked each parent to report on their own personal beliefs (i.e.:

mothers were not reporting about fathers' beliefs). The agreement statistics were used, in these cases, to assess whether the mother-father pairs shared concordant beliefs. The fatherhood belief questions were Likert-type with the following four response options: strongly disagree, mildly disagree, mildly agree, and strongly agree. Therefore, we calculated all of the agreement statistics appropriate for ordinal items. Results of the agreement analyses are present in Section 7.4 of the following chapter.

Except where indicated, all of the above analyses were performed using SAS software version 9.4 (SAS Institute, Inc., Cary, NC, USA). Bhapkar tests were performed using a third party SAS macro program, "MARGHOMG" [207].

Chapter 7

Results: Measuring Fathers' Contributions to Infants' Care

7.1 Description of the MIHS fathering sub-study cohort

In this section we present descriptive statistics for fathers, mothers and infants in the MIHS Fathering Sub-study, using data reported by mothers at enrolment and at 2-week visits (Table 7.1 on page 101). In total, 178 infants and their mothers were enrolled in the MIHS and attended the 2-week study visit and therefore were eligible for the sub-study. The fathers of 71 (39.9%) of these infants were enrolled and completed a 2-week fathering questionnaire. Our analyses of mother-father agreement (results presented in Section 7.4) were based on this sub-sample of 71 mother-father pairs. The frequency distribution of reasons for father's non-participation in the study are presented in Appendix B.5 Table B.4. The most common reason why the father did not participate was because the mother did not want him to (21/107 = 19.6%). In nearly half of these cases, the mother and father were not in a romantic relationship at the time of the first visit. Figure 7.1 on page 99 depicts the flow of participants through the Fathering Sub-study.

Among the entire cohort of fathers on whom data were collected in the Fathering Sub-study, just over 90% were identified as Black Africans. This is consistent with 2011 national census data showing that Black Africans made up the majority of residents of the three areas of Kraaifontein (Bloekombos, Wallacedene, and Scottsdene) in which most of our participants were living [208]. Because past experience with caring for children may influence a father's parenting practices, it is important to note that two thirds of fathers in the complete cohort had one or more children in addition to the infant in the study. Of those, two thirds had a child with a different woman from the mother in this study.

To assess whether families with a participating father were comparable to those with a non-participating father, we present the descriptive statistics stratified by father's status on the study (Table 7.1 on page 101). Participating fathers differed from non-participating fathers most obviously in the characteristics of their relationship with their infant's mother. The average participating father knew the mother for longer, was more likely to have been living with her at conception, and was more likely to have negotiated with the mother to resolve recent relationship conflict. Although the majority of both participating and non-participating fathers were in either a marital or exclusive, non-marital relationship with the mother at the 2-week visit, a far greater percentage of non-participating fathers (18.7% vs. 2.8%) were no longer seeing the mother or only seeing her about the infant. Mothers paired to participating fathers tended to be younger and were more likely to know the father's HIV-status than were mothers paired to non-

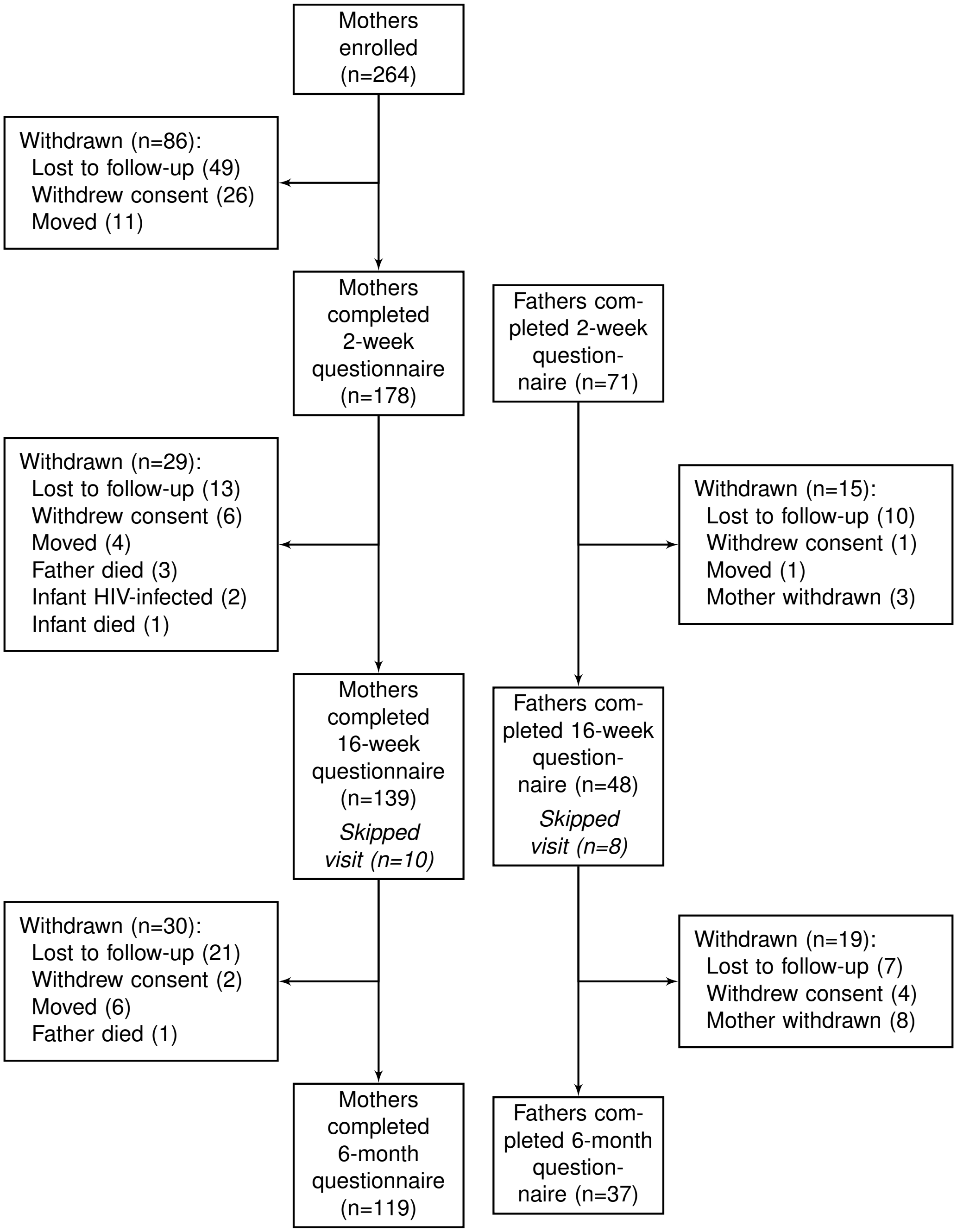


Figure 7.1: Flowchart of participants' progress through MIHS Fathering Sub-study

participating fathers. In addition to differences in parental relationship, participating fathers were also considerably more likely than non-participating fathers (76.1% vs. 44.9%) to be living with the infant.

The differences in parental relationship and co-residence status between participating and non-participating fathers may have implications for the fathering practices of each group. Because we are forced to rely on mothers' reports of the fathering practices of non-participating fathers, it becomes especially relevant to assess whether mothers' reports tend to agree well with those given by fathers themselves. Nevertheless, the differences in parental relationship between families with participating and non-participating fathers also raise the possibility that the findings of our father-mother agreement analyses will not be generalizable to the latter group.

Table 7.1: Descriptive statistics for complete cohort including a comparison by father's participation status, maternal report at enrolment and 2-week visit: MIHS Fathering Sub-study, 2012-13

		Total	Participating father	Non-participating father	
		N=178	n=71	n=107	
	n	%	%	%	p-value
FATHER'S CHARACTERISTICS					
Age (years)					0.357
18-19	0	0.0	0.0	0.0	
20-24	23	12.9	12.7	13.1	
25-29	55	30.9	40.8	24.3	
30-34	47	26.4	26.8	26.2	
35-39	26	14.6	12.7	15.9	
40-44	16	9.0	7.0	10.3	
45+	2	1.1	0.0	1.9	
Population group					0.526
Black	161	90.5	88.7	91.6	
Coloured	17	9.6	11.3	8.4	
First language					0.278
Afrikaans	16	9.0	11.3	7.5	
Xhosa	118	66.3	57.7	72.0	
Other African	40	22.5	26.8	19.6	
Other non-African	3	1.7	2.8	0.9	
Educational attainment					0.618
Completed primary or less	11	6.2	8.5	4.7	
1 year of secondary	6	3.4	1.4	4.7	
2 years of secondary	22	12.4	11.3	13.1	
3 years of secondary	28	15.7	14.1	16.8	
4 years of secondary	31	17.4	21.1	15.0	
Completed secondary	48	27.0	29.6	25.2	
Some post-secondary	10	5.6	5.6	5.6	
Don't know/Missing	22	12.4	8.5	15.0	
Employment status					0.858
Worked in last week	145	81.5	83.1	80.4	
No work in last week, worked in last year	11	6.2	7.0	5.6	
No work in last year	17	9.6	8.5	10.3	
Days worked per week, median (IQR), n=146	5	(5-6)	5 (5-6)	5 (5-6)	0.893
Months worked last year, median (IQR), n=149	12	(8-12)	12 (9-12)	12 (8-12)	0.521
Monthly earnings, thousand Rands, median (IQR), n=111	2.8	(2.0-3.6)	3.0 (2.0-4.0)	2.8 (2.0-3.4)	0.326
Has long-standing, work-limiting illness	11	6.2	7.0	5.6	0.690

Continued on next page

	n	Total N=178 %	Participating father n=71 %	Non-participating father n=107 %	p-value
HIV status					0.012
Infected	28	15.7	19.7	13.1	
Uninfected	68	38.2	49.3	30.8	
Not tested	58	32.6	22.5	39.3	
Don't know/Refused	24	13.5	8.5	16.8	
Number of children sired					0.279
1	53	29.8	36.6	25.2	
2	62	34.8	31.0	37.4	
3+	62	34.8	32.4	36.4	
Has children with other women					0.204
Yes	72	40.5	33.8	44.9	
No	49	27.5	26.8	28.0	
N.A. (only 1 child)	53	29.8	36.6	25.2	
Residing with study infant at 2-wk visit	102	57.3	76.1	44.9	<0.001
MOTHER'S CHARACTERISTICS					
Mother's age (years)					0.021
18-19	13	7.3	7.0	7.5	
20-24	60	33.7	43.7	27.1	
25-29	53	29.8	22.5	34.6	
30-34	31	17.4	22.5	14.0	
35-39	17	9.6	2.8	14.0	
40-44	4	2.3	1.4	2.8	
45+	0	0.0	0.0	0.0	
Mother's educational attainment					0.685
Completed primary or less	10	5.6	5.6	5.6	
1 year of secondary	11	6.2	2.8	8.4	
2 years of secondary	18	10.1	8.5	11.2	
3 years of secondary	28	15.7	15.5	15.9	
4 years of secondary	48	27.0	28.2	26.2	
Completed secondary/some post-secondary	63	35.4	39.4	32.7	
Mother is HIV-infected	94	52.8	47.9	56.1	0.284
Mother worked in year prior to delivery	84	47.2	53.5	43.0	0.168
Mother's monthly income, thousand Rands, median (IQR), n=178	1.1	(0.3-2.2)	1.2 (0.6-2.4)	0.8 (0.3-2.0)	0.044

Continued on next page

	n	Total N=178 %	Participating father n=71 %	Non-participating father n=107 %	p-value
INFANT CHARACTERISTICS					
Sex					0.343
Female	93	52.3	52.1	44.9	
Male	85	47.8	47.9	55.1	
Pregnancy was planned	53	29.8	38.0	24.3	0.052
RELATIONSHIP CHARACTERISTICS					
Living with mother at conception	101	56.7	71.8	46.7	0.001
Relationship with mother at 2-wk visit					0.016
Married	50	28.1	32.4	25.2	
Exclusive couple (not married)	98	55.1	60.6	51.4	
Non-exclusive or casual relationship	6	3.4	4.2	2.8	
No longer seeing mother/only seeing mother about the infant	22	12.4	2.8	18.7	
Time known mother at 2-wk visit					0.002
≤1 year	29	16.3	4.2	24.3	
2-4 years	65	36.5	40.8	33.6	
≥5 years	83	46.6	54.9	41.1	
Father used negotiation to resolve conflict, past 3 mo.§	154	86.5	94.4	81.3	0.013
Father insulted or threatened mother, past 3 mo.	49	27.5	32.4	24.3	0.213
Father hit mother, past 3 mo.	21	11.8	9.9	13.1	0.514
INFANT'S HOUSEHOLD CHARACTERISTICS					
Number of children					0.839
1	57	32.0	29.6	33.6	
2-3	74	41.6	43.7	40.2	
4+	47	26.4	26.8	26.2	
Living with grandparents	41	23.0	18.3	26.2	0.223
Living with mother's adult siblings	37	20.8	18.3	22.4	0.507

Note: §CTS-II Negotiation sub-scale, Cronbach's $\alpha = 0.85$; IQR=InterQuartile Range; wk=week; mo.=months; p-values are from tests of independence between each variable and father's participation status on the study, Pearson's chi-squared tests for categorical variables and Wilcoxon rank-sum tests for continuous variables.

7.2 Description of fathers' parenting practices

Before presenting measurement properties for the fathering questionnaire, we briefly describe the parenting practices of the sample of fathers as reported by mothers at the 2-week study visit. We then present results of bivariable analyses identifying characteristics that were associated with fathers' parenting at the 2-week visit. We end this section by comparing father's reported parenting practices across the three study visits.

7.2.1 Frequency distributions for fathering items by latent mode of paternal influence

There was considerable variation in the frequency fathers performed different **Direct Caregiving** activities when their infants were two weeks old. More than half of the fathers were reported to have held or soothed their infants, talked to them, put them to sleep, or gotten up with them at night at least as often as a few times per week since birth (Figure 7.2 on the following page). In contrast, most fathers had reportedly never dressed or washed their infants or changed their diapers. Taking infants for a walk was very uncommon.

Fathers' **Accessibility** (measured by mother's report of whether he typically spent an hour or more with the infant) varied by the time of day and the day of the week. The majority of fathers reportedly had not spent an hour or more with their children on work-day mornings or afternoons since birth, while about half had spent an hour or more on work-day evenings (Figure 7.3a on page 106). In contrast, around 60% of fathers were reported to have spent an hour or more with their infants on non-work-day afternoons and evenings. It was less common for fathers to spend time alone with their infants. Nevertheless, half of the fathers were reported to have looked after their infant while the mother did other things at least a few times per week (Figure 7.3b). Interestingly, the distribution of the number of nights fathers stayed with their infants per week suggests that one third of the fathers who were not living with their infants full time (15.2% of the total) were still able to spend some nights per week with them (Figure 7.4 on page 107).

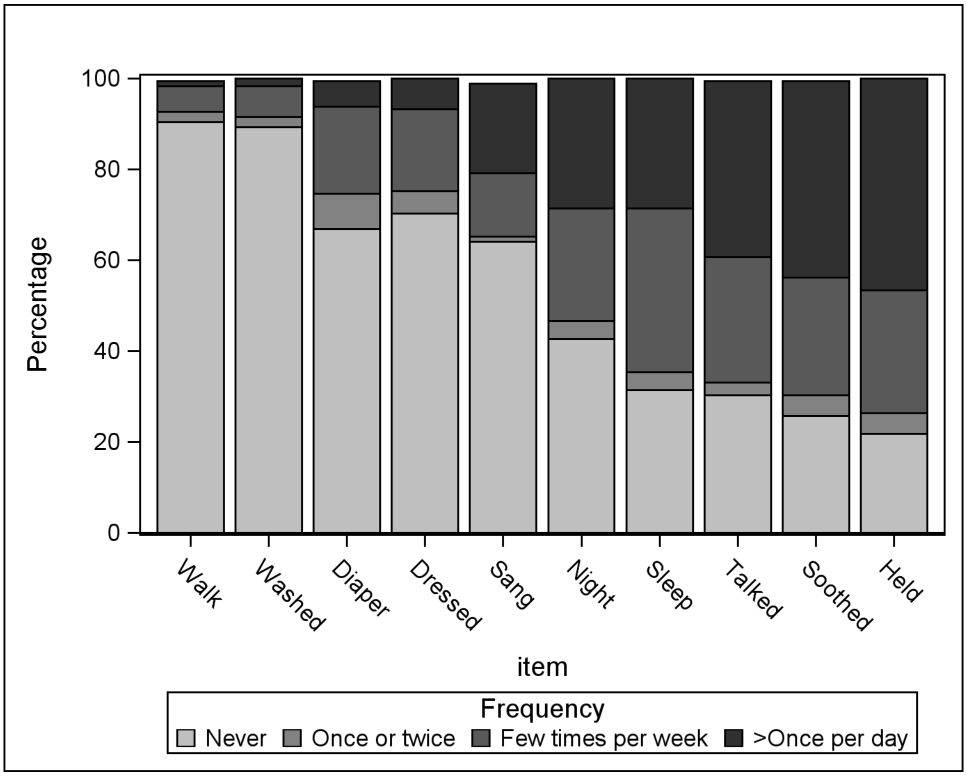
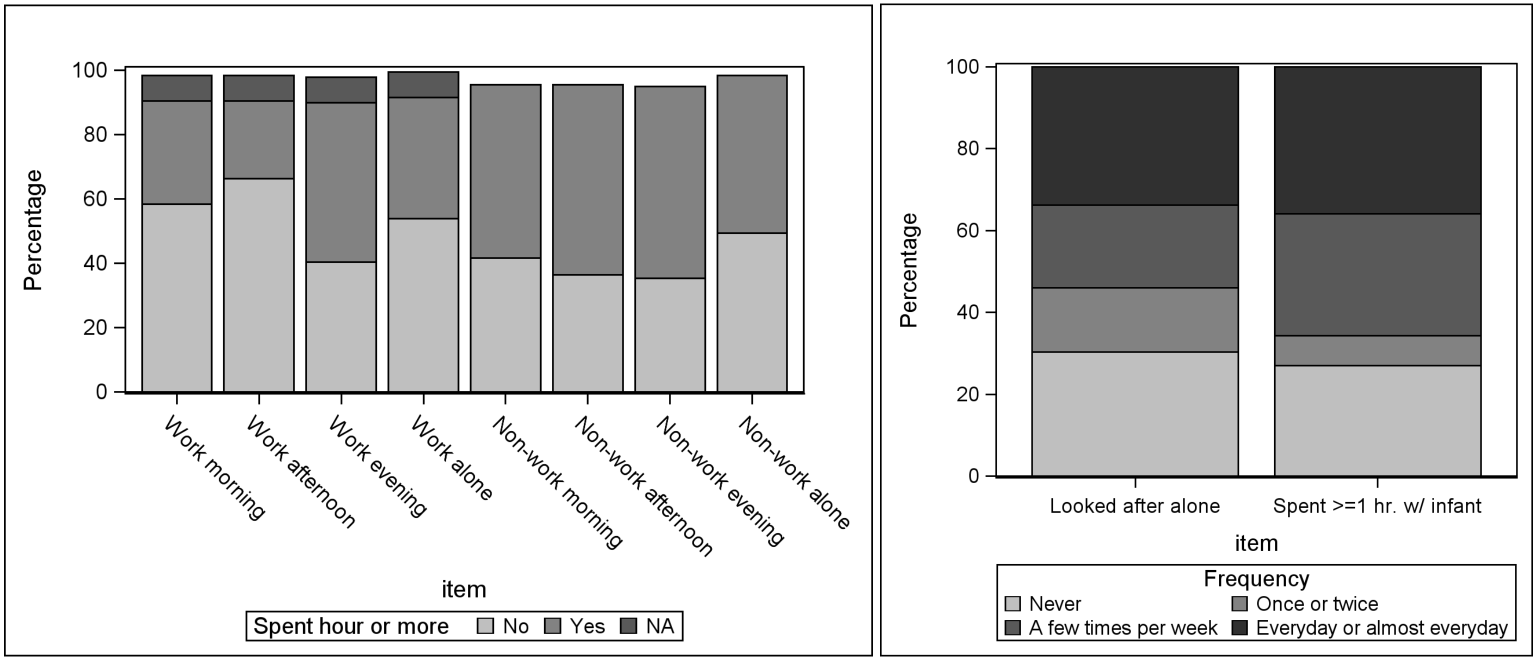


Figure 7.2: Percentage distribution of father's frequency of involvement in **Direct Caregiving** by item, maternal report at 2-week visit (n=178); MIHS Fathering Sub-study, 2012-13.

Walk - Frequency father took infant for a walk since birth
Washed - Frequency father washed or bathed infant since birth
Diaper - Frequency father changed infant's diaper since birth
Dressed - Frequency father dressed infant since birth
Sang - Frequency father sang songs or nursery rhymes to infant since birth
Night - Frequency father got up with infant when she/he woke up at night since birth
Sleep - Frequency father put infant to sleep since birth
Talked - Frequency father talked to infant since birth
Soothed - Frequency father soothed infant when she/he was upset since birth
Held - Frequency father held infant since birth



(a) (b)

Figure 7.3: Percentage distribution of father's **Accessibility** by item, binary items (a) and ordinal items (b), maternal report at 2-week visit (n=178); MIHS Fathering Sub-study, 2012-13.

Work morning - On days when he works, father usually spends an hour or more with infant in the morning
Work afternoon - On days when he works, father usually spends an hour or more with infant in the afternoon
Work evening - On days when he works, father usually spends an hour or more with infant in the evening
Work alone - On days when he works, father usually spends a full hour or more alone with infant
Non-work morning - On days when he does not work, father usually spends an hour or more with infant in the morning
Non-work afternoon - On days when he does not work, father usually spends an hour or more with infant in the afternoon
Non-work evening - On days when he does not work, father usually spends an hour or more with infant in the evening
Non-work alone - On days when he does not work, father usually spends a full hour or more alone with infant
Looked after alone - How often father looked after infant while mother did other things since birth
Spent >=1 hr. w/ infant - Number of days father spends an hour or more with infant in an average week

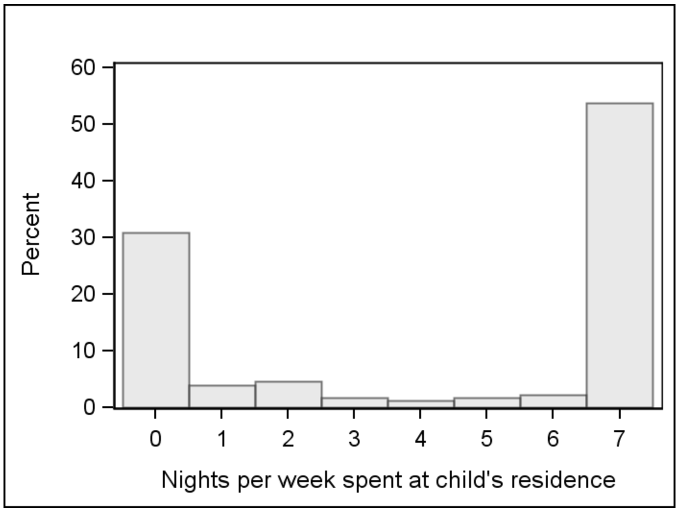
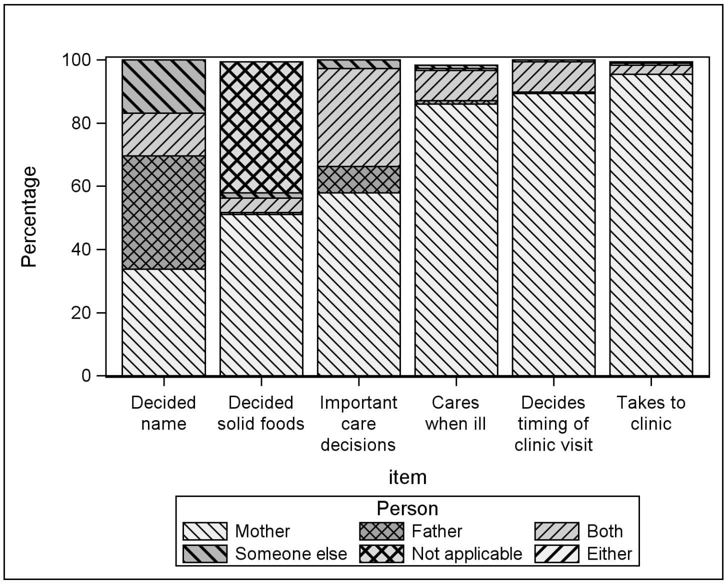


Figure 7.4: Frequency distribution of number of nights per week father spent at the house where the infant lives, maternal report at 2-week visit (n=178); MIHS Fathering Sub-study, 2012-13.

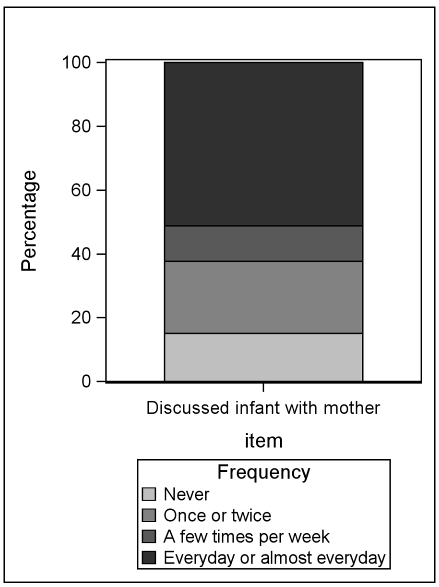
There was also large variability in who had primary **Responsibility** for different aspects of the infant's care. In the majority of cases mothers said that they alone had primary responsibility for the infant's health care needs (Figure 7.5). They reported that less than 10% of fathers (alone or together with the mother) had taken their infant to health clinics or doctors offices, decided when their infant needed to be taken to clinics, or cared for their infant when they were sick. In contrast, the father was reported to be the person most likely to have decided the infant's name, and in about 40% of cases the mother reported that the father was involved in making important decisions about the infant's care. Almost 50% of mothers reported that the decision of when to begin feeding the infant solid foods had not yet been made.

We observed less variability in responses to items measuring fathers' **Material Provisioning** and **Practical Support for Mother**. In the majority of cases, fathers were the primary provider for their children's expenses, including paying for child care items (e.g.: diapers and wet wipes) and clothing (Figure 7.6 on page 109). The father was also reported to be the most likely person to have been paying for food for the child's household. However, this item was distinct in that, the second most common provider of household food was someone other than the mother or father, usually a maternal grandparent or sibling. Almost 40% of mothers reported that paying for medicines and toys was not applicable for their infants. However, in most cases where these items were applicable, the father was reportedly the primary provider.

Almost half of the fathers had never done the practical support items we asked about, which included cooking, tidying and washing dishes. On the other hand, approximately 20% had reportedly done each item a few times per week or more often (Figure 7.7 on page 110).



(a)



(b)

Figure 7.5: Percentage distribution of person with primary **Responsibility** for infant's care by item (a) and frequency father talked with mother about the infant (b), maternal report at 2-week visit (n=178); MIHS Fathering Sub-study, 2012-13. "Both" refers to the "Father and Mother decided together" response option. "Either" refers to the "Sometimes father, sometimes mother" response option.

Decided name - Person who decided what infant's name would be
Decided solid foods - Person who decided when infant would start eating solid foods
Important care decisions - Person who makes important decisions about infant's care
Cares when ill - Person who usually cares for infant when she/he is ill
Decides timing of clinic visits - Person who decides when infant needs to be taken to clinic or doctor
Takes to clinic - Person who usually takes infant when she/he needs to be taken to clinic or doctor
Discussed infant with mother - Frequency father talked with mother about infant since birth

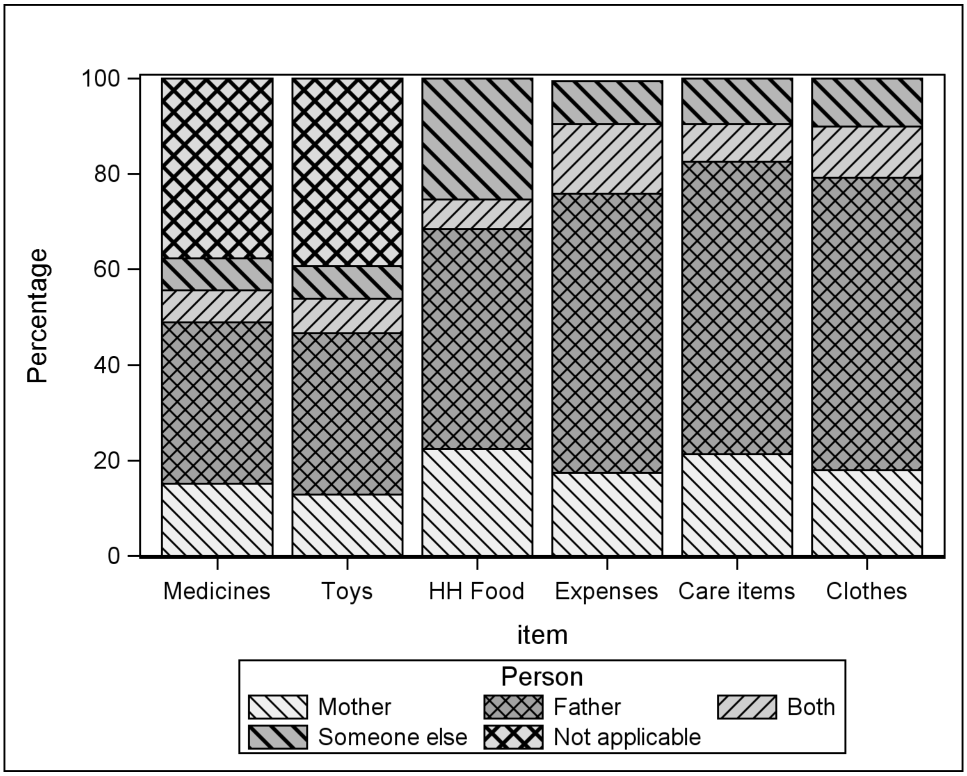


Figure 7.6: Percentage distribution of person who mainly provided for child's material needs (**Material Provisioning**) by item, maternal report at 2-week visit (n=178); MIHS Fathering Sub-study, 2012-13.

Medicines - Person who mainly paid for medicines for infant since birth
Toys - Person who mainly paid for toys for infant since birth
HH Food - Person who mainly paid for food for the infant's household since birth
Expenses - How expenses for infant are shared
Care items - Person who mainly paid for child care items (like diapers or wet wipes) since birth
Clothes - Person who mainly paid for infant's clothing since birth

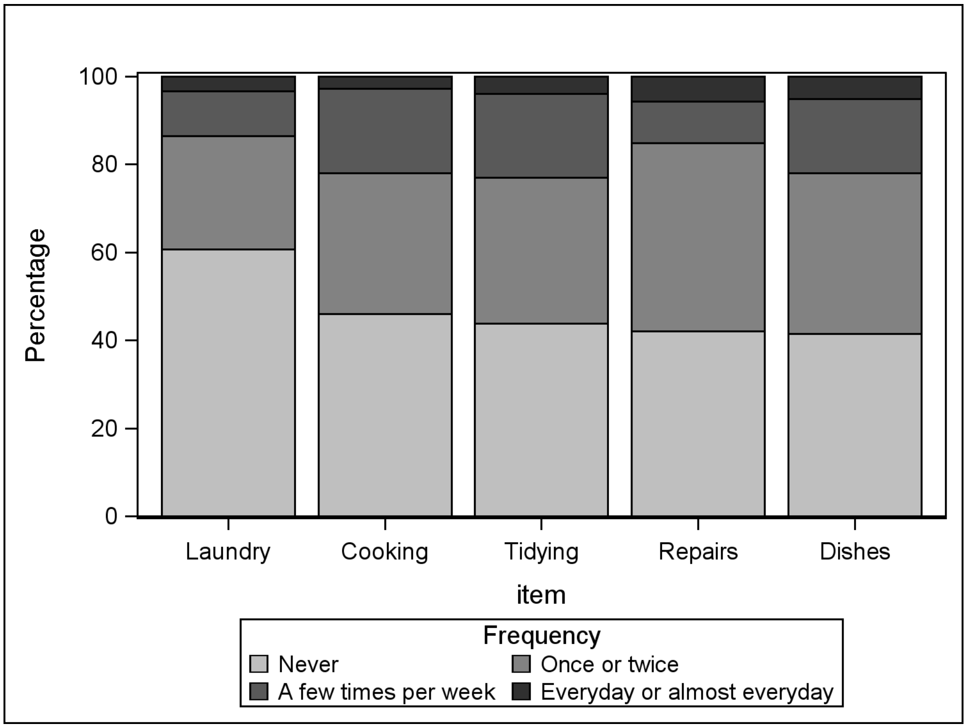


Figure 7.7: Percentage distribution of father's frequency of giving **Practical Support to Mother** by item, maternal report at 2-week visit (n=178); MIHS Fathering Sub-study, 2012-13.

Laundry - How often father washed clothes for members of infant's household since infant's birth
Cooking - How often father cooked a meal for the members of infant's household since infant's birth
Tidying - How often father cleaned or tidied the house since infant's birth
Repairs - How often father repaired something in the house that was damaged or broken since infant's birth
Dishes - How often father washed the dishes or cooking pots since infant's birth

7.2.2 Characteristics associated with fathering item responses at 2-week visit

In tables 7.2 to 7.5 (pages 113-119) we present gamma statistics (γ) and Pearson chi-square test p-values from cross-tabulations of mothers' responses to the fathering questionnaire items and selected sociodemographic, relationship and household variables measured at the 2-week study visit.

In general, characteristics of the parental relationship, household structure and father's involvement during pregnancy were significantly associated with questionnaire items measuring all five modes of paternal influence. For example, being married or in an exclusive non-marital relationship, versus not, was positively associated with father's reported frequency of: soothing, holding, and dressing his infant; talking and singing to her/him; changing her/his diaper; putting the infant to sleep; waking up with the infant at night; spending time with the infant and looking after her/him while the mother did other things; and providing practical support to the mother (γ range: 0.62-1.00, chi-square p <0.05). Being married or in an exclusive relationship was also associated with increased probability of reportedly having paid for the infant's clothing and expenses, child care items, and food for the household (γ range: 0.86-0.93; chi-square p <0.001). Similar positive associations were observed with variables measuring whether the mother experienced any relationship negotiation from the father (CTS-II negotiation scale) in the past 3 months, whether the father attended antenatal clinic visits, whether he bought things for the baby during the pregnancy, felt the baby move in the mother's stomach, and whether he was at the clinic or hospital during the infant's birth. Residing with the infant and having enrolled in the MIHS were also positively associated with responses to items in all five modes of influence.

Fathers whose children were residing with the mother's parent(s) or adult sibling(s) were doing **Direct Caregiving** and **Practical Support for Mother** items significantly less frequently (γ range: -0.03 to -0.90), and were less likely to spend time with the infant (γ range: 0.27 to -0.82), compared to fathers whose infants were not living with other adult relatives. In addition, fathers whose infants were residing with a maternal grandparent were also less likely to pay for the **Material Provisioning** items (γ range: -0.49 to -0.86, chi-square p<0.01).

Characteristics related to father's past experience as a parent were associated with items measuring some modes of influence. For example, fathers who had a child with another woman performed many of the **Direct Caregiving** and **Practical Support** items less frequently (γ range: 0.05 to -0.47), and were less likely to pay for the **Material Provisioning** items (γ range: -0.23 to -0.50) compared to fathers who only had children with the mother in the study. Similarly, fathers with three or more children were reportedly significantly less likely to have been paying for the **Material Provisioning** items compared to fathers with fewer children (γ range: -0.30 to -0.35, chi-square p<0.05) with the exception that they were equally likely to be paying for food for the household (γ = 0.10, chi-square p>0.05).

In contrast, father's sociodemographic, employment and health characteristics, and mother and infant characteristics were not significantly associated with items measuring any mode of paternal influence. The exception was the pair of variables measuring whether the father worked for pay in the past 7 days and in the past 12 months. For example, fathers who worked in the past 12 months were significantly more likely to have paid for all **Material Provisioning** items (γ range: 0.90-0.94, chi-square p <0.001) than fathers who had not worked. Fathers who had worked in the past 12 months also performed the **Practical Support** items significantly more frequently (γ range: 0.40-0.79, chi-square p <0.05), spent more time with the infant, and looked after the infant more often while the mother did other things (γ = 0.20, chi-square p <0.05). Having worked in the past 12 months was also positively associated with frequency of having done the **Direct Caregiving** items, but these associations were not statistically significant.

Table 7.2: Gamma statistics and results of Pearson's chi-square tests for cross-tabulations of items measuring father's **Direct Caregiving** with covariates, maternal report at 2-week visit; MIHS Fathering Sub-study, 2012-13.

	Soothed[1]	Held[2]	Sleep[3]	Talked[4]	Night[5]	Sang[6]	Walk[7]	Dressed[8]	Bathed[9]	Diaper[10]
FATHER CHARACTERISTICS										
Coloured vs. Black	-0.03	-0.07	-0.21	-0.01	-0.21	-0.01	-0.20	0.05	0.09	0.24
Non-Xhosa- vs. Xhosa-speaker	0.09	0.17	0.02	0.03	0.03	0.11	-0.21	-0.02	0.20	0.01
>=Secondary vs. <Secondary education	-0.14	-0.15	-0.22	-0.20	-0.20	-0.19	-0.19	-0.28	0.16	-0.25
Unknown vs. <Secondary education	-0.33	-0.37	-0.34	-0.37	-0.20	-0.55	-0.08	-0.22	-0.42	0.22
Worked in last 7 days	0.26	0.29	0.22	0.27	0.27	0.17	-0.08	0.37	1.00	0.33
Worked in last 12 months	0.25	0.32	0.19	0.38	0.38	0.41	0.28	0.34	1.00	0.25
Has long-standing illness	-0.12	-0.13	-0.27	-0.08	-0.07	-0.17	-1.00	-1.00	-1.00	-1.00
Number of children sired (increasing)	0.05	0.10	0.06	0.06	0.08	0.13	-0.18	-0.07	-0.18	0.06
Has a child with another woman	**-0.44**	**-0.47**	**-0.41**	-0.33	-0.37	-0.38	0.05	-0.35	-0.29	-0.41
Co-resident vs. non-co-resident	***0.79***	***0.80***	***0.82***	***0.78***	***0.92***	***0.75***	***1.00***	***0.64***	0.63	***0.71***
MIHS participant	***0.59***	***0.61***	***0.49***	***0.59***	***0.60***	0.26	0.56	0.34	0.28	0.30
MOTHER CHARACTERISTICS										
Worked year before birth	0.25	0.21	0.15	**0.29**	0.14	0.23	0.21	-0.22	-0.10	0.00
HIV-infected	-0.09	-0.05	-0.12	-0.18	-0.15	-0.08	0.22	-0.03	-0.13	-0.13
INFANT CHARACTERISTICS										
Female vs. Male	-0.03	0.00	0.06	-0.03	0.15	0.36	0.49	0.00	-0.32	0.08
RELATIONSHIP CHARACTERISTICS										
Married vs. Not	***0.54***	***0.63***	***0.61***	***0.50***	***0.66***	***0.50***	0.08	0.38	0.29	**0.42**
Married/Exclusive relationship vs. not	***0.82***	***0.80***	***0.76***	***0.75***	***0.74***	***1.00***	0.50	**0.73**	0.57	**0.62**
Mother disclosed her HIV status to father	***0.54***	***0.57***	***0.55***	***0.60***	***0.51***	0.40	0.75	**0.49**	0.60	0.37
Mother desires father to be involved in future	***0.71***	***0.76***	***0.77***	***0.71***	***0.77***	0.64	1.00	1.00	1.00	1.00
Father negotiated to resolve conflict, past 3 mo.	***0.52***	**0.48**	**0.55**	***0.56***	***0.62***	0.48	1.00	0.69	1.00	0.58
Father insulted or threatened mother, past 3 mo.	-0.09	-0.13	-0.07	0.05	0.07	-0.16	-0.07	0.07	-0.02	0.00
HOUSEHOLD CHARACTERISTICS										
Number of resident children (increasing)	-0.11	-0.09	-0.08	-0.17	-0.16	-0.13	-0.43	-0.12	-0.18	-0.05
Living with grandparents	***-0.64***	***-0.61***	***-0.66***	***-0.57***	***-0.87***	**-0.60**	-0.36	-0.26	-0.03	-0.38
Living with mother's adult siblings	***-0.51***	***-0.50***	***-0.59***	***-0.41***	***-0.65***	-0.44	-0.63	-0.14	-0.40	**-0.41**

Continued on next page

	Soothed[1]	Held[2]	Sleep[3]	Talked[4]	Night[5]	Sang[6]	Walk[7]	Dressed[8]	Bathed[9]	Diaper[10]
PRENATAL INVOLVEMENT										
Father attended antenatal visits	***0.53***	***0.63***	***0.56***	***0.57***	***0.52***	***0.40***	0.18	**0.41**	0.55	**0.41**
Father bought things for baby	***0.62***	***0.65***	***0.66***	***0.65***	***0.65***	***0.64***	0.60	**0.67**	0.66	***0.71***
Father felt baby move in mother's stomach	***0.67***	***0.72***	***0.69***	***0.72***	***0.60***	***0.79***	1.00	***1.00***	1.00	**0.64**
Father was present at birth	***0.63***	***0.65***	***0.69***	***0.62***	***0.64***	***0.54***	0.22	***0.45***	**0.66**	***0.51***

Note: Chi-square test p-values key: Bold - p <0.05; Italicized - p <0.01; Underlined - p<0.001; mo.=months

[1]Frequency father soothed infant when she/he was upset since birth

[2]Frequency father held infant since birth

[3]Frequency father put infant to sleep since birth

[4]Frequency father talked to infant since birth

[5]Frequency father got up with infant when she/he woke up at night since birth

[6]Frequency father sang songs or nursery rhymes to infant since birth

[7]Frequency father took infant for a walk since birth

[8]Frequency father dressed infant since birth

[9]Frequency father washed or bathed infant since birth

[10]Frequency father changed infant's diaper since birth

Table 7.3: Gamma statistics and results of Pearson's chi-square tests for cross-tabulations of items measuring father's **Accessibility** with covariates, maternal report at 2-week visit; MIHS Fathering Sub-study, 2012-13.

	Work Mornings[1]	Work Afternoons[2]	Work Evenings[3]	Work Alone[4]	Non-work Mornings[5]	Non-work Afternoons[6]	Non-work Evenings[7]	Non-work Alone[8]	Freq. Spent hr.[9]	Looked After Alone[10]	Nights per week[11]
FATHER CHARACTERISTICS											
Coloured vs. Black	-0.37	-0.11	-0.32	0.34	-0.03	-0.30	-0.37	-0.05	0.12	-0.31	0.15
Non-Xhosa- vs. Xhosa-speaker	0.12	-0.25	-0.06	***0.52***	0.02	-0.28	0.23	0.34	0.18	0.07	0.17
>=Secondary vs. <Secondary education	0.08	0.10	-0.17	**-0.39**	0.14	0.19	0.15	-0.37	-0.19	-0.27	**-0.43**
Unknown vs. <Secondary education	-0.25	-0.63	-0.17	-0.31	0.09	-0.18	0.18	0.03	-0.32	-0.26	-0.32
Worked in last 7 days	0.02	-0.24	0.60	-1.00	-0.47	-0.22	-0.15	-0.27	**0.09**	**0.22**	0.39
Worked in last 12 months	NA	NA	NA	NA	-1.00	-1.00	-1.00	-0.49	**0.20**	**0.20**	0.51
Has long-standing illness	-0.22	0.03	**-0.45**	-0.35	-0.51	-0.45	-0.72	-0.52	-0.34	-0.45	0.01
Number of children sired (increasing)	0.07	-0.11	0.14	0.08	-0.01	-0.17	-0.03	0.04	-0.04	0.05	0.15
Has a child with another woman	-0.26	0.02	-0.25	-0.30	-0.75	-0.18	-0.21	-0.44	**-0.36**	***-0.52***	-0.38
Co-resident vs. non-co-resident	***0.64***	0.10	***0.85***	0.35	***0.67***	***0.60***	***0.84***	0.18	***0.80***	***0.89***	***0.98***
MIHS participant	0.16	0.15	-0.05	0.20	-0.06	0.15	0.01	0.13	***0.48***	***0.54***	***0.50***
MOTHER CHARACTERISTICS											
Worked year before birth	0.12	-0.08	-0.19	-0.21	0.06	0.03	0.05	-0.21	0.11	0.03	0.12
HIV-infected	0.05	0.22	0.15	-0.03	0.04	-0.30	-0.05	0.01	-0.08	0.01	-0.05
INFANT CHARACTERISTICS											
Female vs. Male	0.09	-0.13	0.02	0.01	-0.15	-0.03	-0.33	0.06	-0.08	-0.05	0.08
RELATIONSHIP CHARACTERISTICS											
Married vs. Not	0.35	0.08	**0.58**	0.20	**0.50**	0.33	0.41	0.16	***0.40***	***0.70***	***0.86***
Married/Exclusive relationship vs. not	0.01	1.00	***0.85***	0.17	***0.86***	**0.76**	**0.79**	0.06	***0.81***	***0.82***	***0.73***
Mother disclosed her HIV status to father	-0.20	0.13	***0.58***	-0.35	0.10	-0.11	0.19	-0.16	***0.48***	***0.49***	***0.55***
Mother desires father involved in future	0.76	0.63	***0.86***	0.64	***0.94***	***0.72***	***0.64***	0.65	***0.71***	***0.80***	***0.72***
Father negotiated resolve conflict, past 3 mo.	0.16	-0.11	-0.25	0.02	0.11	0.38	0.01	0.39	***0.61***	***0.57***	0.43
Father insulted/threatened mother, past 3mo.	-0.28	-0.14	-0.31	0.30	-0.36	-0.09	**-0.59**	0.13	0.05	-0.08	0.11
HOUSEHOLD CHARACTERISTICS											
Number of resident children (increasing)	-0.05	-0.09	-0.34	-0.22	-0.04	-0.31	-0.41	-0.16	**-0.20**	-0.13	**-0.34**
Living with grandparents	***-0.66***	-0.03	***-0.65***	-0.26	***-0.73***	***-0.64***	***-0.78***	**-0.45**	***-0.41***	***-0.63***	***-0.82***
Living with mother's adult siblings	**-0.60**	-0.07	**-0.57**	0.01	**-0.48**	-0.13	***-0.77***	0.27	***-0.52***	***-0.53***	***-0.74***

Continued on next page

	Work Mornings[1]	Work Afternoons[2]	Work Evenings[3]	Work Alone[4]	Non-work Mornings[5]	Non-work Afternoons[6]	Non-work Evenings[7]	Non-work Alone[8]	Freq. Spent hr.[9]	Looked After Alone[10]	Nights per week[11]
PRENATAL INVOLVEMENT											
Father attended antenatal visits	0.26	0.29	**0.52**	0.19	0.27	0.40	**0.56**	0.22	***0.57***	***0.53***	***0.60***
Father bought things for baby	**1.00**	**1.00**	***0.79***	0.49	***0.75***	***0.79***	***0.72***	0.24	***0.62***	***0.66***	***0.56***
Father felt baby move in mother's stomach	0.53	0.32	***0.76***	0.18	**0.61**	0.38	**0.67**	0.29	***0.72***	***0.69***	***0.55***
Father was present at birth	0.31	**0.44**	***0.54***	0.20	0.34	0.41	**0.55**	0.07	***0.67***	***0.61***	***0.63***

Note: Chi-square test p-values key: Bold - p <0.05; Italicized - p <0.01; Underlined - p<0.001; NA=Not Applicable; mo.=months

[1]On days when he works, father usually spends an hour or more with infant in the morning

[2]On days when he works, father usually spends an hour or more with infant in the afternoon

[3]On days when he works, father usually spends an hour or more with infant in the evening

[4]On days when he works, father usually spends a full hour or more alone with infant

[5]On days when he does not work, father usually spends an hour or more with infant in the morning

[6]On days when he does not work, father usually spends an hour or more with infant in the afternoon

[7]On days when he does not work, father usually spends an hour or more with infant in the evening

[8]On days when he does not work, father usually spends a full hour or more alone with infant

[9]Number of days father spends an hour or more with infant in an average week

[10]How often father looked after infant while mother did other things since birth

[11]Number of nights per week father spends in the house where the infant lives

Table 7.4: Gamma statistics and results of Pearson's chi-square tests for cross-tabulations of items measuring father's **Responsibilit**y and **Material Provisionin**g with covariates, maternal report at 2-week visit; MIHS Fathering Sub-study, 2012-13.

	RESPONSIBILITY						PROVISIONING			
FATHER CHARACTERISTICS										
Coloured vs. Black	0.41	0.35	***0.84***	0.32	**0.58**	-0.28	-0.04	-0.13	-0.11	-0.11
Non-Xhosa- vs. Xhosa-speaker	0.24	0.26	***0.83***	0.16	**0.33**	0.11	0.30	**0.37**	0.20	0.12
>=Secondary vs. <Secondary education	0.02	-0.19	-0.08	-0.17	-0.15	0.13	-0.15	-0.09	-0.02	**-0.40**
Unknown vs. <Secondary education	0.04	-0.49	-1.00	0.06	-0.35	**-0.37**	**-0.46**	**-0.48**	-0.35	**-0.49**
Worked in last 7 days	0.21	-0.02	1.00	0.04	0.19	***0.26***	***0.80***	***0.80***	***0.80***	***0.69***
Worked in last 12 months	0.29	-0.05	1.00	-0.27	0.37	***0.43***	***0.90***	***0.94***	***0.93***	***0.92***
Has long-standing illness	-0.05	0.36	-1.00	-1.00	-0.47	-0.30	-0.55	-0.43	-0.50	-0.34
Number of children sired (increasing)	0.06	-0.05	0.30	0.12	-0.05	-0.23	**-0.35**	**-0.35**	**-0.30**	0.10
Has a child with another woman	-0.21	0.01	-0.19	0.11	-0.16	***-0.58***	**-0.43**	**-0.49**	-0.23	***-0.50***
Co-resident vs. non-co-resident	***0.81***	***0.74***	0.58	***0.89***	***0.45***	***0.51***	***0.66***	***0.64***	***0.62***	***0.96***
MIHS participant	**0.38**	0.34	0.20	0.23	**0.32**	***0.39***	***0.57***	***0.63***	***0.58***	***0.48***
MOTHER CHARACTERISTICS										
Worked year before birth	0.14	0.18	**1.00**	0.17	0.02	0.05	-0.02	0.12	0.16	0.01
HIV-infected	0.10	-0.30	-0.40	-0.30	-0.07	-0.05	-0.03	-0.02	-0.16	-0.10
INFANT CHARACTERISTICS										
Female vs. Male	0.11	0.20	0.30	0.39	-0.13	-0.05	0.01	-0.25	-0.17	0.06
RELATIONSHIP CHARACTERISTICS										
Married vs. Not	0.30	0.13	0.44	0.38	0.18	***0.56***	***0.59***	***0.56***	***0.38***	***0.90***
Married/Exclusive relationship vs. not	**0.65**	0.22	1.00	0.00	***0.63***	***0.92***	***0.93***	***0.92***	***0.89***	***0.86***
Mother disclosed her HIV status to father	**0.39**	0.54	1.00	0.42	***0.43***	***0.29***	***0.51***	***0.47***	***0.51***	***0.56***
Mother desires father to be involved in future	***0.72***	1.00	1.00	0.57	***0.94***	***0.83***	***0.92***	***0.93***	***0.90***	***0.84***
Father negotiated to resolve conflict, past 3 mo.	0.36	1.00	-0.15	0.17	**0.55**	***0.62***	***0.70***	***0.58***	***0.65***	**0.42**
Father insulted or threatened mother, past 3 mo.	-0.19	0.19	0.46	-0.38	0.11	-0.11	-0.23	-0.22	-0.25	0.01
HOUSEHOLD CHARACTERISTICS										
Number of resident children (increasing)	-0.28	-0.20	-0.50	-0.16	-0.01	-0.06	-0.19	-0.20	**-0.27**	**-0.33**
Living with grandparents	***-0.55***	-0.44	-1.00	**-1.00**	-0.27	-0.31	***-0.49***	***-0.56***	***-0.61***	***-0.86***
Living with mother's adult siblings	***-0.69***	-0.66	-1.00	-0.45	**-0.42**	-0.08	-0.21	-0.18	-0.20	***-0.79***

Continued on next page

	RESPONSIBILITY						PROVISIONING			
	Important care decisions[1]	Decides timing clinic visits[2]	Takes to clinic visits[3]	Cares when ill[4]	Decided name[5]	Discussed infant with mother[6]	Clothes[7]	Expenses[8]	Care items[9]	HH food[10]
PRENATAL INVOLVEMENT										
Father attended antenatal visits	***0.56***	0.30	0.17	***0.67***	0.16	***0.61***	***0.79***	***0.76***	***0.62***	***0.64***
Father bought things for baby	***0.61***	0.37	1.00	0.42	***0.64***	***0.85***	***0.99***	***0.98***	***0.97***	***0.86***
Father felt baby move in mother's stomach	***0.68***	0.58	1.00	0.29	***0.60***	***0.78***	***0.77***	***0.76***	***0.73***	***0.70***
Father was present at birth	***0.64***	***0.74***	0.40	***0.68***	***0.47***	***0.53***	***0.64***	***0.60***	***0.58***	***0.63***

Note: Chi-square test p-values key: Bold - p <0.05; Italicized - p <0.01; Underlined - p<0.001; mo.=months

[1]Father/both father and mother make(s) important decisions about infant's care

[2]Father/both father and mother decide(s) when infant needs to be taken to clinic or doctor

[3]Father/both father and mother usually take(s) infant when she/he needs to be taken to clinic or doctor

[4]Father/both father and mother usually care(s) for infant when she/he is ill

[5]Father/both father and mother decided what infant's name would be

[6]Frequency father talked with mother about infant since birth

[7]Mainly father/father and mother equally paid for infant's clothing since birth

[8]Mainly father/father and mother equally pay(s) for the infant's expenses

[9]Mainly father/father and mother equally paid for child care items (like diapers or wet wipes) since birth

[10]Mainly father/father and mother equally paid for food for the infant's household since birth

Table 7.5: Gamma statistics and results of Pearson's chi-square tests for cross-tabulations of items measuring father's **Practical Support for Mother** with covariates, maternal report at 2-week visit; MIHS Fathering Sub-study, 2012-13.

	Tidying[1]	Dishes[2]	Cooking[3]	Laundry[4]	Repairs[5]
FATHER CHARACTERISTICS					
Coloured vs. Black	0.00	-0.08	-0.12	-0.21	0.30
Non-Xhosa- vs. Xhosa-speaker	0.11	0.17	0.10	-0.07	0.11
>=Secondary vs. <Secondary education	-0.16	-0.13	**-0.29**	***-0.11***	-0.17
Unknown vs. <Secondary education	-0.30	-0.32	-0.20	0.03	-0.12
Worked in last 7 days	0.36	0.32	**0.35**	0.44	0.37
Worked in last 12 months	***0.48***	**0.40**	**0.48**	**0.79**	**0.49**
Has long-standing illness	-0.21	-0.46	-0.29	-0.76	-0.26
Number of children sired (increasing)	0.14	0.13	0.21	0.02	0.03
Has a child with another woman	**-0.39**	**-0.34**	***-0.28***	-0.39	**-0.36**
Co-resident vs. non-co-resident	***0.93***	***0.86***	***0.93***	***0.87***	***0.86***
MIHS participant	***0.37***	***0.34***	***0.30***	***0.39***	***0.42***
MOTHER CHARACTERISTICS					
Worked year before birth	0.14	0.17	0.06	0.04	0.32
HIV-infected	-0.26	-0.20	0.06	-0.09	-0.05
Mother disclosed her HIV status to father	***0.45***	***0.48***	***0.44***	0.39	***0.45***
Mother desires father to be involved in future	***0.75***	***0.71***	***0.69***	0.78	***0.69***
INFANT CHARACTERISTICS					
Female vs. Male	0.08	-0.01	-0.01	0.08	-0.06
RELATIONSHIP CHARACTERISTICS					
Married vs. Not	***0.60***	***0.53***	***0.52***	***0.47***	***0.32***
Married/Exclusive relationship vs. not	***0.72***	***0.77***	***0.75***	***0.80***	***0.73***
Father negotiated to resolve conflict, past 3 mo.	***0.48***	***0.60***	**0.48**	0.37	***0.63***
Father insulted or threatened mother, past 3 mo.	0.00	0.02	0.03	0.08	0.11
HOUSEHOLD CHARACTERISTICS					
Number of resident children (increasing)	-0.20	-0.28	**-0.27**	-0.22	***-0.34***
Living with grandparents	***-0.80***	***-0.74***	***-0.85***	***-0.90***	***-0.65***
Living with mother's adult siblings	***-0.70***	***-0.56***	***-0.71***	**-0.49**	***-0.67***
PRENATAL INVOLVEMENT					
Father attended antenatal visits	***0.58***	***0.59***	***0.40***	***0.59***	***0.45***
Father bought things for baby	***0.66***	***0.71***	***0.68***	***0.85***	***0.61***
Father felt baby move in mother's stomach	***0.62***	***0.59***	***0.47***	***0.73***	***0.54***
Father was present at birth	***0.62***	***0.65***	***0.69***	***0.66***	***0.64***

Note: Chi-square test p-values key: Bold - p <0.05; Italicized - p <0.01; Underlined - p<0.001; mo.=months

[1]How often father cleaned or tidied the house since infant's birth

[2]How often father washed the dishes or cooking pots since infant's birth

[3]How often father cooked a meal for the members of infant's household since infant's birth

[4]How often father washed clothes for members of infant's household since infant's birth

[5]How often father repaired something in the house that was damaged or broken since infant's birth

7.2.3 Changes in fathering item responses across study visits

Of the 178 mothers who completed the 2-week fathering questionnaire, 109 (61.2%) also completed questionnaires at the 16-week and 6-month visits. This sub-group did not differ significantly from the complete cohort on any of the sociodemographic and health characteristics measured at baseline (Table B.5, Appendix B.6). Figures 7.8-7.14 (pages 121-128) depict percentage frequency distributions of responses for the fathering items by study visit and mode of paternal influence, as reported by mothers with complete follow-up to 6 months.

In general, fathers' accessibility to their children and their frequency performing direct caregiving activities increased progressively and significantly over the three visits. The **Direct Caregiving** items showing the greatest relative increases were those measuring the frequency of *taking the child for a walk* (percentage doing item a few times a week or more increased from 7% to 50% between 2-week and 6-month visits, $p<0.001$), *dressing the child* (percentage doing item a few times a week or more increased from 24% to 56% between 2-week and 6-month visits, $p<0.001$) and *singing songs or nursery rhymes* (percentage doing item a few times a week or more increased from 34% to 63% between 2-week and 6-month visits, $p<0.001$).

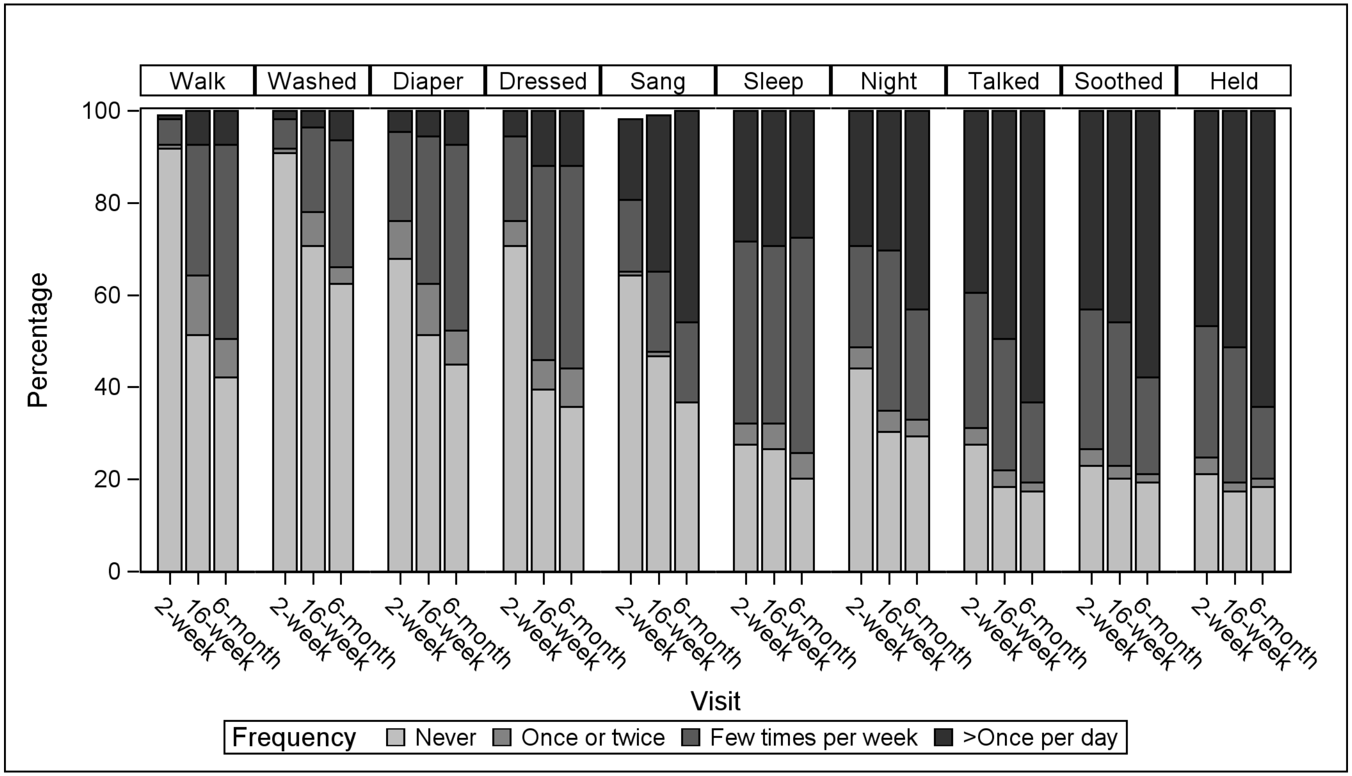


Figure 7.8: Percentage distribution of father's frequency of involvement in **Direct Caregiving** by item at study visits at 2 weeks, 16 weeks and 6 months of age, maternal report (n=109); MIHS Fathering Sub-study, 2012-13.

Walk - Frequency father took infant for a walk since birth
Washed - Frequency father washed or bathed infant since birth
Diaper - Frequency father changed infant's diaper since birth
Dressed - Frequency father dressed infant since birth
Sang - Frequency father sang songs or nursery rhymes to infant since birth
Sleep - Frequency father put infant to sleep since birth
Night - Frequency father got up with infant when she/he woke up at night since birth
Talked - Frequency father talked to infant since birth
Soothed - Frequency father soothed infant when she/he was upset since birth
Held - Frequency father held infant since birth

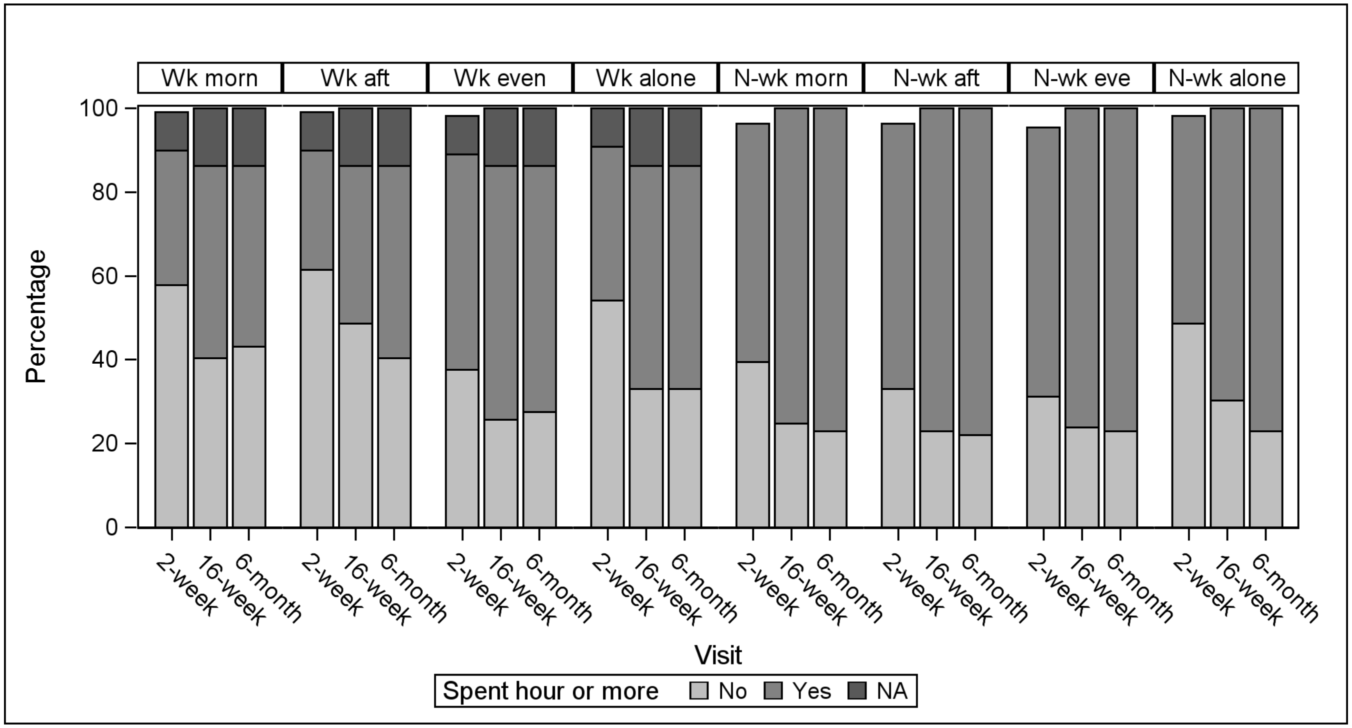


Figure 7.9: Percentage distribution of father's **Accessibility** measured by binary items at study visits at 2 weeks, 16 weeks and 6 months of age, maternal report (n=109); MIHS Fathering Sub-study, 2012-13.

Wk morn - On days when he works, father usually spends an hour or more with infant in the morning
Wk aft - On days when he works, father usually spends an hour or more with infant in the afternoon
Wk even - On days when he works, father usually spends an hour or more with infant in the evening
Wk alone - On days when he works, father usually spends a full hour or more alone with infant
N-wk morn - On days when he does not work, father usually spends an hour or more with infant in the morning
N-wk aft - On days when he does not work, father usually spends an hour or more with infant in the afternoon
N-wk eve - On days when he does not work, father usually spends an hour or more with infant in the evening
N-wk alone - On days when he does not work, father usually spends a full hour or more alone with infant

In contrast, the probability that fathers were paying for their children's material needs remained relatively constant over time. For example, the percentage of fathers who paid for child care items (alone or shared with mother) was 73% at 2 weeks and 69% at 6 months (p=0.30). As an exception, the probability that fathers were sharing the cost of the household's food with the mother increased significantly from 6% at the 2-week visit to 21% at the 6-month visit (p<0.001). The frequency fathers performed household chores also remained relatively constant. For example, 24% of fathers did dishes a few times a week or more at the 2-week visit compared to 20% at the 6-month visit (p=0.24).

Mothers reported that the probability the father was making important decisions about the infant's care declined significantly from 43% at the 2-week visit to 24% at the 16-week visit (p<0.001). The probability of deciding when the infant should be taken to health clinics, and of caring for the infant when she/he was ill also reportedly declined slightly, but not significantly (p=0.28 and p=0.10, respectively). In contrast, the percentage of fathers who talked to mothers "everyday or almost everyday" about the infant increased significantly from 55% to 69% between the 2-week and 6-month visits (p=0.03; Figure 7.14 on page 128).

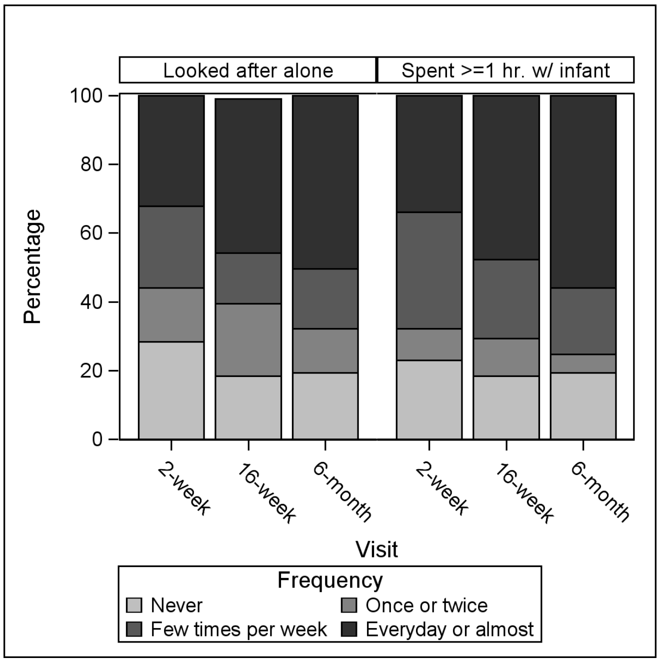


Figure 7.10: Percentage distribution of father's **Accessibility** measured by ordinal items at study visits at 2 weeks, 16 weeks and 6 months of age, maternal report (n=109); MIHS Fathering Sub-study, 2012-13.

Looked after al - How often father looked after infant while mother did other things since birth
Spent >=1 hr. w/ infant - Number of days father spends an hour or more with infant in an average week

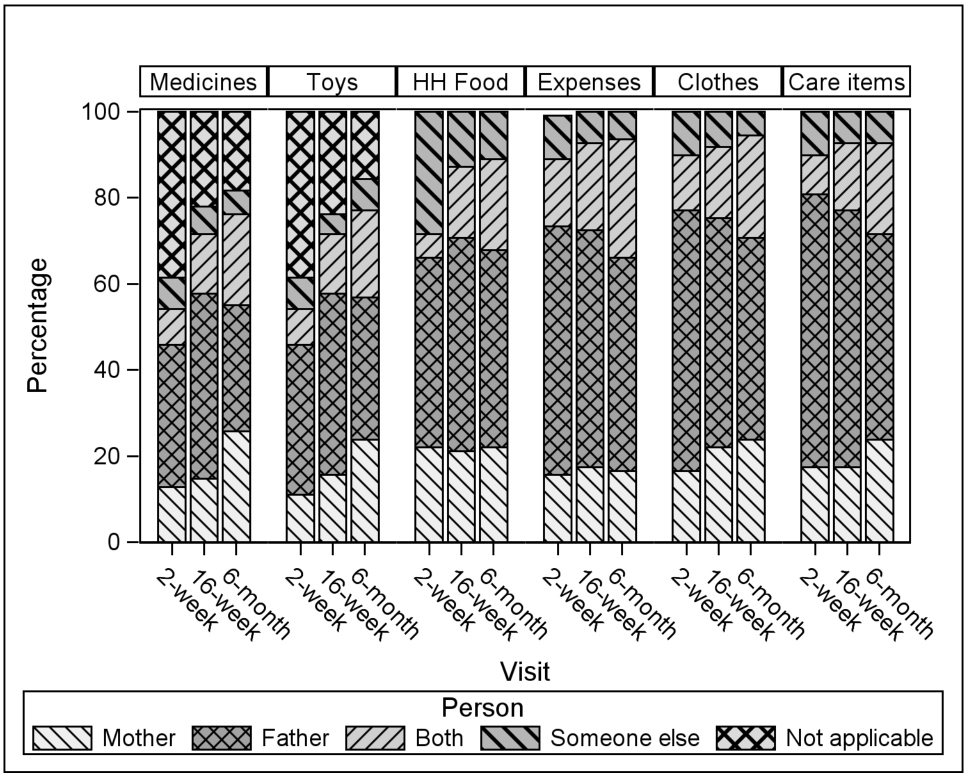


Figure 7.11: Percentage distribution of person who mainly provided for infant's material needs (**Material Provisioning**) by item at study visits at 2 weeks, 16 weeks and 6 months of age, maternal report (n=109); MIHS Fathering Sub-study, 2012-13.

Medicines - Person who mainly paid for medicines for infant since birth
Toys - Person who mainly paid for toys for infant since birth
HH Food - Person who mainly paid for food for the infant's household since birth
Expenses - How expenses for infant are shared
Clothes - Person who mainly paid for infant's clothing since birth
Care items - Person who mainly paid for child care items (like diapers or wet wipes) since birth

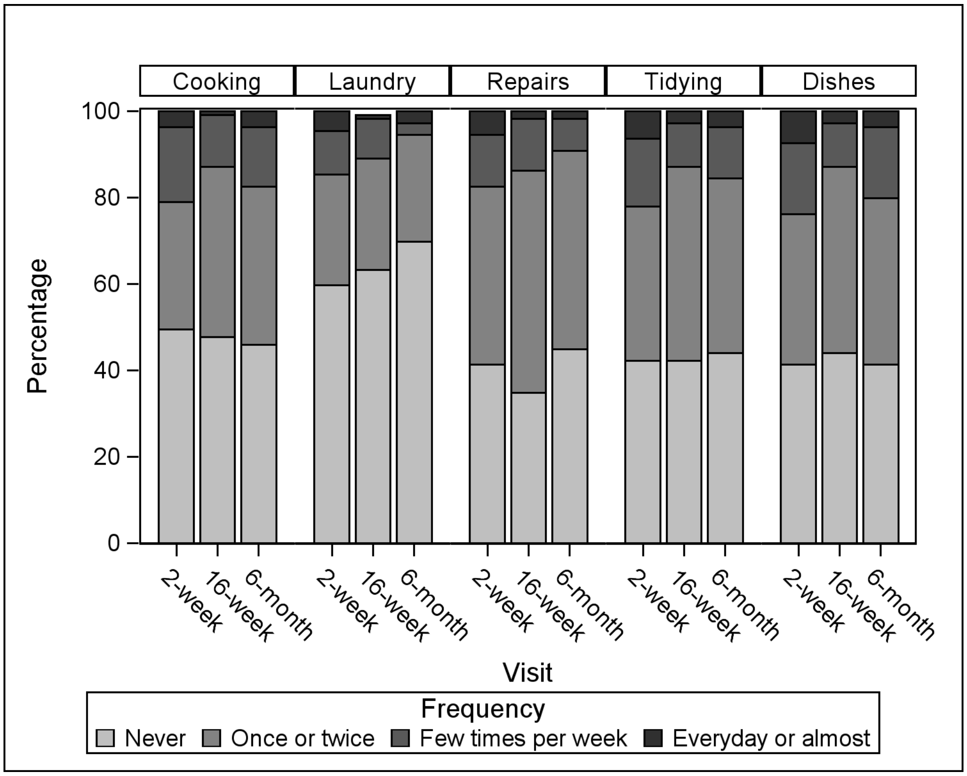


Figure 7.12: Percentage distribution of father's frequency of giving **Practical Support to Mother** by item at study visits at 2 weeks, 16 weeks and 6 months of age, maternal report (n=109); MIHS Fathering Sub-study, 2012-13.

Cooking - How often father cooked a meal for the members of infant's household since infant's birth
Laundry - How often father washed clothes for members of infant's household since infant's birth
Repairs - How often father repaired something in the house that was damaged or broken since infant's birth
Tidying - How often father cleaned or tidied the house since infant's birth
Dishes - How often father washed the dishes or cooking pots since infant's birth

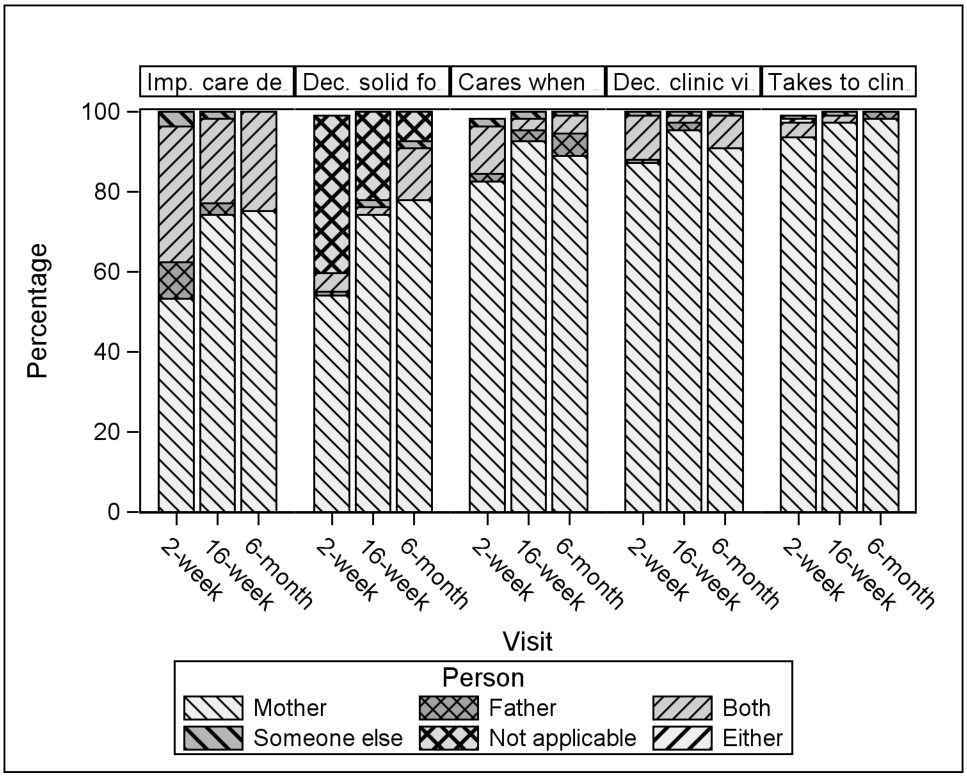


Figure 7.13: Percentage distribution of person with primary **Responsibility** for infant's care by item at study visits at 2 weeks, 16 weeks and 6 months of age, maternal report (n=109); MIHS Fathering Sub-study, 2012-13. "Both" refers to the "Father and Mother decided together" response option. "Either" refers to the "Sometimes father, sometimes mother" response option.

Imp care de - Person who makes important decisions about infant's care
Dec. solid fo - Person who decided when infant would start eating solid foods
Cares when - Person who usually cares for infant when she/he is ill
Dec. clinic vi - Person who decides when infant needs to be taken to clinic or doctor
Takes to clin - Person who usually takes infant when she/he needs to be taken to clinic or doctor

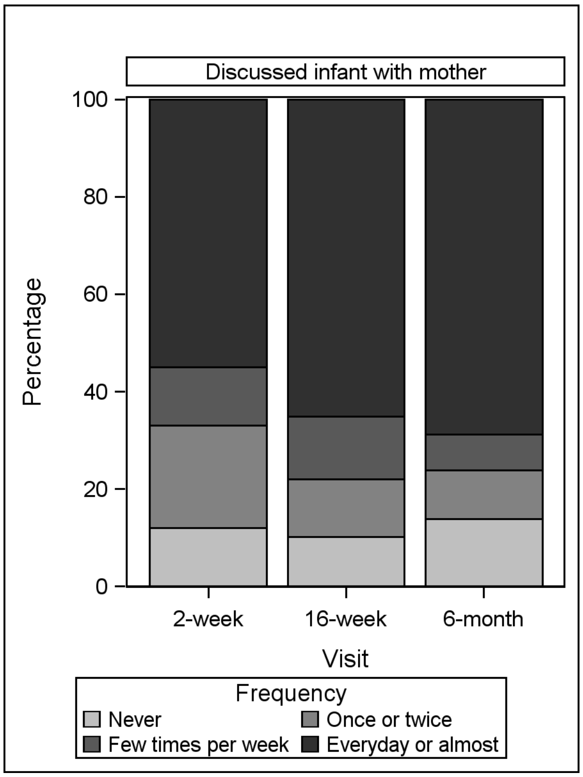


Figure 7.14: Percentage distribution of frequency father talked to mother about the infant (**Responsibility**) at study visits at 2 weeks, 16 weeks and 6 months of age, maternal report (n=109); MIHS Fathering Sub-study, 2012-13.

7.3 Measurement properties of the fathering questionnaire

This section presents results of our analyses assessing the measurement properties of the fathering questionnaire. First, we present findings from the IRT model for each mode of paternal influence. Second, we present estimates of the correlation between each mode of influence. In the final subsection, we present findings from MIMIC models comparing co-resident and non-co-resident fathers levels of contribution and assessing for differential item functioning.

7.3.1 Item Response Theory modelling

For each of five modes of father's influence (Direct Caregiving, Accessibility, Responsibility, Material Provisioning, and Practical Support for Mother) a unidimensional IRT model was found to fit the questionnaire data acceptably well with some modification. Therefore, each conceptually-related set of fathering items on the questionnaire can be considered as manifestations of a single common latent variable. We present the IRT model results for each mode of influence under a separate heading below. For each IRT model we present a table of item parameter estimates. We also present Item (or Category) Characteristic Curves for an illustrative subset of items in the model. Finally, we present a graph of the Total Information Curve and Item Information Curves for the set of items, and a histogram depicting the distribution of father's locations along that latent mode of influence as estimated for our sample.

IRT model results: Direct Caregiving

A undimensional model fit to the complete set of 10 Direct Caregiving items presented in Figure 7.2 did not have acceptable fit (chi-square test p-value: 0.000; RMSEA: 0.104; CFI: 0.993). In this model the items measuring dressing, washing, diaper changing, and taking the child for a walk had the smallest slope estimates. Excluding the three items related to child's hygiene produced a model with acceptable fit (chi-square test p-value: 0.161; RMSEA: 0.045, CFI: 0.999). Further tests of including each of the hygiene items separately and in pairs to this model, showed that only the diaper changing item produced significantly better model fit. Comparing the reduced model to the model which included the diaper item, the corrected Chi-squared difference test p-value was 0.000, indicating that the reduced model had significantly poorer fit. Below we present the findings from the model that included the diaper item. We also tested a separate IRT model for the three hygiene items but, in this model, the *Dress* item had negative residual variance. This result could be due to poor model fit or to the *Dress* and *Diaper* items being too highly correlated.

In the final model for father's direct caregiving (Table 7.6 on the following page), items measuring frequency of soothing and holding the infant were the most discriminating, with slopes equal to 7.79 (SE: 2.22) and 6.83 (SE: 1.53). These items also had the lowest threshold estimates. For example, the three thresholds for the soothed item were -4.78 (SE: 1.41), -3.30 (SE: 1.24) and 1.79 (SE: 0.92). This is consistent with the fact that most fathers had soothed and held their infants at least once or twice since birth (Figure 7.2). All of the slopes were statistically significant at the 0.05 level by the Wald Chi-square test. However, the standard errors for the *Soothed* and *Held* item slopes were relatively large, reflecting

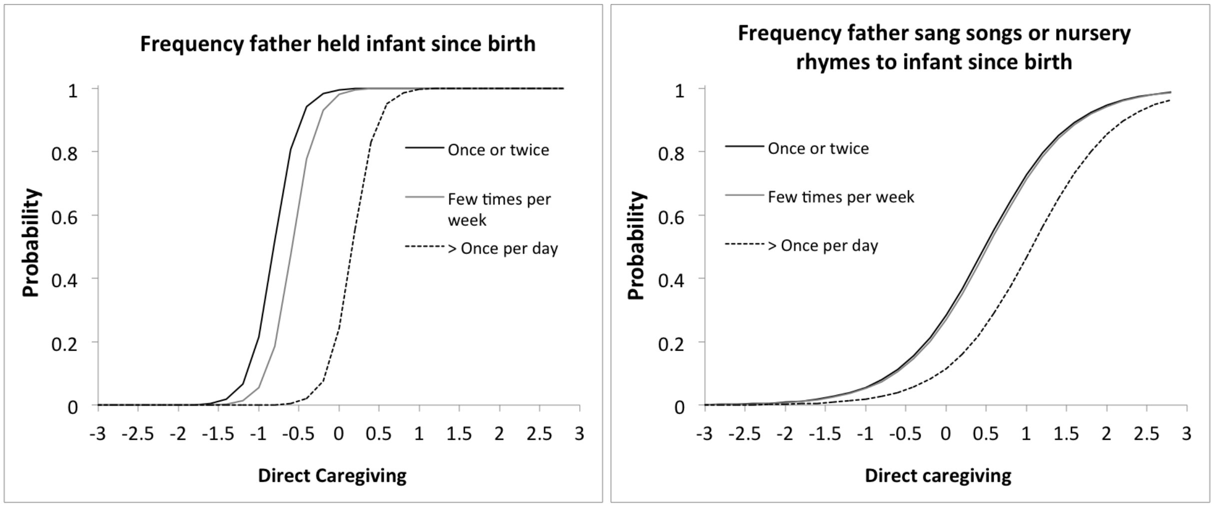
Table 7.6: Item slope and threshold estimates (standard errors) from an IRT model for father's **Direct Caregiving**, maternal report data, 2-week visit: MIHS Fathering Sub-study, 2012-13.

Item	Slope	Threshold 1	Threshold 2	Threshold 3
Soothed[1]	7.79 (2.22)	-4.78 (1.41)	-3.30 (1.24)	1.79 (0.92)
Held[2]	6.83 (1.53)	-5.54 (1.29)	-3.99 (1.03)	1.14 (0.76)
Sleep[3]	4.54 (0.77)	-2.05 (0.57)	-1.45 (0.53)	2.78 (0.60)
Talked[4]	3.71 (0.59)	-1.85 (0.48)	-1.45 (0.46)	1.31 (0.44)
Night[5]	3.31 (0.57)	-0.51 (0.38)	-0.16 (0.38)	2.06 (0.43)
Sang[6]	1.91 (0.35)	0.93 (0.27)	0.99 (0.27)	2.04 (0.29)
Walk[7]	1.31 (0.44)	2.86 (0.42)	3.20 (0.44)	5.15 (0.66)
Diaper[8]	1.24 (0.23)	0.93 (0.22)	1.40 (0.23)	3.32 (0.36)

Note: Model fit statistics: Chi-square p: 0.255; RMSEA: 0.032; CFI: 1.000
[1]Frequency father soothed infant when she/he was upset since birth
[2]Frequency father held infant since birth
[3]Frequency father put infant to sleep since birth
[4]Frequency father talked to infant since birth
[5]Frequency father got up with infant when she/he woke up at night since birth
[6]Frequency father sang songs or nursery rhymes to infant since birth
[7]Frequency father took infant for a walk since birth
[8]Frequency father changed infant's diaper since birth

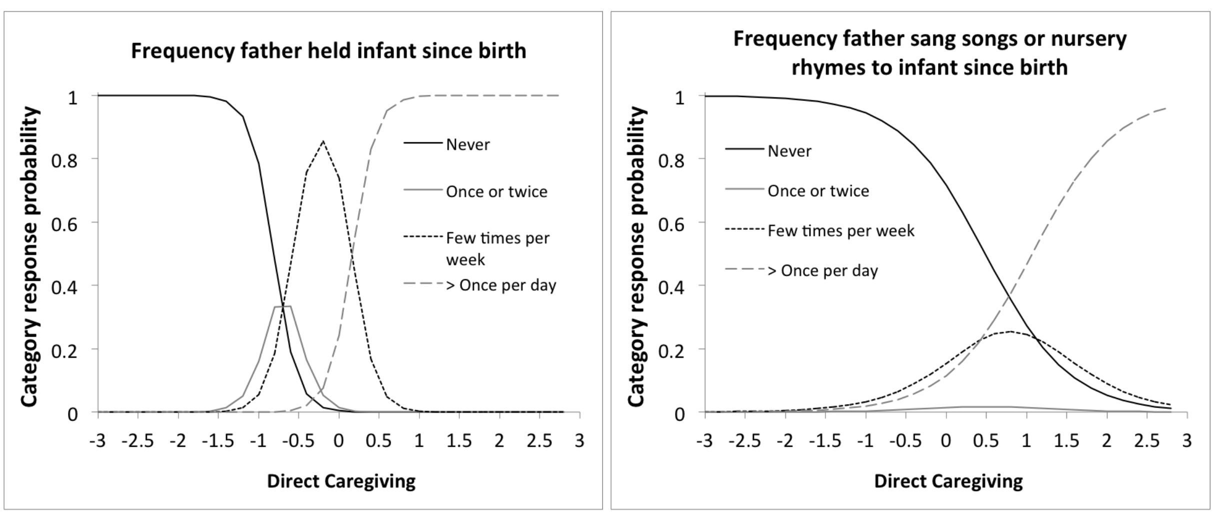
imprecision in these estimates (Table 7.6). Items measuring the frequency of diaper changing and taking the infant for a walk were the least discriminating at 1.24 (SE: 0.23) and 1.31 (SE: 0.44), respectively, while the *Walk* item also had the highest threshold values, at 2.86 (SE: 0.42), 3.20 (SE: 0.44) and 5.15 (SE: 0.66). This is consistent with very few fathers having taken their infant for walks between birth and 2 weeks.

The item parameters can also be interpreted graphically. For the *Held* and *Sang* items, figure 7.15 on page 131 depicts the probability of selecting each response option or higher as a function of the father's latent level of involvement in direct caregiving. Similar graphs are shown for the other items in Appendix B.7. The curves are steeper for the *Held* item because the discrimination is higher. The value of the latent trait where the curve crosses 50% probability corresponds to the location for that category boundary. In the figure for the *Sang* item, the displacement of the steepest parts of the probability curves to higher values of direct caregiving (relative to the corresponding values for the *Held* item) indicates that the *Sang* item had a higher location. For all items in this set, there was no point on the direct caregiving scale at which the probability of being in the "Once or twice" response category was estimated to be greater than the probability of being in any other category. We present the Category Response Curve for the *Held* item as an illustration (Figure 7.16a on page 131). This suggests that, in future uses of the direct caregiving questionnaire items, the "Once or twice" response option could be collapsed into the "Never" or "A few times per week" options. We also observed that the *Sang* item functioned more like a binary than an ordinal item, in that only "Never" and "> Once per day" were likely response options (Figure 7.16b).



(a) (b)

Figure 7.15: Category characteristic curves for items measuring the frequency the father held (a) and sang (b) to the infant since birth in the IRT model for **Direct Caregiving**. These curves show the probability of being in each response category or higher as a function of the father's latent level of involvement in direct caregiving.



(a) (b)

Figure 7.16: Category response curves for items measuring the frequency the father held (a) and sang (b) to the infant since birth in the IRT model for **Direct Caregiving**. These curves show the probability of being exactly in each response category as a function of the father's latent level of direct caregiving.

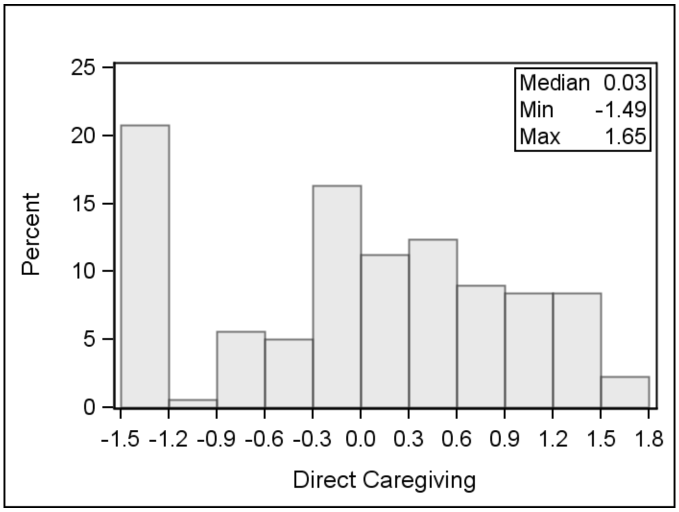


Figure 7.17: Distribution of father's location estimates on the latent **Direct Caregiving** mode of influence, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

Figure 7.17 presents the distribution of person location estimates along the latent direct caregiving variable for the fathers in our sample. The distribution appears somewhat normal around the origin, but with an additional sharp peak (comprised of around 30% of the fathers' estimates) at the lower end of the scale.

The total information curve for the direct caregiving items (figure 7.18) is bimodal with peaks at values of approximately -0.5 and 0.5 on the scale of the latent variable. Recall that the origin of the scale is set at the estimated mean level of direct caregiving in the population, and 1 unit on the scale is set equal to the population standard deviation. Therefore, the Information Curve indicates that this set of items gave most precise estimates for levels of direct caregiving within 1 standard deviation of the population mean. As such, the father's location estimates of direct caregiving between -1.5 and -1.2 in figure 7.17 were associated with large error.

Figure 7.18 also shows partial information curves for the *Held*, *Sleep*, *Night* and *Sang* items. The bimodal shape of the total information curve was due to the bimodal shape of the individual item information curves. Individual items provide most information at values close to their locations [209, p. 99]. For this set of items the first and second thresholds were located close together (figure 7.15 on the previous page), therefore they contributed information together forming the first peak in the item information curve. Information contributed by the third threshold forms the second peak in the item information curve. An item's information is proportional to its discrimination. Therefore, the *Soothed*, *Held*, *Sleep*, *Talk*, and *Night* items contributed the most to the Total Information. For example, in figure 7.18 the information curve for the *Held* item is higher than the curve for the less discriminating *Sang* item.

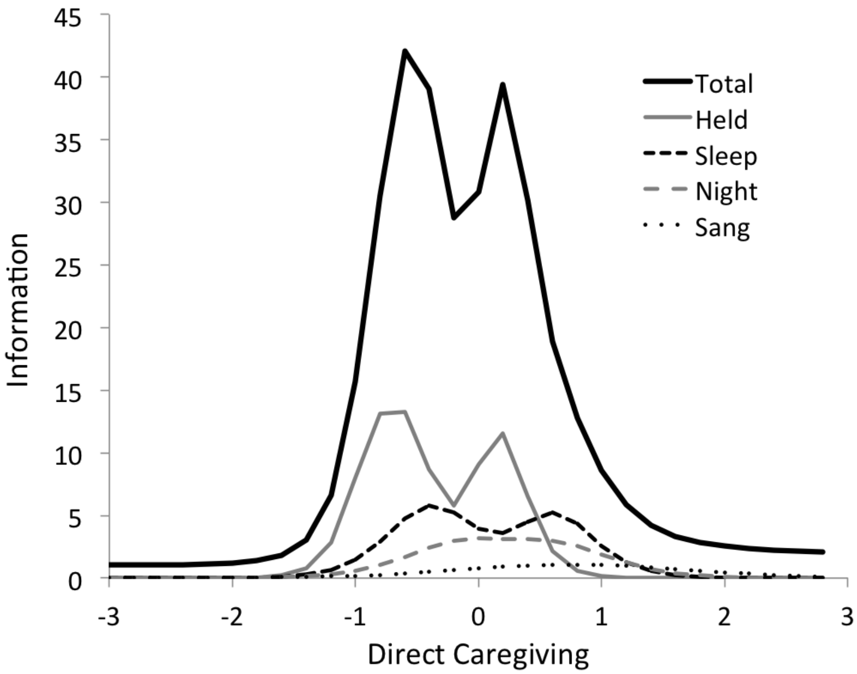


Figure 7.18: Total information curve for items measuring father's **Direct Caregiving**, including partial information curves for *Held*, *Sleep*, *Night*, and *Sang* items, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

IRT model results: Accessibility

As shown in table 7.7 on the following page, among the accessibility items, whether the father spent an hour or more with his infant on non-work-day afternoons had the highest slope at 5.54 (SE: 1.42), while the continuous variable measuring the number of nights per week the father stayed at the house where his infant lived had the lowest slope at 2.32 (SE: 0.14). All slope estimates were reasonably large and were significant by Wald chi-square test.

Item characteristic curves for the three dichotomous items (*Non-work afternoon*, *Non-work morning*, and *Non-work alone*) showed that all were located close to the mean level of accessibility (Figure 7.19 on page 135). Whereas the thresholds for both ordinal items spanned a reasonably wide range of values above and below the mean. (The category characteristic curves for the ordinal items are presented in Appendix (B.7).) Consistent with where the items were located, the total information curve for this set of items has a single peak of approximately 25 located at a point on the accessibility scale slightly below 0 (Figure 7.20). Similarly to the direct caregiving items, the accessibility items provided most precise estimates of father's location at points on the accessibility scale that are within 1 standard deviation of the estimated population mean level of accessibility

In our sample, the distribution of father's location estimates on the latent accessibility scale (Figure 7.21 on page 136) had a somewhat normal-appearing peak around the origin, a second peak at the lower end of the scale (between -1.43 and -1.35) and a third peak at the upper end of the scale (between 1.05 and 1.29). The father's location estimates making up the latter two peaks had large associated

Table 7.7: Item slope and threshold estimates (standard errors) from an IRT model for father's **Accessibility**, maternal report data, 2-week visit: MIHS Fathering Sub-study, 2012-13.

Item	Slope	Threshold 1	Threshold 2	Threshold 3
Non-work afternoon[1]	5.53 (1.42)	-1.27 (0.63)		
Non-work morning[2]	4.82 (1.23)	-0.33 (0.48)		
Looked after alone[3]	4.18 (0.67)	-2.24 (0.51)	0.18 (0.41)	2.23 (0.51)
Spent hr.[4]	3.40 (0.46)	-2.30 (0.38)	-1.19 (0.38)	1.68 (0.39)
Non-work alone[5]	2.56 (0.45)	0.21 (0.30)		
Nights per week[6]	2.32 (0.14)	4.23[†] (0.24)		

Note: Model fit statistics: Chi-square p: 0.491; RMSEA: 0.000; CFI: 1.000
[†]This estimate is an intercept rather than a threshold. Parameter estimates for continuous variables do not have an IRT interpretation.
[1]On days when he does not work, father usually spends an hour or more with infant in the afternoon
[2]On days when he does not work, father usually spends an hour or more with infant in the morning
[3]How often father looked after infant while mother did other things since birth
[4]Number of days father spends an hour or more with infant in an average week
[5]On days when he does not work, father usually spends a full hour or more alone with infant
[6]Number of nights per week father spends in the house where the infant lives

uncertainty (as can be seen, in Figure 7.20, from the low values on the total information curve in these regions of the trait).

IRT model results: Responsibility

Parameter estimates from the IRT model measuring father's latent responsibility are shown in Table 7.8 on page 137. Items with the highest discrimination were those measuring whether the father was involved in making important decisions about his infant's care (3.03, SE: 1.40) and whether he was involved in deciding when to take his infant to the clinic or doctor (2.38, SE: 0.88). Whether the father was involved in deciding his infant's name and the frequency he talked with the mother about the infant had lower discriminations, at 1.33 (SE: 0.39) and 1.03 (SE: 0.26), respectively.

The *Important decisions* and *Decided name* items were located close to the origin of the latent responsibility scale (Figure 7.22 on page 137), while the category boundary locations for the *Discussed child with mother* item were located approximately at -2, -0.5 and 0 (Figure 7.23 on page 138). In contrast, both items related to children's health care (*Decides timing clinic visits* and *Cares when ill*) were located quite high on the latent responsibility scale, at 1.6 and 1.7, respectively (Figure 7.22 on page 137).

Because the locations of the Responsibility items fell into two clusters, one around 0 and one around

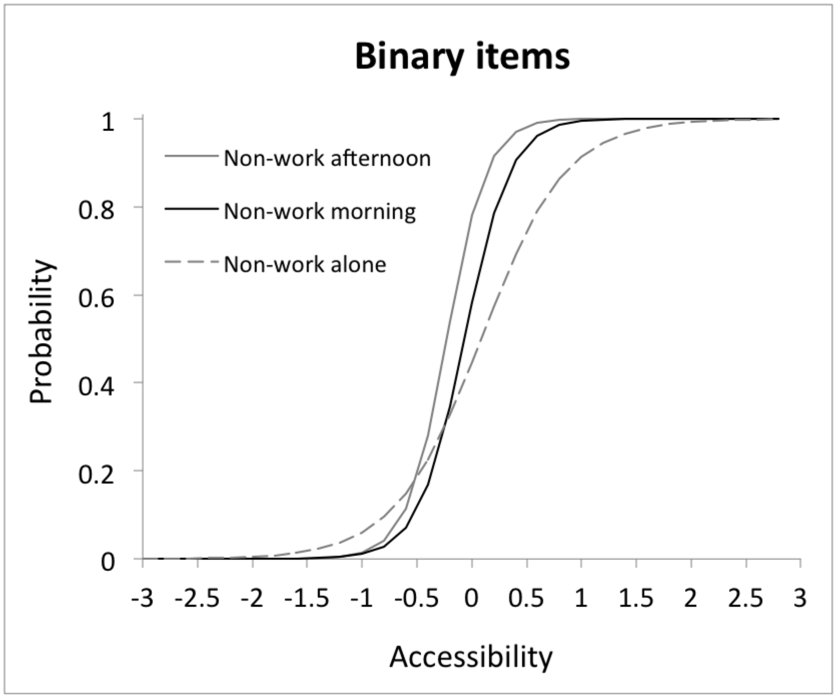


Figure 7.19: Item characteristic curves for dichotomous items in the IRT model for father's **Accessibility**. These curves show the probability of being in the "Yes" response category as a function of the father's latent level of accessibility.

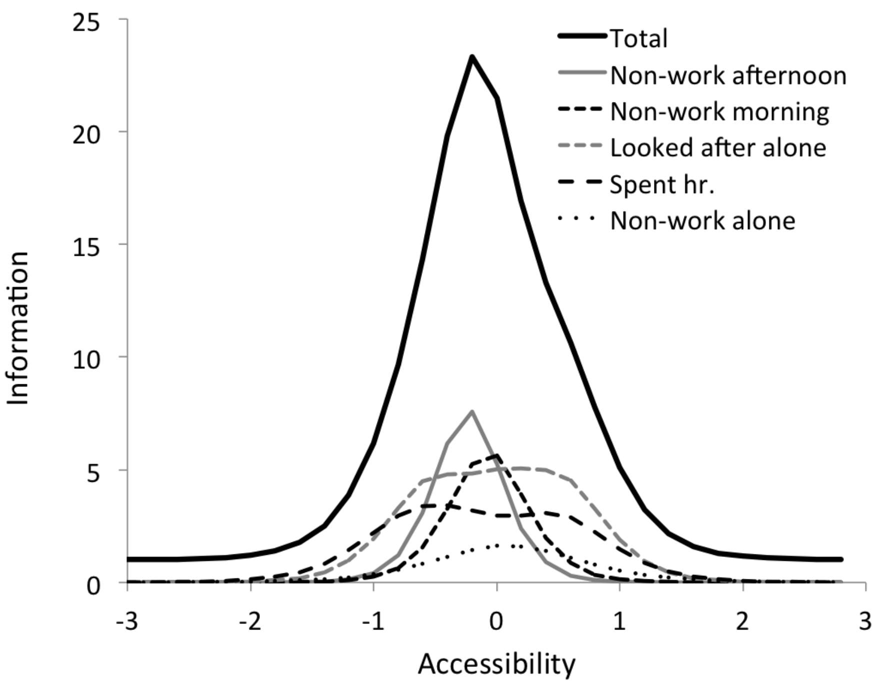


Figure 7.20: Total and partial information curves for items measuring father's **Accessibility**, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

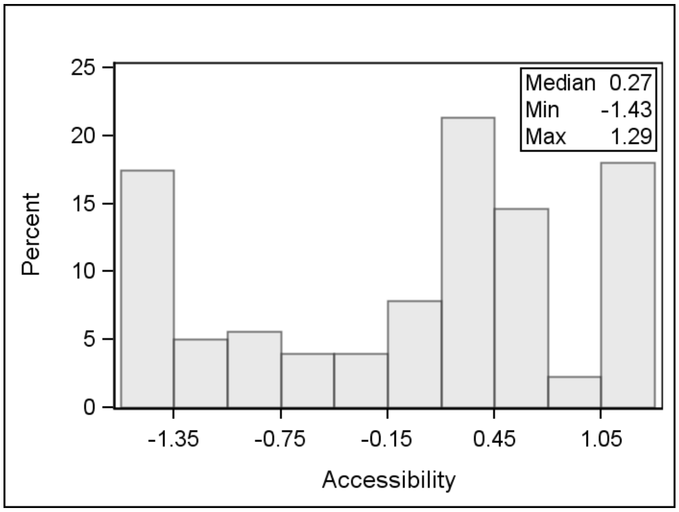


Figure 7.21: Distribution of father's location estimates on the latent **Accessibility** mode of influence, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

1.6-1.7, the total information curve was bimodal (Figure 7.24 on page 138). This set of items gave most precise estimates for levels of responsibility between 0 and 2. However, with the highest peak of the information curve reaching only 4.5, the Responsibility items gave considerably less information than the sets of items measuring the other four latent modes of influence.

Figure 7.25 on page 139 depicts the distribution of father's location estimates on the latent responsibility scale. These estimates were approximately uniformly distributed between values of -1.2 and 0. There was also a second peak with a mode at about 0.6 and a long right tail out to higher levels of the responsibility scale. Because the total information function was uniformly low for this set of items, all of the fathers in the sample had relatively imprecise location estimates on the Responsibility scale. Location estimates were particularly imprecise for those fathers whose locations were estimated to be below the average.

Table 7.8: Item slope and threshold estimates (standard errors) from an IRT model for father's **Responsibility**, maternal report data, 2-week visit: MIHS Fathering Sub-study, 2012-13.

Item	Slope	Threshold 1	Threshold 2	Threshold 3
Important care decisions[1]	3.03 (1.40)	0.99 (0.47)		
Decides timing clinic visits[2]	2.38 (0.88)	3.76 (0.93)		
Cares when ill[3]	1.71 (0.59)	2.93 (0.57)		
Decided name[4]	1.33 (0.39)	0.04 (0.20)		
Discussed infant with mother[5]	1.03 (0.26)	-2.02 (0.23)	-0.55 (0.19)	-0.01 (0.19)

Note: Model fit statistics: Chi-square p: 0.275; RMSEA: 0.039; CFI: 0.991
[1]Father/both father and mother make(s) important decisions about infant's care
[2]Father/both father and mother decide(s) when infant needs to be taken to clinic or doctor
[3]Father/both father and mother usually care(s) for infant when she/he is ill
[4] Father/both father and mother decided what infant's name would be
[5]Frequency father talked with mother about infant since birth

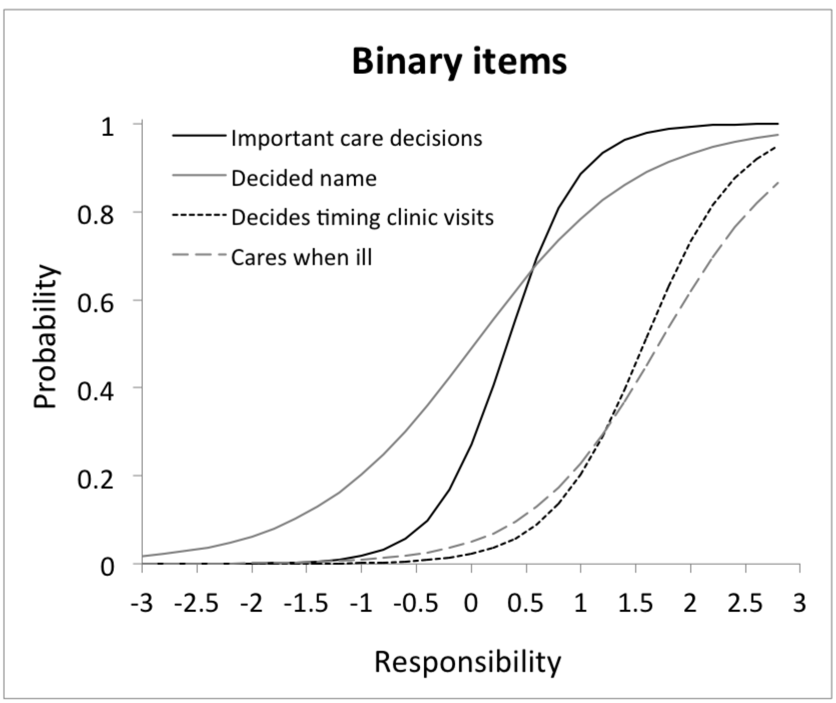


Figure 7.22: Item characteristic curves for dichotomous items in the IRT model for father's **Responsibility**. These curves show the probability of being in the "Yes" response category as a function of the father's latent level of responsibility.

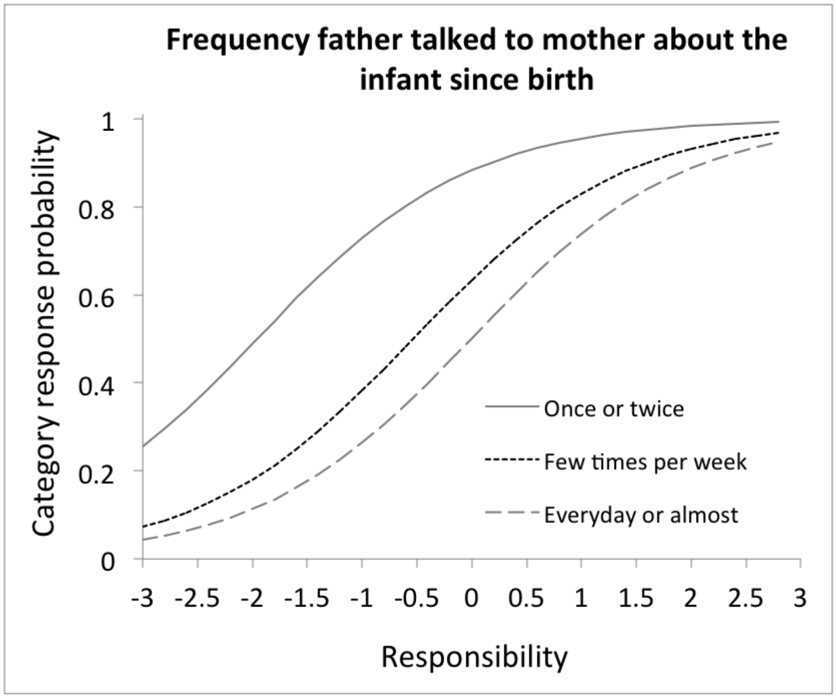


Figure 7.23: Category characteristic curves for item measuring the frequency the father talked to the mother about the infant since birth in the IRT model for father's **Responsibility**. These curves show the probability of being in each response category or higher as a function of the father's latent level of responsibility.

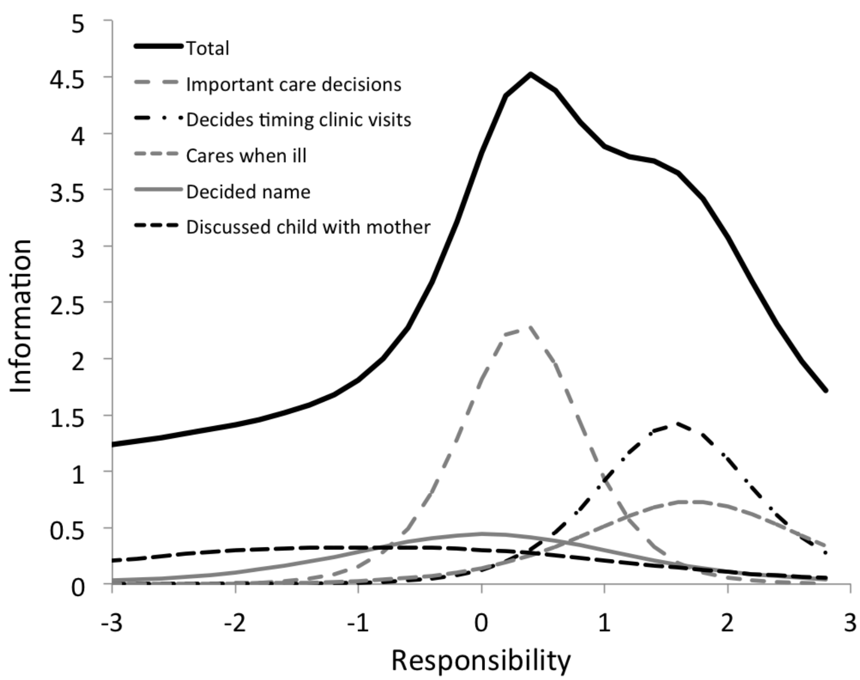


Figure 7.24: Total and partial information curves for items measuring father's **Responsibility**, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

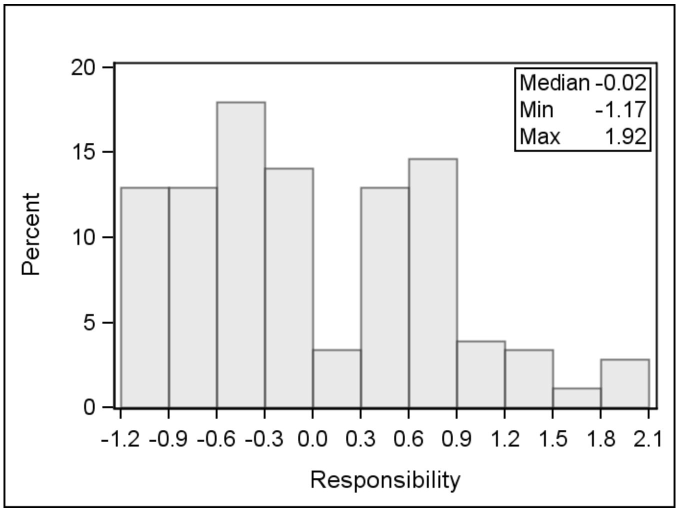


Figure 7.25: Distribution of father's location estimates on the latent **Responsibility** mode of influence, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

IRT model results: Material Provisioning

The IRT model for father's Material Provisioning included only four items. As seen in Table 7.9 on the following page, all of these items were estimated to have reasonably large slopes, but with relatively large standard errors. In fact, the slope for the most discriminating item (whether the father paid for his infant's clothing) was not statistically significant because of the imprecision of the estimate (Wald Chi-square p-value: 0.13). All other slope parameters were statistically significant at the 0.05 level. The item measuring whether the father paid for food for his infant's household had the lowest slope at 1.85 (SE: 0.50). The threshold values for all items in this set were below zero on the latent material provisioning scale. As a result, the information curve was narrow with a peak between -1 and 0 (Figure 7.27 on page 141), indicating imprecise father's location estimates in regions of the material provisioning scale above the population mean. Because there were few items in the model for material provisioning, father's location estimates were clumped at a small number of discrete values (Figure 7.28 on page 141). Almost half of the location estimates clumped together at the upper end of the scale, with another large peak, comprised of 25% of the fathers' estimates, at the lower end of the scale. Visualizing the Total Information Curve (Figure 7.27) aligned with the histogram of person location estimates (Figure 7.28), it is clear that locations on the material provisioning scale were precisely estimated for only a minority of fathers in our sample.

Table 7.9: Item slope and threshold estimates (standard errors) from an IRT model for father's **Material Provisioning**, maternal report data, 2-week visit: MIHS Fathering Sub-study, 2012-13.

Item	Slope	Threshold
Clothes[1]	11.95 (7.84)	-6.58 (4.09)
Expenses[2]	9.77 (4.61)	-5.81 (2.58)
Care items[3]	6.77 (2.12)	-3.33 (1.12)
Household Food[4]	1.85 (0.50)	-0.14 (0.25)

Note: Model fit statistics: Chi-square p: 0.870; RMSEA: 0.000; CFI: 1.000

[1]Mainly father/father and mother equally paid for infant's clothing since birth

[2]Mainly father/father and mother equally pay(s) for the infant's expenses

[3]Mainly father/father and mother equally paid for child care items (like diapers or wet wipes) since birth

[4]Mainly father/father and mother equally paid for food for the infant's household since birth

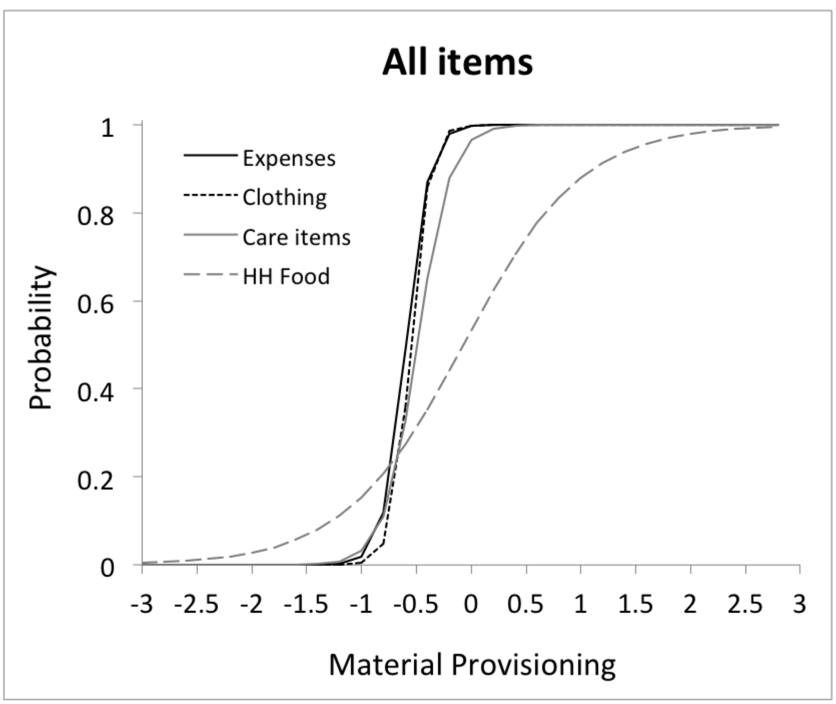


Figure 7.26: Item characteristic curves for items in the IRT model for father's **Material Provisioning**. These curves show the probability of being in the "Yes" response category as a function of the father's latent level of material provisioning.

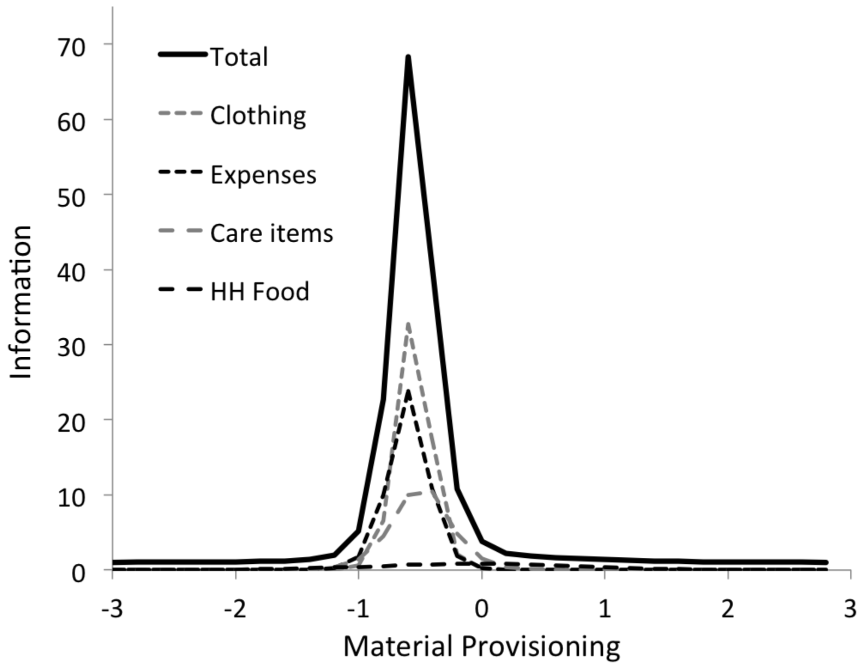


Figure 7.27: Total and partial information curves for items measuring father's **Material Provisioning**, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

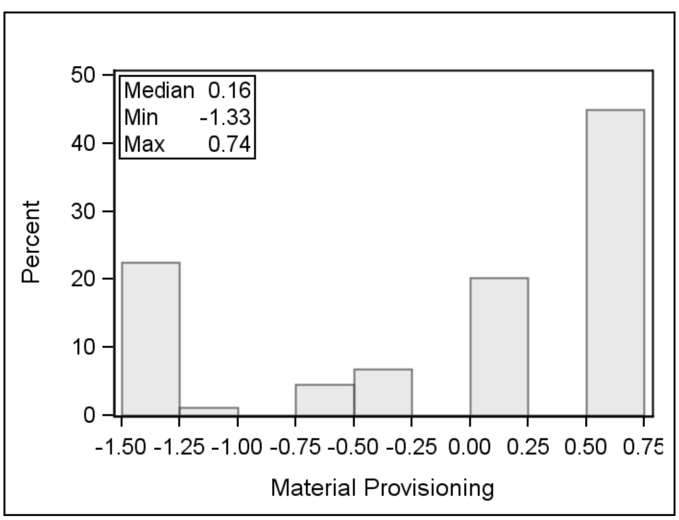


Figure 7.28: Distribution of fathers' location estimates on the latent **Material Provisioning** mode of influence, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

Table 7.10: Item slope and threshold estimates (standard errors) from an IRT model for father's **Practical Support for Mother**, maternal report data, 2-week visit: MIHS Fathering Sub-study, 2012-13.

Item	Slope	Threshold 1	Threshold 2	Threshold 3
Tidying[1]	6.23 (1.78)	-0.32 (0.61)	4.59 (1.19)	10.61 (2.63)
Dishes[2]	4.28 (0.81)	-0.62 (0.44)	3.44 (0.66)	7.15 (1.24)
Cooking[3]	3.45 (0.63)	-0.11 (0.35)	2.86 (0.56)	6.92 (1.13)
Laundry[4]	2.34 (0.42)	0.82 (0.27)	2.92 (0.38)	5.11 (0.66)
Repairs[5]	2.27 (0.40)	-0.49 (0.27)	2.71 (0.40)	4.25 (0.54)

Note: Model fit statistics: Chi-square p: 0.519; RMSEA: 0.000; CFI: 1.000
[1]How often father cleaned or tidied the house since infant's birth
[2]How often father washed the dishes or cooking pots since infant's birth
[3]How often father cooked a meal for the members of infant's household since infant's birth
[4]How often father washed clothes for members of infant's household since infant's birth
[5]How often father repaired something in the house that was damaged or broken since infant's birth

IRT model results: Practical Support For Mother

Father's practical support for mother was measured by five ordinal items reflecting the frequency the father tidied, washed dishes, cooked, did laundry and made repairs for the infant's household. All items in the set had reasonably high and statistically significant discrimination estimates (Table 7.10). The *Tidying* item was most discriminating, at 6.23 (SE: 1.78) and the *Laundry* and *Repairs* items were least discriminating at 2.34 (SE: 0.42) and 2.27 (SE: 0.40), respectively. The response category thresholds for all items were well separated. The category characteristic curve for the *Dishes* item (Figure 7.29 on the following page) illustrates this wide, even separation between the category boundary probabilities. The curves for the other items showed a similar pattern (shown in Figures B.11-B.14, Appendix B.7). Based on these curves, the distance between highest and lowest category boundary location for each item ranged from 1.75 to 2.09. With the exception of the *Laundry* item, the lower threshold of these items fell just below zero on the latent practical support for mother scale, and the two upper thresholds fell above zero. Correspondingly, the information curve has three peaks, one just below zero and two above zero (Figure 7.30 on the next page). The items were found to provide imprecise estimates of father's locations below -1 on the practical support for mother scale, but precise estimates between about -0.5 and 2.5. The father's location estimates for our sample had a bimodal distribution with a somewhat normal-appearing peak between -0.8 and 2.0 and a second narrow peak between -1.2 and -0.8. Estimates in the latter peak, which account for approximately a third of the fathers in the sample, were imprecise. Whereas, person location estimates for the remaining two thirds of the fathers were in the region of the practical support for mother scale where our items had high total information.

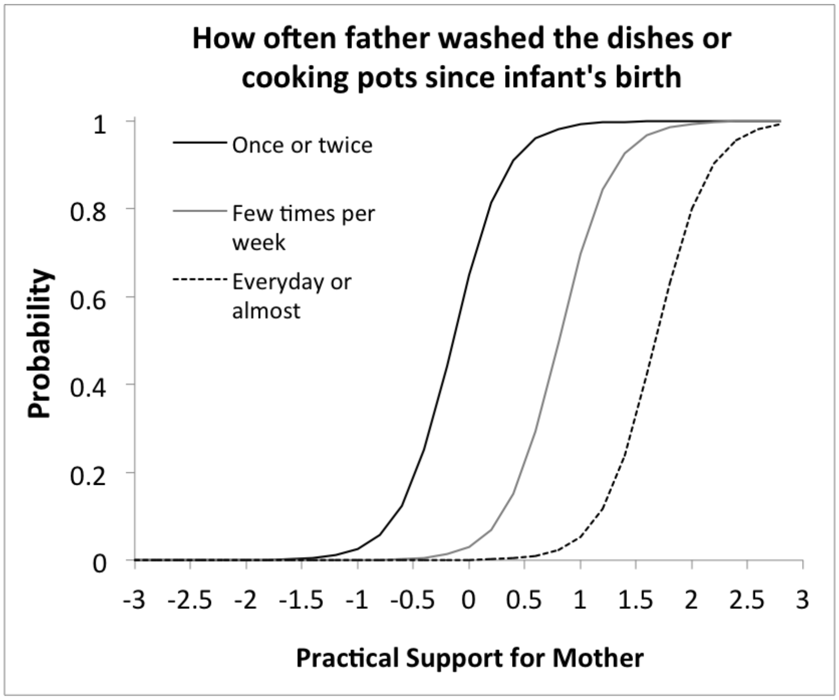


Figure 7.29: Category characteristic curves for item measuring how often the father the washed dishes or cooking pots since the infant's birth in the IRT model for father's **Practical Support for Mother**. These curves show the probability of being in each response category or higher as a function of the father's latent level of practical support for mother.

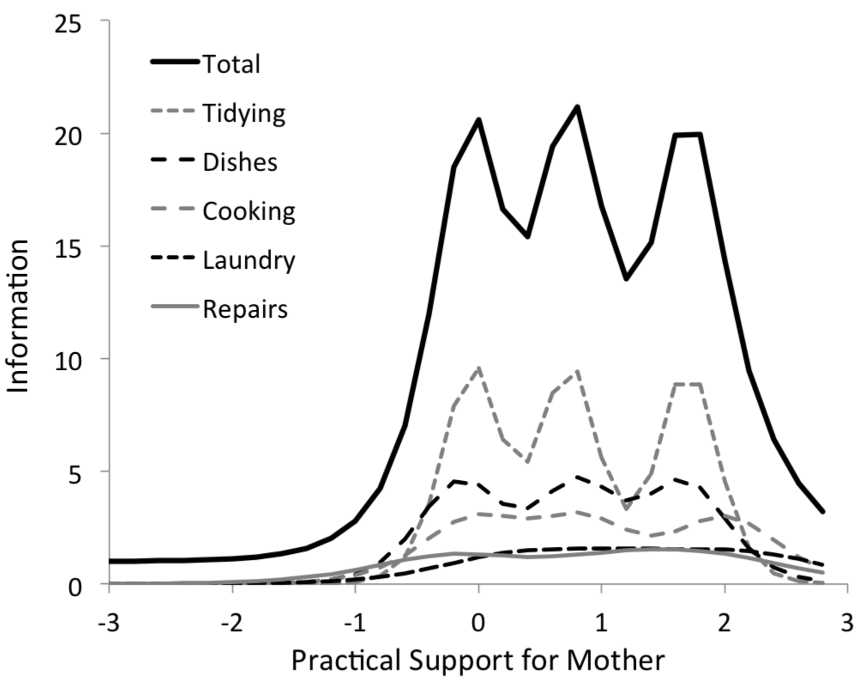


Figure 7.30: Total and partial information curves for items measuring father's **Practical Support for Mother**, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

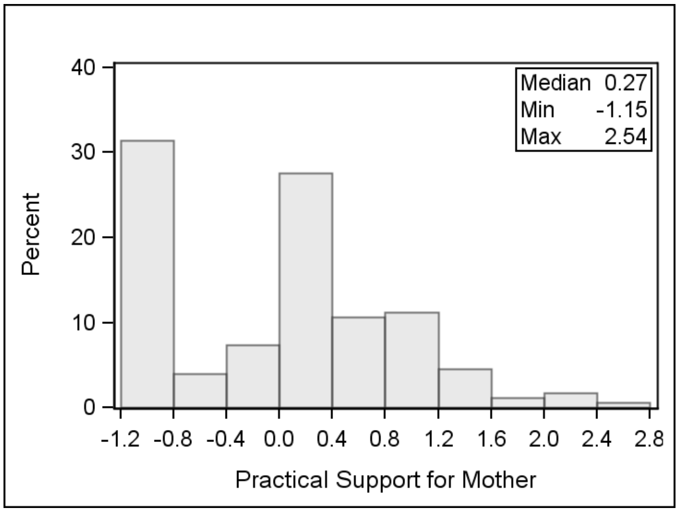


Figure 7.31: Distribution of father's location estimates on the latent **Practical Support for Mother** mode of influence, maternal report data, 2-week visit; MIHS Fathering Sub-study, 2012-13.

7.3.2 Inter-mode correlations

Our first attempt to fit a single structural equation model to the five IRT models described above resulted in a solution having small negative residual variance estimates for the variables measuring whether the father pays for the household's food (*HH food*) and whether he spends an hour or more with his child on non-work-day afternoons (*Non-work afternoon*). This problem can result from high correlation between items in the model, and may have been exacerbated by our small sample size.

Modification indices suggested that model fit could be improved by freeing the slope of the *HH food* item on the latent Practical Support for Mother variable. Because we felt it was theoretically justifiable for "paying for household food" to be a measure of father's practical support for mother, we next fit a model in which we allowed this slope to be freely estimated. We also removed the *Non-work afternoon* item from the model. Because this item had high correlation with the *Non-work morning* item, we felt that removing it would not result in much loss of information in the model of father's Accessibility. This refined model had acceptable fit by RMSEA (0.043), CFI (0.993), and TLI (0.992), but not by chi-square test (p-value: 0.0001).

Previous research has shown that chi-square tends to overreject adequately fitting models with categorical observed variables when sample sizes are small, but that the other fit indices can still be used to identify reasonably fitting models under these conditions [200]. Based on this evidence, we accepted the refined structural equation model for the purpose of estimating correlations between the five latent modes of paternal influence.

The correlations (and associated standard errors) are presented in table 7.11 on the following page. They reflect the strength of the correlation between the estimated distribution of each pair of latent modes of influence in the population. Each mode of influence was found to be at least modestly highly correlated with all of the others. Direct Caregiving and Accessibility were most highly correlated at 0.92 (SE: 0.02). Material Provisioning was the least correlated with the other latent modes of influence,

Table 7.11: Correlations (standard errors) among latent modes of paternal influence, maternal report data, 2-week visit (n=178); MIHS Fathering Sub-study, 2012-13.

Mode of influence	1	2	3	4	5
1. Direct caregiving	–				
2. Accessibility	.92 (0.02)	–			
3. Responsibility	.79 (0.06)	.79 (0.06)	–		
4. Practical Support	.79 (0.04)	.77 (0.04)	.74 (0.05)	–	
5. Provisioning	.60 (0.07)	.63 (0.07)	.68 (0.08)	.60 (0.06)	–

with values ranging from 0.60 to 0.68.

7.3.3 Effect of co-residence status on father's level of each mode of influence and results of tests for differential item functioning

In this section, we present results of analyses intended to estimate the average difference between the level of each mode of paternal influence for fathers who were living with their infants at 2 weeks compared to fathers who were not. As with the preceding analyses in this section, these estimates were based on mothers' reports.

Cross tabulations and Pearson's chi-square tests demonstrated that residing with the infant was associated with reportedly doing Direct Caregiving and Practical Support for Mother items significantly more frequently. It was also associated with significantly increased likelihood of spending time with the infant, of providing for the infant's material needs, and of having responsibility for the infant's care needs. These results are depicted graphically in figures 7.32 to 7.37 (pages 146 to 152).

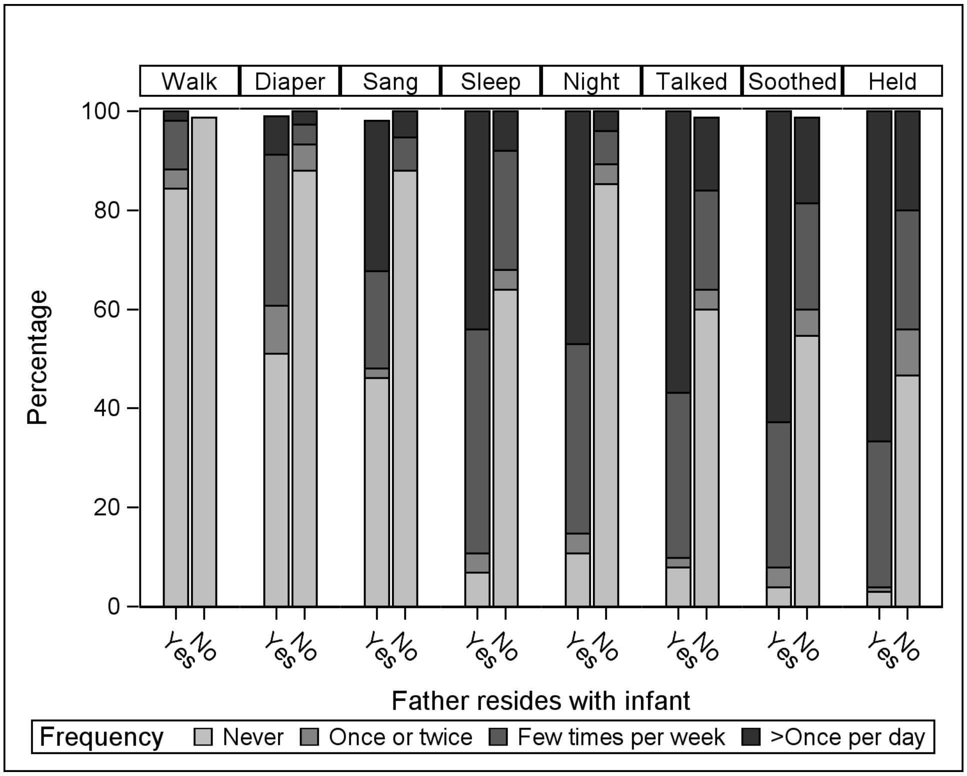
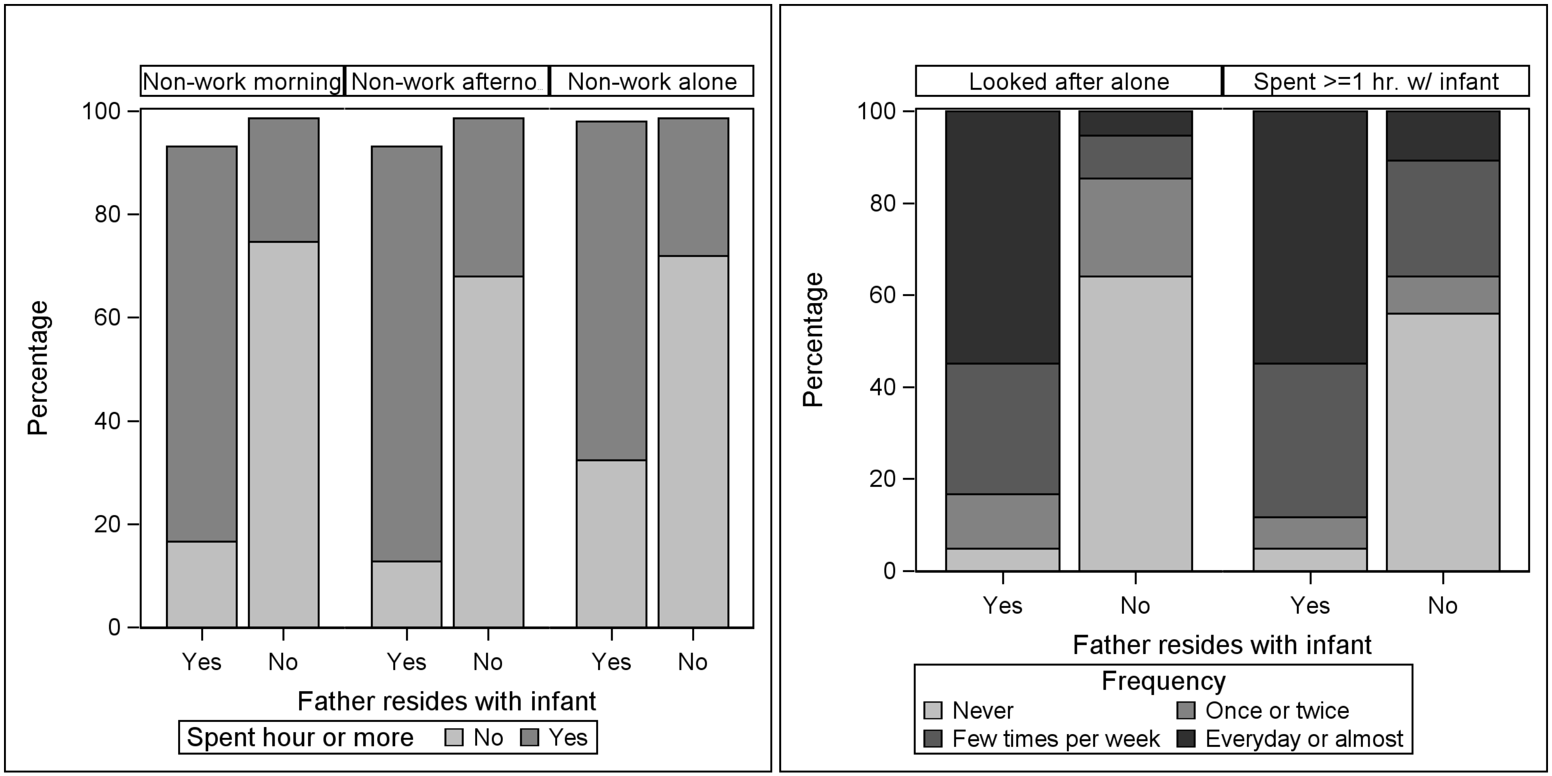


Figure 7.32: Percentage distribution of father's frequency of involvement in **Direct Caregiving** by item and whether he was living with his infant, maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Walk - Frequency father took infant for a walk since birth
Diaper - Frequency father changed infant's diaper since birth
Sang - Frequency father sang songs or nursery rhymes to infant since birth
Night - Frequency father got up with infant when she/he woke up at night since birth
Sleep - Frequency father put infant to sleep since birth
Talked - Frequency father talked to infant since birth
Soothed - Frequency father soothed infant when she/he was upset since birth
Held - Frequency father held infant since birth



(a) (b)

Figure 7.33: Percentage distribution of father's **Accessibility** by item and whether he was living with his infant for binary items (a) and ordinal items (b), maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Non-work morning - On days when he does not work, father usually spends an hour or more with infant in the morning
Non-work afterno - On days when he does not work, father usually spends an hour or more with infant in the afternoon
Non-work alone - On days when he does not work, father usually spends a full hour or more alone with infant
Looked after alone - How often father looked after infant while mother did other things since birth
Spent >=1 hr. w/ infant - Number of days father spends an hour or more with infant in an average week

The reported frequency of performing each direct caregiving item was higher for co-resident compared to non-co-resident fathers. However, within each group of fathers defined by their co-residence status, the relative frequency between each pair of items was similar. In other words, for both groups of fathers, holding, soothing, and talking to the child were more frequent care activities than diaper changing and singing (Figure 7.32). The item measuring the frequency the father got up with the infant during the night is the exception. The frequency of doing this item was particularly low among non-co-resident fathers. Presumably, many of these fathers were not able to perform this item because they did not usually spend nights at the same house as their infant.

A smaller percentage of non-co-resident than co-resident fathers were reported to have been paying for their infant's material needs at 2-weeks (Figure 7.36). Despite this, approximately 50% of non-co-resident fathers were reported to be the person who mainly paid for their infant's expenses, including care items and clothing. The item measuring who mainly paid for food for the infant's household was distinct in this set. Dramatically fewer non-co-resident fathers were paying for this item compared to the other items. In about half of the cases where the father was non-co-resident, one of the mother's relatives was paying for the household's food.

Among non-co-resident fathers, 21.3% (n=16) were no longer seeing the mother at 2 weeks. Excluding fathers who were no longer seeing the mother did not qualitatively change the results of the stratified frequency distributions (B.15 to B.20, Appendix B.8 on page 287). However, the magnitude of differences between co-resident and non-co-resident fathers' reported contributions were modestly attenuated across all modes of influence. The largest attenuation was in the Material Provisioning items. For example, comparing Figure 7.36 on page 151 to Figure B.19 on page 294, the percentage of non-co-resident fathers who were paying for the infant's clothing increased from 54.7% to 68.4% after excluding fathers who were no longer seeing the mother (versus 85.3% of co-resident fathers). Similarly, the percentage who were paying for child care items increased from 52.0% to 64.9% (versus 82.4% of co-resident fathers). Nevertheless, even after excluding fathers who were no longer seeing the mother, co-resident fathers were still significantly more likely to be paying for infants' material needs than non-co-resident fathers. These findings suggest that no longer being in a relationship with the mother contributes to, but does not completely account for, the tendency for non-co-resident fathers to be less involved in their infants' care than co-resident fathers.

We fit a MIMIC model for each latent mode of paternal influence, which included a regression of the latent mode of influence on a binary variable indicating whether the father and infant were living together at the 2-week visit. In addition, for the MIMIC model for Direct Caregiving we also regressed the *Night* item on the co-residence status covariate. Similarly, in the MIMIC model for Material Provisioning, we regressed the *HH food* item on the co-residence status variable. We present the effect estimates from these regressions in Table 7.12 on page 150.

Living together was associated with a statistically significant increase in father's location estimates on all latent modes of influence. The largest effects of living with the infant were on father's locations on the Accessibility and Practical Support for Mother scales: on average, fathers who were living with their infants were located 2.49 units (95% CI: 1.54 - 3.44) higher on the Accessibility scale and 2.45

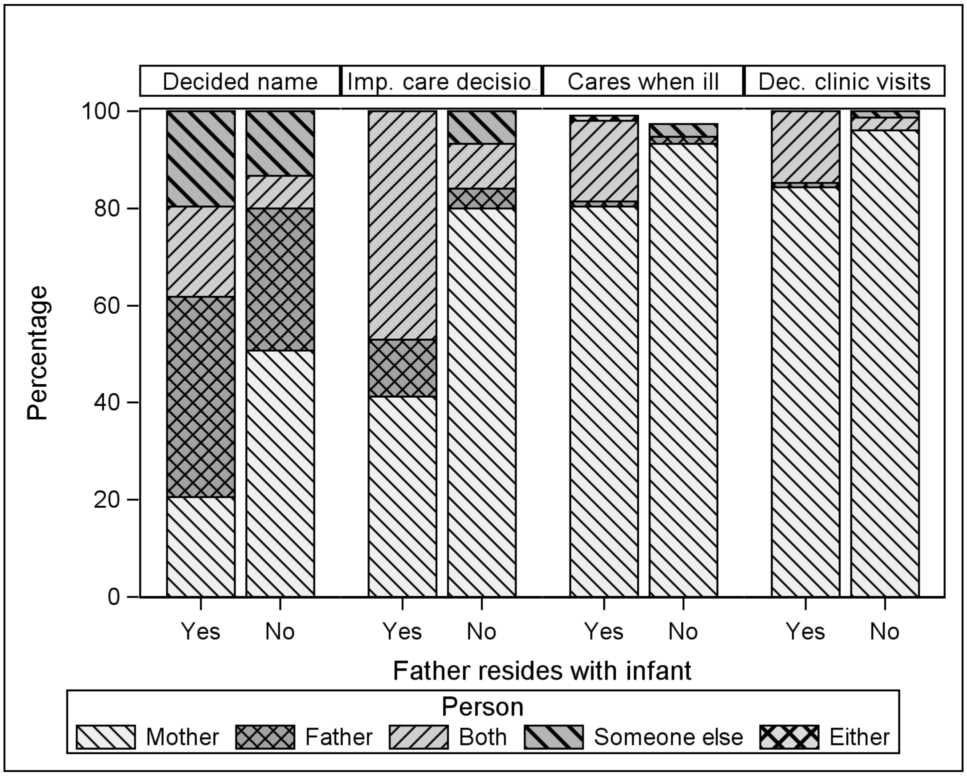


Figure 7.34: Percentage distribution of person with primary **Responsibility** for infant's care by item and whether father and infant were living together, maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Decided name - Person who decided what infant's name would be
Imp. care decisio - Person who makes important decisions about infant's care
Cares when ill - Person who usually cares for infant when she/he is ill
Dec. clinic visits - Person who decides when infant needs to be taken to clinic or doctor

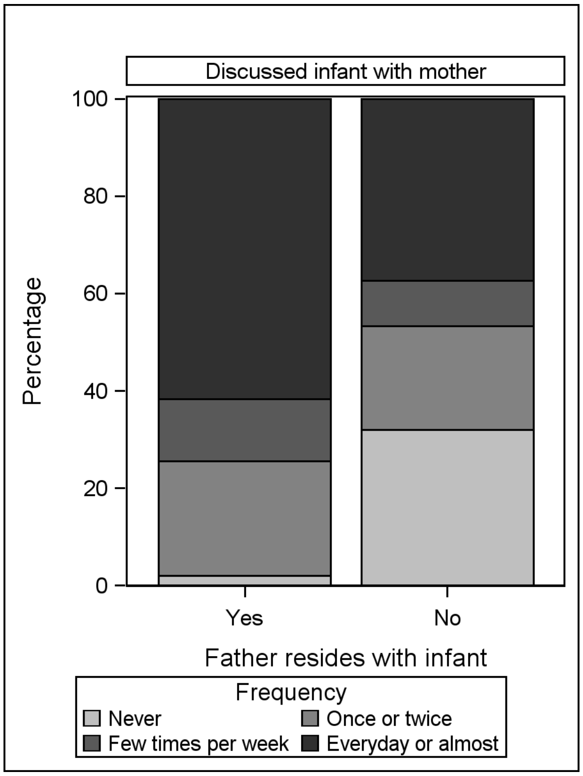


Figure 7.35: Percentage distribution of frequency father talked with mother about the infant stratified by whether he was living with the infant, maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Discussed infant with mother - Frequency father talked with mother about infant since birth

Table 7.12: Regression coefficients (95% confidence intervals) from MIMIC models with father's co-residence status as the independent variable, including tests of differential item functioning (DIF) for two items, maternal report at 2-week study visit: MIHS Fathering Sub-study, 2012-13.

Dependent variable	Coefficient (95% CI)
Accessibility	2.49 (1.54 - 3.44)
Practical Support	2.45 (1.95 - 2.95)
Direct caregiving	1.70 (1.30 - 2.11)
Responsibility	1.62 (1.15 - 2.08)
Material Provisioning	0.94 (0.55 - 1.33)
DIF Tests	
Night item[1]	2.47 (1.38 - 3.55)[§]
HH food item[2]	4.40 (2.89 - 5.91)[§]

Note: [§]Estimates are on the log-odds scale.
[1]Frequency father got up with infant when she/he woke up at night since birth
[2]Mainly father/father and mother equally paid for food for the infant's household since birth

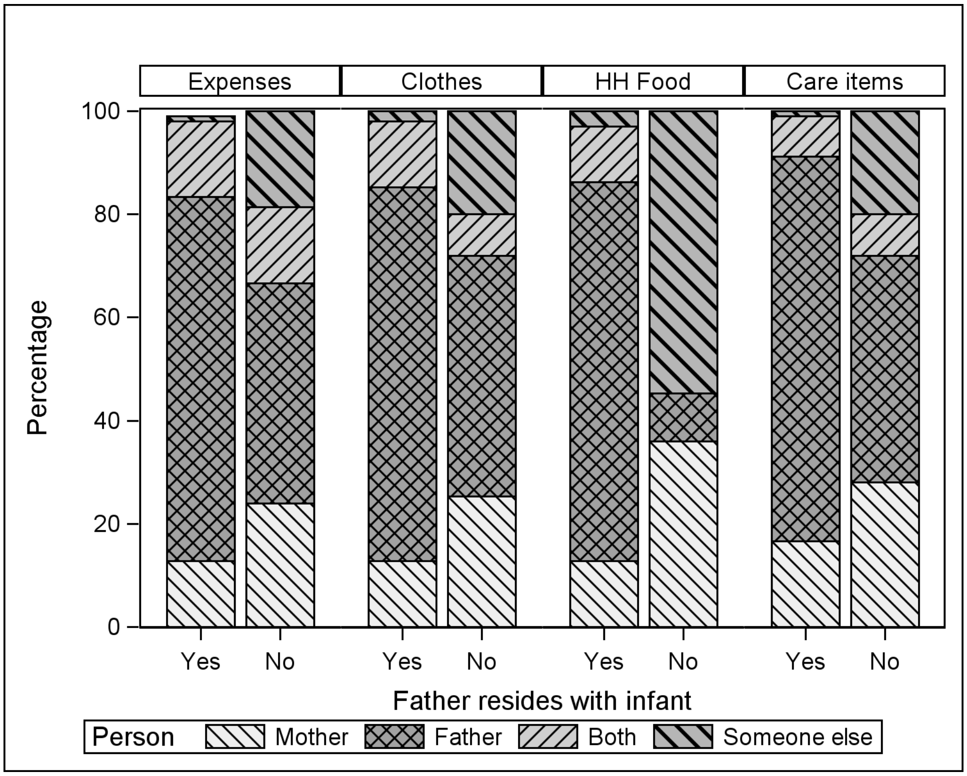


Figure 7.36: Percentage distribution of person who provides for the infant's material needs (**Material Provisioning**) by item and whether father and infant were living together, maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

HH Food - Person who mainly paid for food for the infant's household since birth
Expenses - How expenses for infant are shared
Care items - Person who mainly paid for child care items (like diapers or wet wipes) since birth
Clothes - Person who mainly paid for infant's clothing since birth

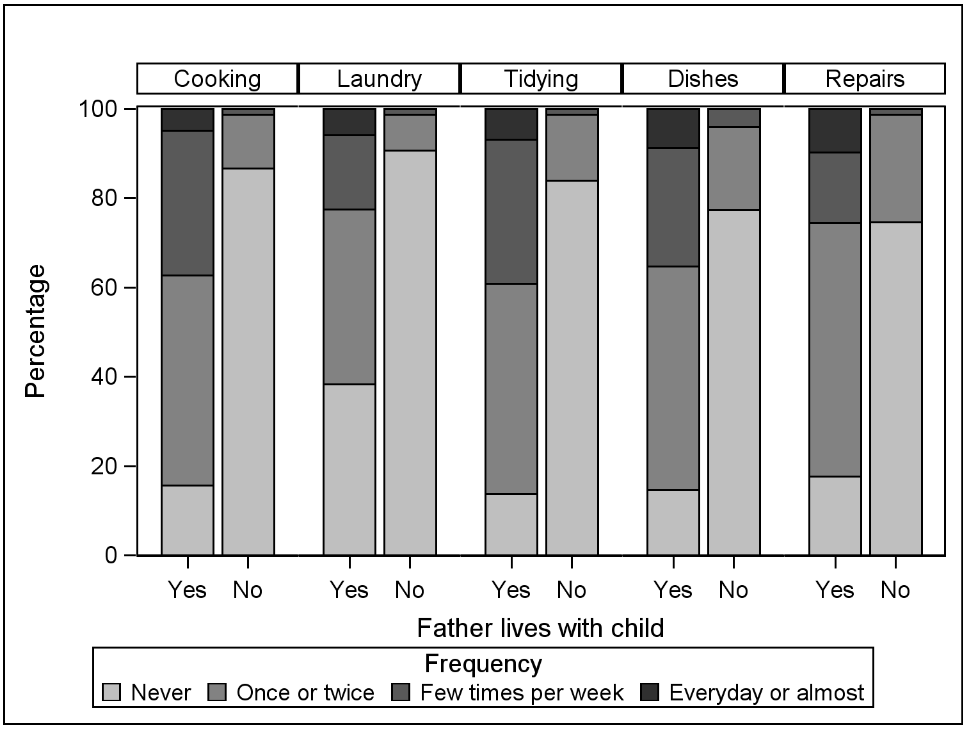


Figure 7.37: Percentage distribution of father's frequency of giving **Practical Support to Mother** by item and whether he was living with his infant, maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Laundry - How often father washed clothes for members of infant's household since infant's birth
Cooking - How often father cooked a meal for the members of infant's household since infant's birth
Tidying - How often father cleaned or tidied the house since infant's birth
Repairs - How often father repaired something in the house that was damaged or broken since infant's birth
Dishes - How often father washed the dishes or cooking pots since infant's birth

units (95% CI: 1.95 - 2.95) higher on the Practical Support for Mother scale than fathers who were not living with their infants. Whereas, the smallest effect of living together was on father's location on the Material Provision scale, estimated at a 0.92-unit (95% CI: 0.55 - 1.33) increase. The latent scales were fixed such that 1 unit was equal to 1 standard deviation in the estimated distribution of father's locations in the population. Therefore, the average co-resident father was estimated to be 2.49 standard deviations above the average non-co-resident father on the Accessibility scale, and 0.94 standard deviations above on the Material Provisioning scale.

For each response category of the *Night* item, living together was associated with 11.79 (95% CI: 3.99-34.84) times the odds of being reported to be in the next highest category or higher versus the present category or lower. Living together was also associated with 81.45 (95% CI: 2.16-369.86) times the odds of being reported to be paying for the household's food. These odds ratios estimate the **direct effect** of co-residence on mothers' responses to the *Night* and *HH food* items. That is, the effect after controlling for the observed tendency for co-resident fathers to have higher locations on the Direct Caregiving and Material Provisioning scales, which has an **indirect effect** on the responses of all items measuring these two modes of influence. Although the direct effect estimates had low precision, the lower limits of the 95% CIs indicate that the effects are likely large and in the positive direction. This is evidence that these items function differently for co-resident and non-co-resident fathers.

7.4 Agreement between father's and mother's reports of father's parenting

To determine the reliability of mothers as proxy respondents for fathers, this section presents results of our analyses of agreement between paired fathers' and mothers' fathering questionnaire responses at the 2-week study visit. We present a separate results table for each of the five modes of paternal influence (Tables 7.13 to 7.17). We also present separate tables for father's sociodemographic and relationship characteristics (Table 7.19), father's health characteristics (Table 7.20), and mothers' and fathers' beliefs on fatherhood (Table 7.21). Each table includes estimates of Overall Agreement (OA) and Specific Agreement (SA), p-values from tests of marginal homogeneity, and the mean and standard deviation of mothers' and fathers' responses for each item. For ordinal items we also present p-values from tests of overall bias and identify any response thresholds that were significantly different for fathers' and mothers' (i.e.: thresholds that had equality test p-values <0.05).

In the subsections that follow, we first present estimates of overall and specific agreement for the fathering items. We then present results of analyses intended to determine whether lack of agreement between mothers' and fathers' item responses resulted from disagreement over the definition of the underlying variables being measured or disagreement over the definition of the available response categories. In the final two subsections we present results showing agreement between mothers' and fathers' reports of father's sociodemographic and health characteristics, and the extent of consensus between their beliefs on fatherhood.

Table 7.13: Estimated proportion of overall agreement (OA), proportions of specific agreement, Bhapkar and Bias test p-values, thresholds with equality test p-values <0.05 and mean score (standard deviation) based on father (F) and mother (M) responses, **Direct Caregiving** items (plus four-category **Accessibility** and **Responsibility** items, where indicated): MIHS Fathering Sub-study, 2013-14

		Specific Agreement†							Mean (SD)	
Item	OA (95% CI)	1	2	3	4	Bhapkar	Bias	Thresholds	F	M
Direct Caregiving										
Soothed[1]	0.73 (0.62-0.83)	0.46	0.40	0.22	0.87	0.017	0.009	4	3.7 (0.8)	3.4 (1.0)
Held[2]	0.69 (0.58-0.80)	0.50	0.00	0.17	0.83	0.040	0.033	2,4	3.7 (0.6)	3.5 (0.9)
Bathed[3]	0.65 (0.54-0.76)	0.80	0.00	0.00	0.25	0.182	0.063	2	1.5 (1.0)	1.3 (0.8)
Talked[4]	0.63 (0.51-0.73)	0.53	0.00	0.33	0.75	0.008	0.017	4	3.5 (1.0)	3.4 (0.9)
Walk[5]	0.59 (0.48-0.69)	0.74	0.18	0.21	0.00	0.016	0.001	2,3	1.7 (1.0)	1.3 (0.7)
Night[6]	0.56 (0.45-0.68)	0.74	0.00	0.33	0.67	0.395	0.123	None	3.1 (1.2)	3.0 (1.2)
Sleep[7]	0.44 (0.34-0.56)	0.56	0.00	0.32	0.53	0.026	0.046	4	3.3 (1.0)	3.1 (1.0)
Diaper[8]	0.42 (0.31-0.53)	0.57	0.14	0.24	0.32	0.195	0.121	None	2.1 (1.2)	1.8 (1.1)
Dressed[9]	0.37 (0.25-0.48)	0.58	0.15	0.13	0.21	0.001	0.000	2,3,4	2.4 (1.3)	1.8 (1.1)
Sang[10]	0.36 (0.26-0.48)	0.41	0.00	0.09	0.43	0.001	0.000	2,3,4	3.0 (1.3)	2.1 (1.3)
Accessibility										
Freq. spent hr.[11]	0.59 (0.48-0.70)	0.44	0.00	0.40	0.74	0.000	0.000	4	3.6 (0.7)	3.2 (0.9)
Looked after alone[12]	0.52 (0.41-0.63)	0.38	0.30	0.39	0.67	0.906	1.000	None	3.2 (1.0)	3.1 (1.1)

Continued on next page

		Specific Agreement†							Mean (SD)	
Item	OA (95% CI)	1	2	3	4	Bhapkar	Bias	Thresholds	F	M
Responsibility										
Discussed infant with mother[13]	0.48 (0.37-0.59)	0.00	0.00	0.08	0.67	0.000	0.012	3	3.7 (0.5)	3.3 (0.9)

Note: †Response options: 1=Not at all; 2=Rarely/A few times a month; 3=A few times a week/About once a day; 4=More than once a day. CI=Confidence Interval; SD=Standard Deviation.

[1]Frequency father soothed infant when she/he was upset since birth

[2]Frequency father held infant since birth

[3]Frequency father washed or bathed infant since birth

[4]Frequency father talked to infant since birth

[5]Frequency father took infant for a walk since birth

[6]Frequency father got up with infant when she/he woke up at night since birth

[7]Frequency father put infant to sleep since birth

[8]Frequency father changed infant's diaper since birth

[9]Frequency father dressed infant since birth

[10]Frequency father sang songs or nursery rhymes to infant since birth

[11]Number of days father spends an hour or more with infant in an average week

[12]How often father looked after infant while mother did other things since birth

[13]Frequency father talked with mother about infant since birth

7.4.1 Overall and specific agreement between mothers' and fathers' fathering item responses

There was poor agreement between fathers' and mothers' reports of fathers' parenting practices. Across the fathering items as a whole, the proportion of overall agreement (OA) varied from a high of 0.91 (95% CI: 0.84-0.97) for *pays for child care items* to a low of 0.30 (95% CI: 0.18-0.41) for *frequency washes household members' clothes* (Tables 7.13 to 7.17). Even within each conceptually-related set of fathering items, the OA varied widely. For example, among items measuring father's **Direct Caregiving**, the OA ranged from a high of 0.73 (95% CI: 0.62-0.83) for *frequency soothed child* to a low of 0.36 (95% CI: 0.26-0.48) for *frequency sang to child* (Tables 7.13). The **Financial Provisioning** and **Practical Support for Mother** items were the exceptions to this. The OAs were consistently high (greater than 70%) for all **Financial Provisioning** items and consistently low (less than 60%) for all **Practical Support for Mother** items (Tables 7.14 and 7.16, respectively).

Items with reasonably high overall agreement typically had one or more response category with a low proportion of specific agreement (SA). For example, the item measuring how *frequently the father held the infant* had a reasonably high OA at 0.69 (95% CI: 0.58-0.80; Table 7.13). However, for that item, only the "More than once a day" response category had a high SA (0.83). Whereas, the "Rarely/A few times per month" and "A few times a week/About once a day" response categories had SAs that were 0.00 and 0.17, respectively.

For very few items was the proportion of specific agreement high for all response categories. In part, this was due to the "skewness" of mothers' and fathers' marginal response distributions, which resulted in certain response options being rarely used. For example, as presented in the previous chapter, mothers rarely used the "Rarely/A few times per month" response option for the Direct Caregiving items (Figure 7.2 on page 105). For rarely-used response options, proportions of specific agreement were estimated with low precision. Nevertheless, the presence of low proportions of specific agreement for most items implies that, even where the OA was high, it was usually driven by agreement on the one or two most frequently-used response categories. For example, high specific agreement on the "Yes" category appeared to drive the high levels of overall agreement for all of the **Financial Provisioning** items. Overall, 87% of fathers and mothers agreed that the father had a primary role in *paying for the infant's clothing* (Table 7.13). Looking at the SAs for this item, if a randomly selected parent from our cohort responded "Yes", it was 93% likely the other parent also chose "Yes". In contrast, if the randomly selected parent said "No", it was only 18% likely the other parent agreed.

Table 7.14: Estimated proportion of overall agreement (OA), proportions of specific agreement, McNemar test p-value and mean (standard deviation) based on father and mother responses, **Accessibility** items: MIHS Fathering Sub-study, 2013-14

Item	OA (95% CI)	Specific Agreement		McNemar	Mean (SD)	
		No	Yes		Father	Mother
Spent 1+ nights away[1]	0.90 (0.81-0.96)	0.91	0.82	0.26	0.3 (0.4)	0.3 (0.5)
Work mornings[2]	0.54 (0.37-0.64)	0.46	0.54	0.22	0.5 (0.5)	0.5 (0.5)
Work afternoons[3]	0.61 (0.43-0.69)	0.58	0.53	0.65	0.4 (0.5)	0.4 (0.5)
Work evenings[4]	0.80 (0.64-0.86)	0.35	0.84	0.53	0.8 (0.4)	0.8 (0.4)
Work alone[5]	0.51 (0.36-0.61)	0.37	0.56	0.34	0.5 (0.5)	0.6 (0.5)
Non-work mornings[6]	0.81 (0.69-0.89)	0.40	0.83	0.13	0.9 (0.3)	0.8 (0.4)
Non-work afternoons[7]	0.82 (0.71-0.90)	0.00	0.86	0.53	0.9 (0.3)	0.9 (0.3)
Non-work evenings[8]	0.84 (0.71-0.92)	0.27	0.86	0.74	0.9 (0.3)	0.9 (0.3)
Non-work alone[9]	0.51 (0.39-0.61)	0.24	0.65	0.34	0.7 (0.5)	0.7 (0.5)

Note: CI=Confidence Interval; SD=Standard Deviation
[1]Father spent one or more nights in a different house from the infant
[2]On days when he works, father usually spends an hour or more with infant in the morning
[3]On days when he works, father usually spends an hour or more with infant in the afternoon
[4]On days when he works, father usually spends an hour or more with infant in the evening
[5]On days when he works, father usually spends a full hour or more alone with infant
[6]On days when he does not work, father usually spends an hour or more with infant in the morning
[7]On days when he does not work, father usually spends an hour or more with infant in the afternoon
[8]On days when he does not work, father usually spends an hour or more with infant in the evening
[9]On days when he does not work, father usually spends a full hour or more alone with infant

Table 7.15: Estimated proportion of overall agreement (OA), proportions of specific agreement, McNemar test p-value, and mean (standard deviation) based on father and mother responses, **Responsibility** items: MIHS Fathering Sub-study, 2013-14

Item	OA (95% CI)	Specific Agreement		McNemar	Mean (SD)	
		No	Yes		Father	Mother
Decided name[1]	0.69 (0.58-0.79)	0.58	0.76	0.286	0.7 (0.5)	0.6 (0.5)
Takes to clinic visits[2]	0.63 (0.51-0.75)	0.77	0.13	0.000	0.4 (0.5)	0.0 (0.2)
Important care decisions[3]	0.55 (0.44-0.66)	0.30	0.67	0.000	0.8 (0.4)	0.5 (0.5)
Cares when ill[4]	0.50 (0.39-0.61)	0.62	0.26	0.000	0.5 (0.5)	0.1 (0.4)
Decides timing clinic visits[5]	0.45 (0.35-0.56)	0.58	0.20	0.000	0.5 (0.5)	0.1 (0.4)

Note: CI=Confidence Interval; SD=Standard Deviation
[1]Father/both father and mother decided what infant's name would be
[2]Father/both father and mother usually take(s) infant when she/he needs to be taken to clinic or doctor
[3]Father/both father and mother make(s) important decisions about infant's care
[4]Father/both father and mother usually care(s) for infant when she/he is ill
[5]Father/both father and mother decide(s) when infant needs to be taken to clinic or doctor

Table 7.16: Estimated proportion of overall agreement (OA), proportions of specific agreement, McNemar test p-value, and mean (standard deviation) based on father and mother responses, **Material Provisioning** items: MIHS Fathering Sub-study, 2013-14

Item	OA (95% CI)	Specific Agreement		McNemar	Mean (SD)	
		No	Yes		Father	Mother
Care items[1]	0.91 (0.84-0.97)	0.40	0.95	0.031	1.0 (0.2)	0.8 (0.4)
Clothes[2]	0.87 (0.80-0.94)	0.18	0.93	0.004	1.0 (0.1)	0.9 (0.4)
Expenses[3]	0.85 (0.76-0.93)	0.15	0.91	0.012	1.0 (0.2)	0.9 (0.3)
Household food[4]	0.77 (0.66-0.86)	0.45	0.85	0.001	0.9 (0.3)	0.7 (0.5)

Note: CI=Confidence Interval; SD=Standard Deviation
[1]Mainly father/father and mother equally paid for child care items (like diapers or wet wipes) since birth
[2]Mainly father/father and mother equally paid for infant's clothing since birth
[3]Mainly father/father and mother equally pay(s) for the infant's expenses
[4]Mainly father/father and mother equally paid for food for the infant's household since birth

Table 7.17: Estimated proportion of overall agreement (OA), proportions of specific agreement, Bhapkar and Bias test p-values, thresholds with equality test p-values <0.05 and mean score (standard deviation) based on father (F) and mother (M) responses, **Practical Support for Mother** items: MIHS Fathering Sub-study, 2013-14

Item		Specific Agreement†							Mean (SD)	
	OA (95% CI)	1	2	3	4	Bhapkar	Bias	Thresholds	F	M
Cooking[1]	0.53 (0.39-0.62)	0.67	0.47	0.47	0.33	0.004	0.003	3	2.3 (1.0)	2.0 (0.9)
Laundry[2]	0.43 (0.31-0.54)	0.57	0.41	0.12	0.18	0.818	0.637	None	1.9 (1.0)	1.8 (0.9)
Repairs[3]	0.39 (0.27-0.51)	0.44	0.48	0.24	0.16	0.004	0.021	3,4	2.5 (1.1)	2.0 (0.8)
Dishes[4]	0.37 (0.25-0.48)	0.47	0.48	0.20	0.11	0.015	0.006	3,4	2.4 (1.1)	2.1 (0.8)
Tidying[5]	0.30 (0.18-0.41)	0.45	0.35	0.22	0.10	0.000	0.001	3,4	2.6 (1.0)	2.1 (0.8)

Note: †Response options: 1=Never; 2=Once or twice; 3=A few times a week; 4=Everyday or almost everyday. CI=Confidence Interval; SD=Standard Deviation.

[1]How often father cooked a meal for the members of infant's household since infant's birth

[2]How often father repaired something in the house that was damaged or broken since infant's birth

[3]How often father washed the dishes or cooking pots since infant's birth

[4]How often father cleaned or tidied the house since infant's birth

[5]How often father washed clothes for members of infant's household since infant's birth

Table 7.18: Pearson correlation and descriptive statistics for item total scores (mother and father report) by mode of paternal influence

		Mother		Father	
Mode	Correlation	Median	IQR	Median	IQR
Accessibility	.76	16	10-17	16	14-18
Provisioning	.52	4	3-4	4	3-4
Direct caregiving	.48	23	18-26	26	22-28
Practical support	.38	10	7-11	11	10-15
Responsibility	.19	5	4-6	7	5-8

Note: IQR=InterQuartile Range.

7.4.2 Sources of disagreement between mothers' and fathers' fathering item responses

Disagreement over construct definition

We estimated the correlation between mothers' and fathers' responses as evidence for whether they tended to agree in their understanding (or definition) of the fathering practice being assessed. The paired response data for all ordinal items were found to have poor fit with the model for the polychoric correlation. Therefore, we were unable to use this approach to assess agreement between parents' definitions of the underlying fathering practices.

In table 7.18 we present descriptive statistics for mothers' and fathers' total scores on items included in each of the five unidimensional IRT models (presented in the preceding chapter). For each latent mode of paternal influence, we also present the Pearson coefficient for the correlation between mothers' and fathers' item total scores. The correlation between mothers' and fathers' **Accessibility** scores was 0.76, suggesting strong agreement. The corresponding coefficients for items in the **Direct Caregiving** and **Provisioning** models were more modest at 0.48 and 0.52, respectively. The relatively low correlation between mothers' and fathers' total scores for items measuring father's **Practical Support for Mother** and **Responsibility** (0.38 and 0.19, respectively) suggests parents had less shared understanding of these modes of influence than of the other three.

Disagreement over response category definitions

Our tests of marginal homogeneity provided evidence that mothers and fathers differed in their propensity to use the available response categories for most items. For example, for all **Material Provisioning** items, McNemar tests showed significant differences (test p-values <0.05) between mothers' and fathers' marginal response probabilities. Similarly, Bhapkar test results for all **Direct Caregiving** items except the *Washed*, *Night*, and *Diaper* items suggest significantly different marginal response rates. Interestingly, the **Accessibility** items were the exception: McNemar test results suggest that mothers' and fathers' marginal response rates were homogeneous for all items in this set. For the majority of dichotomous items, the lack of marginal homogeneity resulted from a tendency for fathers to use the "Yes" response option more frequently than mothers. For example, for all **Responsibility** items, the mean of the fathers' responses is higher than the mean of the mothers' responses (Table 7.15).

In addition, tests of overall bias and threshold equality provide evidence that fathers and mothers differed in their definitions of the available response options for most ordinal items.

Fathers' reported frequencies of doing most **Practical Support for Mother** and **Direct Caregiving** items were biased upwards relative to frequencies reported by mothers (i.e.: bias test p-values <0.05 in tables 7.17 and 7.13). The same was true for the **Accessibility** item measuring how frequently the father spent an hour or more with the infant, and for the **Responsibility** item measuring how frequently the father talked to the mother about the infant (Table 7.13).

For the **Practical Support for Mother** items, fathers and mothers tended to have different definitions for the threshold between "once or twice in two weeks" and "a few times per week" and the threshold between "a few times per week" and "everyday". In contrast, for the **Direct Caregiving** items, we observed significant differences for all threshold definitions (in different combinations for different items).

7.4.3 Agreement on father's sociodemographic and health characteristics

There was clearly better agreement between fathers' and mothers' responses to questions about father's sociodemographic characteristics and characteristics of their relationship. Among these types of questions, those having the poorest agreement were about the father's educational attainment and employment history (Table 7.19). There was also decent agreement on questions about father's health status, including HIV testing and test results (Table 7.20). The notable exceptions were questions about father's alcohol consumption, on which mothers tended to report more frequent consumption than did fathers (Table 7.20).

Table 7.19: Estimated proportion of overall agreement (OA), lowest proportion of specific agreement (SA), Marginal Homogeneity (MH) and Bias test p-values, and thresholds with equality test p-values <0.05 based on father and mother responses, Father's sociodemographics and father-mother relationship characteristics: MIHS Fathering Sub-study, 2013-14

		Lowest SA				
Item	OA (95% CI)	Estimate	Category	MH	Bias	Thresholds
Population group	0.99 (0.96-1.00)	0.93	Non-Black	1.000	NA	NA
Worked in last year	0.88 (0.37-0.91)	0.42	Yes	1.000	NA	NA
Language	0.87 (0.79-0.94)	0.00	Other non-Afr.	0.868	NA	NA
Relationship at conception	0.85 (0.77-0.93)	0.00	Casual	0.027	NA	NA
Worked in last week	0.82 (0.73-0.90)	0.60	No	0.039	NA	NA
Number children sired	0.80 (0.72-0.90)	0.72	2	0.336	0.28	None
Living together at conception	0.80 (0.70-0.89)	0.56	No	0.057	NA	NA
Years known mother	0.75 (0.65-0.85)	0.00	$\leq$1 year	0.757	0.33	None
Child with other woman	0.69 (0.48-0.77)	0.63	No	0.774	NA	NA
Days worked/week	0.60 (0.45-0.71)	0.00	1,3	0.384	0.84	None
Educational attainment	0.46 (0.35-0.58)*	0.00	1 yr secondary	0.054	0.46	5
Number of months worked in last year	0.40 (0.26-0.51)*	0.00	1-11	0.000	0.016	3,4,5,6, 11,12

Note: CI=Confidence Interval.

*Percent overall agreement calculated with "Don't know" treated as a valid response option.

Table 7.20: Estimated proportion of overall agreement (OA), lowest proportion of specific agreement (SA), Marginal Homogeneity (MH) and Bias test p-values, and thresholds with equality test p-values <0.05 based on father and mother responses, Father's health: MIHS Fathering Sub-study, 2013-14

		Lowest SA				
Item	OA (95% CI)	Estimate	Category	MH	Bias	Thresholds
Used street drugs in past month	0.96 (0.92-1.00)	0.40	Yes	1.000	NA	NA
Last HIV test result was positive	0.95 (0.72-0.93)	0.79	Yes	1.000	NA	NA
Has long-term, work-limiting illness	0.85 (0.77-0.93)	0.29	Yes	0.344	NA	NA
Taking HIV medications	0.82 (0.38-0.90)	0.53	No	1.000	NA	NA
Ever had HIV test	0.73 (0.62-0.83)*	0.53	No	0.581	NA	NA
Frequency drank alcohol in past month	0.63 (0.51-0.75)	0.00	6-7 days/week	0.012	0.005	3§
Frequency drank $\geq$6 drinks in past month	0.54 (0.28-0.61)	0.00	Never; 6-7 days/week	0.001	0.016	3§

Note: CI=Confidence Interval.

*Percent overall agreement calculated with "Don't know" treated as a valid response option.

§Threshold between response options "2=Maybe once in the month" and "3=About once a week"

7.4.4 Consensus of fatherhood beliefs

In relation to the mothers' and fathers' beliefs on fatherhood, we observed two distinct patterns of agreement. The first two items in Table 7.21 on the following page had high overall percentages of agreement and homogeneity of fathers' and mothers' marginal response rates. This appeared to be because almost all respondents strongly agreed with these items (observed in the high specific agreement for the "strongly agree" response category, and the mean response close to 4 for both fathers and mothers). We observed a different pattern for the other four fatherhood belief items. In our cohort there was wide variation in belief about whether: i) "it is less important for a father to spend time with his children than it is for him to provide financially for them"; ii) "it is difficult for men to express affectionate feelings toward babies" and iii) "the father more than the mother should be the one to teach their children 'right' from 'wrong"' (Figures 7.38-7.40). The percentages of overall agreement were very low for these items. There was also a significant overall bias for the latter two: fathers tended to more strongly agree that they should be the ones to teach right from wrong, and more strongly disagree that it is difficult for men to express affectionate feelings toward babies. Interestingly, although there was variation of opinion about whether financial provisioning is more important than spending time with children, this variation was similar across fathers and mothers, resulting in no overall bias. Finally, while most fathers strongly agree that "a father should be as heavily involved as the mother in the care of their children", a modest percentage of mothers disagreed with this item (Figure 7.41). This resulted in a significant overall bias.

Table 7.21: Estimated proportion of overall agreement (OA), proportions of specific agreement (SA), Bhapkar and Bias test p-values, thresholds with equality test p-values <0.05 and mean score (standard deviation) based on father (F) and mother (M) responses, Fatherhood beliefs: MIHS Fathering Sub-study, 2013-14

		SA†							Mean (SD)	
Item	OA (95% CI)	1	2	3	4	Bhapkar	Bias	Thresholds	F	M
Fathers must keep children safe and protected	0.93 (0.87-0.99)	0.00	*NA**	0.00	0.96	0.953	0.654	None	3.9 (0.4)	3.9 (0.4)
Important for fathers to give encouragement to mothers	0.90 (0.82-0.96)	0.00	0.00	0.00	0.95	0.518	0.251	None	4.0 (0.2)	3.9 (0.5)
Father should be as involved as mother in children's care	0.79 (0.69-0.87)	0.00	0.00	0.00	0.88	0.039	0.020	2,3,4	4.0 (0.2)	3.7 (0.8)
Difficult for men to express affection toward babies	0.34 (0.24-0.46)	0.27	0.18	0.00	0.46	0.025	0.007	2,3,4	2.5 (1.4)	3.1 (1.2)
Spending time together is less important than providing financially	0.31 (0.20-0.41)	0.40	0.00	0.18	0.33	0.093	0.373	None	2.4 (1.4)	2.5 (1.2)
Father more than mother should teach right from wrong	0.26 (0.16-0.37)	0.00	0.12	0.25	0.38	0.000	0.000	3,4	3.5 (1.0)	2.6 (1.1)

Note: CI=Confidence Interval; SD=Standard Deviation. †Response options: 1=Strongly disagree; 2=Mildly disagree; 3=Mildly agree; 4=Strongly agree. *No respondents used this category

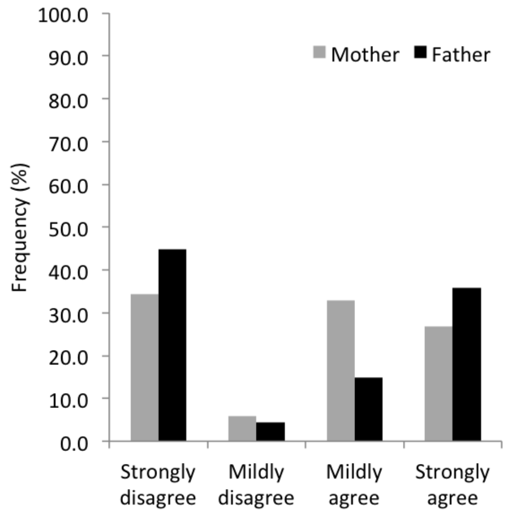


Figure 7.38: Comparison of marginal distribution of fathers' and mothers' responses to belief that it is less important for a father to spend time with his children than it is for him to provide financially for them: MIHS Fathering Sub-study, 2013-14

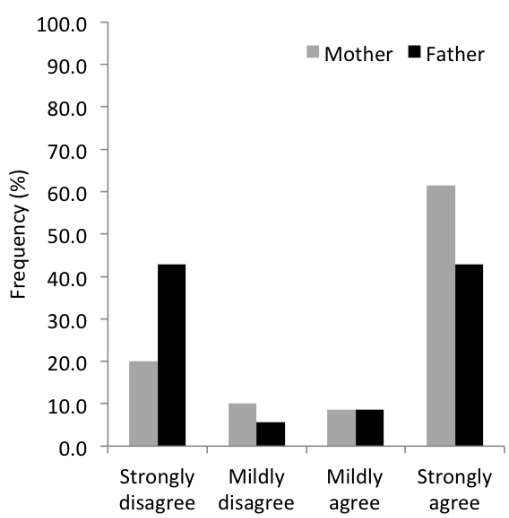


Figure 7.39: Comparison of marginal distribution of fathers' and mothers' responses to belief that it is difficult for men to express affectionate feelings toward babies: MIHS Fathering Sub-study, 2013-14

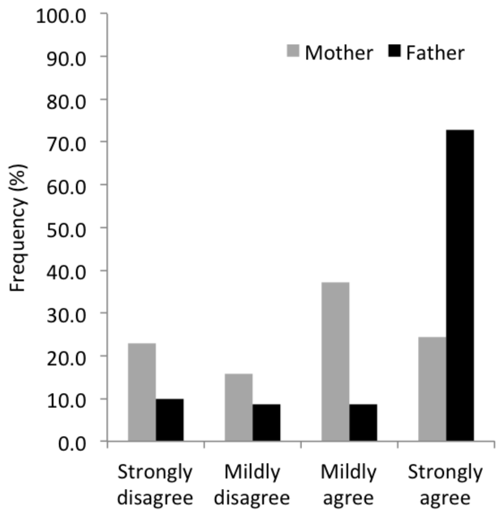


Figure 7.40: Comparison of marginal distribution of fathers' and mothers' responses to belief that the father more than the mother should be the one to teach their children 'right' from 'wrong': MIHS Fathering Sub-study, 2013-14

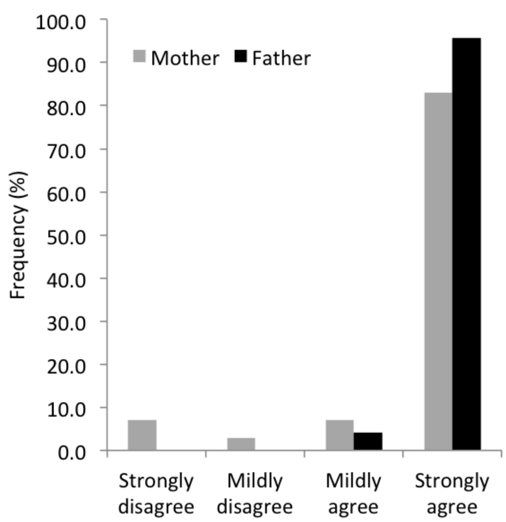


Figure 7.41: Comparison of marginal distribution of fathers' and mothers' responses to belief that a father should be as heavily involved as the mother in the care of their children: MIHS Fathering Sub-study, 2013-14

Chapter 8

Discussion: Measuring Fathers' Contributions to Infants' Care

The second part of this project had two main aims. First, we examined the measurement properties of a comprehensive fathering questionnaire adapted from survey research on fathers in the US. Our purpose here was to determine whether sets of questions about related fathering practices could be used to reliably measure fathers' positions on five latent variables, each representing a distinct mode of contributing to infants' care. Within this part, we also examined whether, in our sample, measurements from the questionnaire would enable valid inferences to be made about the modes of paternal contribution we were putatively measuring. Second, we assessed whether mothers and fathers provided consistent reports of fathers' parenting practices. Our aim was to understand whether mothers could be considered reliable proxy respondents for fathers in research on fathering in South Africa.

8.1 Measurement properties of the fathering questionnaire

To enable population-level research on fathering in South Africa, there is a need for validated, culturally-appropriate instruments for measuring the range of contributions that fathers can make to their children. Because of the high prevalence of residential separation of fathers and children, an instrument suitable for measuring the contributions of both co-resident and non-co-resident fathers would be desirable. In this study we sought to establish whether our questionnaire could be used to obtain precise estimates of fathers' levels of contribution. We also examined whether questionnaire items provided equivalent measurements for co-resident and non-co-resident fathers. Finally, as evidence for the validity of the measurements, we explored whether father's levels on each latent mode of contribution were associated with factors previously demonstrated to influence fathering in other settings.

Our sample was not representative of the South African population. The study participants all lived in a single, low-income suburb in the Western Cape province, almost all were Black Africans, and the majority were first-language isiXhosa speakers. Even so, our sample reflects some important features of the context of fatherhood in South Africa: almost half of the fathers were not living with their infant and only a third were married to their infant's mother. These characteristics have been established as having important influences on fathering, and so they were expected to influence the levels of contribution measured in this study also [47].

8.1.1 Precision of estimates of fathers' contributions

Based on the theoretical framework that informed the design of our questionnaire, we hypothesized that we would be able to provide measures of fathers' reported contributions via five (latent) modes of paternal influence [23]. We tested the fit between the questionnaire response data and this hypothetical model using unidimensional item response theory models. For the most part, we found that the questionnaire data was consistent with the theoretical model. The items designed to measure direct caregiving were a slight exception. To obtain a unidimensional model with acceptable fit to these data, we had to drop two items. These items measured the frequency fathers washed and dressed their infants since birth. Possibly this is evidence that the hypothetical 'Direct Caregiving' mode of influence is actually comprised of two (or more) distinct latent variables. For example, the latent variable we measured with the remaining items may reflect a 'Giving Affection' component of caregiving, while the items we removed may reflect a 'Hygiene' component. By including additional hygiene-related items in future iterations of the questionnaire, it would be possible to test whether these items are measuring a distinct latent variable.

Using IRT models allowed us to estimate properties of questionnaire items and individual fathers together on the same scales. Items designed to measure fathers' levels of Direct Caregiving, Accessibility, and Practical Support for Mother were found to provide precise estimates over the range of values where the majority of fathers in our sample were located. In contrast, items measuring Responsibility gave imprecise estimates across the entire range of the latent trait, especially for locations below the mean. Similarly, the Material Provisioning items gave precise estimates only for a narrow range of values around the mean, whereas the majority of sample fathers were estimated to have levels above or below the mean. Although our sample was not representative of the national population, it did include significant percentages of unmarried and non-co-resident fathers. Thus, the magnitude of variation in levels of contribution via each mode of paternal influence reported among our sample may be indicative of what would be seen in a national sample. (In fact, we expect our sample to be more homogenous.)

Our assessment suggests that the Direct Caregiving, Accessibility and Practical Support for Mother sections of the questionnaire provide reliable estimates for levels of contribution around the average – that is, for most fathers. These sections of the questionnaire should provide reliable measurements in future research involving similar samples of fathers to ours. However, the aim of population-level measurement would likely be to provide precise estimates of fathers' contributions across a wider range of values than we were able to show. Therefore, it would be desirable for future uses of this questionnaire to evaluate items that could provide good discrimination over a broader range of these three modes of paternal influence.

Our assessment also suggests that the questionnaire items measuring father's Material Provisioning and Responsibility need to be better adapted to the South African context before they will give reliable measurements. Response options for both the Material Provisioning and Responsibility items were originally nominal. It is possible in an IRT framework to model nominal response data. However, for most nominal items in our questionnaire, we observed frequent responses for only one or two response options. Because of this response distribution, a larger dataset would be needed to estimate the parameters of a nominal response model with acceptable precision [210]. We chose to dichotomized these items so that we were still able to use the response data. Because each response option of a polytomous item contributes its own information, collapsing the items to make them binary reduced the amount of information they contributed to the total. In the case of the Provisioning items, dichotomizing may also have resulted in the total information becoming concentrated in a narrow region of the scale. Future studies in larger, more diverse samples would be necessary to determine how much information could be gained by modelling these items in their nominal form.

We discuss other potential explanations for the poor performance of the Responsibility and Provisioning items below.

Responsibility

The IRT model for Responsibility gave relatively imprecise person location estimates at all points on the latent trait scale. Because the questionnaire included three moderately high-discrimination (and therefore more informative) items located above the origin of the Responsibility scale but no high-discrimination items below the origin, the person location estimates above the origin were more precise than those below. Even so, the total information function for this set of items was low compared to those of items measuring the other four modes of influence. By implication, this questionnaire is not very reliable for estimating fathers' latent levels of Responsibility, especially for fathers with below-average levels of Responsibility.

A few explanations are possible for why our questionnaire did not provide adequate estimates of father's Responsibility among this sample. First, the practices measured by the responsibility items were more subjective and, therefore, may have been more difficult for mothers to report on than items measuring the other modes of influence. Second, the manifest parenting practices assessed by some of the items may not have been appropriate for our sample or setting. Third, our conceptual development of this mode of influence may not have been sufficient.

Commentaries on the history of father involvement research have noted that responsibility has proven to be the most difficult component to measure [78, 211]. The Responsibility construct has been diversely operationalized because of the wide array of ways in which parents demonstrate responsibility for their children's wellbeing. Half of the Responsibility items in our questionnaire focused on infants' health care needs. Although the health care items were estimated to have reasonably high discrimination, they also had the highest location estimates in the set. In other words, compared to other items, fathers had to have high levels of responsibility before they were likely to be reported to be responsible for the health care items. This is evident in the discrepancy between the relatively large percentage of fathers involved in making important decisions about other aspects of their infant's care and the small percentage who took responsibility for the infant's health care needs. This may be evidence that, in this setting, assessing involvement in infant's health care is only appropriate for measuring the responsibility of "high responsibility" fathers. The corollary is that the way the respondents conceived of the "important decisions" fathers were making in infant care may have had little to do with infant health care. To precisely measure lower levels responsibility would require identifying new items that tap into other ways that fathers manifest their responsibility in this setting.

Researchers working in a number of sub-Saharan African countries have found that sexual and reproductive health are normatively viewed as “women’s concerns” [212, 12]. This attitude possibly extends to the health care of infants, which begins in the form of postpartum health check-ups for mother and infant and largely involves preventative measures rather than treatment of specific illnesses. Therefore, many fathers may see themselves as having a limited role to play in this aspect of their infant’s care. Furthermore, they may receive little encouragement from members of their communities to take a more active role, and doing so may even provoke distrust or derision [212].

Involvement of fathers in their children’s health care needs has previously been found to improve child health outcomes [119]. There is considerable interest in developing interventions to promote more equitable involvement of men in sexual, reproductive, and child health in sub-Saharan Africa as a way of improving the health of women, children and men [11, 12]. In this regard, our finding that fathers had limited responsibility for infant health care may be important, and ought to be confirmed in more representative samples. On the other hand, if involvement in health care is not a normative component of fathers’ responsibility toward their children, a tool which attempts to measure responsibility by focusing predominantly on children’s health care needs probably produces measurements with limited validity.

In informal discussions held with our participants, men and women affirmed the finding that many fathers do not take their children to government clinics. They perceived that some men lack the motivation to wait in the long queues at these clinics. They also suggested that many men and women perceive taking children to clinics to be the mother’s responsibility. Related to this, some mothers may feel that they understand their children’s needs better than fathers do. Also, some fathers cite work as a reason for not being able to attend clinics with children, possibly because they see their income-earning responsibilities as more important or because they perceive they would not get time off work for this purpose. Echoing previous study findings, participants also described a common perception that child health clinics are feminine spaces [212]. For example, one father explained that, when he took his child to the clinic, he was seen as so extraordinary that some nurses joked that they wished he was their husband. While this is an example of a relatively welcoming response by clinic staff to the entry of fathers, it highlights the common perception of this space as devoid of male involvement.

Material Provisioning

Similarly, the Material Provisioning items adapted from the North American context appeared to provide poor measures of the range of provisioning in South Africa. In this case, the items seem to have been too closely related. This can be judged from the fact that the item characteristic curves almost completely overlap. The result is that this set of items can only distinguish fathers into groups above and below the mean level of provisioning; the items did not provide additional information about fathers’ relative levels of provisioning.

This part of the questionnaire could be improved by including additional items which discriminate between fathers at higher and lower positions on the latent scale. Our items asked about the person who mainly paid for different material needs. Possibly, items assessing the frequency the father purchased different child care items, or the actual amount he contributed towards the infant’s material needs during a given period might provide information across a wider range of the Material Provisioning scale. Items assessing more expensive or episodic purchases, for example, health insurance, or items measuring longer-term material investment, such as whether the father is contributing to savings for home improvements or the child's schooling, could be informative about locations at higher levels of the trait. To better measure the material provisioning of very low-income and unemployed fathers, it may be necessary to include questions focusing on non-monetary contributions such as securing clothing or food donations or repurposing discarded building materials.

8.1.2 Effects of co-residence on levels of paternal influence and evidence for differential item functioning

Using MIMIC models we estimated the average effect of co-residence status on father's level of each latent mode of paternal influence. On average, non-co-resident fathers had significantly lower levels of contribution in all five modes. The magnitude of the effect was smallest for scores on the Material Provisioning scale and largest for scores on the Accessibility and Practical Support scales. We emphasize that our findings did not show that non-co-resident fathers were uninvolved in their infant's care. Many were primary providers for their infant's material needs, spent time with their infant and engaged in direct caregiving activities at least a few times a week. However, our results do show that non-co-resident fathers' contributions were lower on all modes of influence, at least as measured by the items on our questionnaire. The MIMIC models also showed that the majority of poorly discriminated location estimates at the lower ends of the Direct Caregiving, Accessibility, Material Provisioning and Practical Support scales were for fathers who were not residing with their children.

A number of factors could account for the observed differences between non-co-resident and co-resident fathers' levels of contribution. Under-reporting of non-co-resident fathers' contributions by mothers or bias in the items included in the questionnaire could have played a part. Additionally, our findings may reflect an actual tendency for non-co-resident fathers to be less involved in their children's care than co-resident fathers.

In a qualitative study in rural KwaZulu-Natal, which examined fathers' involvement with children using reports from fathers, mothers and children, Makusha *et al.* present evidence that mothers systematically under-report the contributions of non-co-resident fathers [213]. Similarly, research in the United States on divorced fathers' payments of child support, suggests that fathers may overreport their payments while mothers may underreport what they receive [214]. We found that mothers' reports of fathers' contributions in all five modes of influence were biased downward relative to fathers' own reports. However, small sample size prevented us from testing whether this bias was larger for non-co-resident fathers.

Additionally, our questionnaire may have biased the location estimates of non-co-resident fathers downwards by being over-represented in items that were easier for co-resident fathers to contribute to. We found some evidence for bias in the items designed to measure Material Provisioning and Direct Caregiving: a single item in the IRT model for each of those modes of influence had statistically significant differential functioning for non-co-resident versus co-resident fathers. We did not test for differential functioning of items measuring Accessibility, Responsibility, and Practical Support because the response frequency distributions for all items measuring these modes of influence appeared to vary in a similar way between co-resident and non-co-resident fathers. Nevertheless, it is possible that some of these items were more relevant for co-resident fathers than non-co-resident fathers, which could imply that they give less information about the latter's contributions to their infants.

If non-co-resident fathers truly do have lower levels of influence in infant's care, intuitively, this should be most dramatic for modes of influence that require being physically present in the infant's life. Our finding that co-residence status had a larger effect on Accessibility, Practical Support for Mother, and Direct Caregiving, than on Material Provisioning is consistent with this hypothesis.

In one of the few previous studies in South Africa to have measured a component of fathering, Madhavan and colleagues examined fathers' financial support for children in a rural area of Mpumalanga province [76]. Using ethnographic methods, they collected retrospective data on lifetime household arrangements and financial support received from fathers for a purposive sample of children aged 0-20 years. In measuring children's household arrangements with fathers they distinguished between a *residential connection* (when father and child co-reside), *household connection* (father is a member of the child's household but they do not co-reside), *social connection* (father has acknowledged paternity but neither co-resides with the child nor is a member of her/his household) and *no connection*[30] (no man had claimed paternity for the child). They found that children who had ever had a social connection with their father were less likely than those who had ever had a residential or household connection to have received financial support from him. Moreover, support was similar for children with residential and household connections. In fact, at the time of the study, a greater percentage of children in residential versus household connections with their father were not receiving any financial support from him.

Our findings are not directly comparable to those of Madhavan *et al.* because of differences in how residential connections were defined in the two studies. Fathers classified as non-co-resident in our study could have been classified by Madhavan *et al.* as having either a household or social connection, or no connection, with their children. Our finding that, on average, fathers in this group had lower (but non-zero) levels of material contributions compared to co-resident fathers is consistent with the previous study's findings. In our study, the best indicator of a father's social connectedness to his infant was his relationship with the mother. We observed that, among non-co-resident fathers, those who were married or in an exclusive, non-marital relationship with the mother were more likely to be contributing to their infant's material needs than were fathers who were no longer seeing the mother. This finding is also consistent with those of Madhavan *et al.*

In addition, it is possible that the association between father's residential status and material provisioning may be modified by whether the infant's household has an urban or rural base. Madhavan and colleagues conducted their study in a rural area with "few local employment opportunities" [76, p. 6]. In their setting, co-resident fathers may have had less means of making financial contributions than non-co-resident fathers. In contrast, among our sample of urban fathers, a very small number were reported to be residing elsewhere for work (8/178 = 4.5%). The most common reason for non-residence

[30] By definition, children with no connection were not receiving financial support from a father.

was that the mother and father had not established a household together. In one fifth of these cases, the mother and father were no longer seeing one another. Mothers would be expected to have more difficulty obtaining financial support from these fathers, particularly if the father had not acknowledged paternity of the child.

Our findings do not definitively establish whether it is appropriate to directly compare the contributions of co-resident and non-co-resident fathers measured by our questionnaire. Future users of the questionnaire could improve comparability of the data by removing the two items with differential item functioning. Alternatively, the "Alignment method" for multiple-group confirmatory factor analysis could be used to identify an optimal model for comparing the trait locations of co-resident and non-co-resident fathers [215]. This method differs from the one used in our study in that it makes it possible for any number of model parameters to be allowed to vary across the two groups of fathers. Nevertheless, previous research, cited above, cautions against over-interpreting differences between co-resident and non-co-resident fathers' contributions when relying on questionnaire data from mothers. Furthermore, it may be necessary to account for whether comparisons involve fathers from urban or rural households or both. Qualitative research exploring the ways in which societal prescriptions of fatherhood depend on fathers' residential and social connectedness with their children could also inform decisions about whether it is valid to use the same questionnaire to measure the contributions of co-resident and non-co-resident fathers.

8.1.3 Validity of measurements of fathers' contributions

Validity is generally only established with long-term, repeated usage of an instrument. The distinction between fathers' direct involvement in caregiving and their financial provisioning and support for the mother has been found in two other studies which used factor analysis to examine the latent variable structure of data from large surveys of US fathers' parenting [216, 217]. This distinction is also clear in qualitative data on young South African fathers' accounts of what it means to be a "good" father [82]. Furthermore, the conceptual distinction between accessibility, engagement and responsibility has improved the comparability of data between different surveys of fathers' time use conducted over the past 30 years [30, 78]. Studies of the relationship between father's involvement and children's early development have suggested that levels of engagement, but not accessibility, predict beneficial outcomes [21]. That these two types of involvement, which are distinct in theory, show different associations with child-wellbeing outcomes is evidence that they are also distinct in reality. These pieces of evidence support the validity of the conceptual framework as a way of identifying distinct modes of paternal influence. This is true despite the fact that there are other potentially important components of fathers' involvement which are not given as much emphasis in this framework [211].

A separate question is whether the items included in our questionnaire provide valid measures of the modes of paternal influence distinguished by the conceptual model. Said another way, do the person location estimates for each latent trait allow for meaningful inferences to be drawn about fathers' behaviour outside of the specific items assessed on the questionnaire [194, p. 184]? As discussed below, we observed evidence for the face validity[31] of the questionnaire items and for the convergent validity[32] of the person location estimates.

Face validity

We assessed the face validity of the questionnaire items during feedback sessions with study staff and participants. Both groups agreed that most items on the questionnaire seemed to be reasonable measures of fathers' contributions to the care of infants. However, they raised concerns about two items designed to measure Direct Caregiving. Some of the staff members laughed at the question about singing to the baby, saying that they felt this was not something African fathers do. This could explain why the singing item was endorsed relatively rarely, and possibly raises concerns about its appropriateness for this cultural setting. However, about one third of mothers reported their infant's fathers had been singing to them a few times per week or more. Therefore, the perception of singing by fathers as something inappropriate did not seem to be unanimously shared by the study population. The validity of this item as a measure of Direct Caregiving deserves evaluation in other samples.

During data collection, some fathers explained that they could not take their children for walks because their family believed that young babies should not be taken out in public. Consistent with this explanation, taking children for walks was reported significantly more frequently at later study visits. In addition, during the post-study discussion groups, participants explained that some men do not display affection to their babies in public because they are worried they will be seen as "bewitched" or too much under the control of their female partners. Some participants also explained that they saw taking babies for walks as something that "White" (Western) fathers do. These pieces of evidence suggest this item may not be a valid measure of father's caregiving in this setting, especially for newborns. Because this item had such low discrimination, it would not have contributed much to the person location estimates. Nevertheless, it should be removed or revised in subsequent uses of the questionnaire.

Convergent validity

The systemic ecological model of fathering that we drew on proposes that fathers' parenting practices are shaped by interacting systems of factors at multiple levels of social organization including individual, inter-personal, institutional and societal (section 2.1.3). We assessed convergent validity of person location estimates from our questionnaire by testing whether they were associated with one another and with other variables in ways predicted by the hypothetical model. The model predicts that fathers' levels of contribution via one mode of care ought to be correlated with their contributions via other modes because they share similar determinants. However, levels of contribution via different modes are unlikely to be equal because they require different types of resources. For example, direct involvement in caregiving requires time to spend with children. Whereas material provisioning requires financial resources,

[31] Face validity is "the degree to which items, or test components, appear to measure a construct that is meaningful to a layperson..." [194, p. 187]

[32] Convergent validity is a component of construct validity that is demonstrated when measurements of a construct show "strong interrelationships with measures of supposedly closely related constructs..." [194, p. 206]

often necessitating time to be directed into wage labour and away from direct caregiving.

Consistent with the above hypotheses, the five latent traits underlying our data were reasonably highly correlated, with the financial provisioning trait being the least correlated with the others. Similarly, factor analyses of fathering datasets from US samples have shown significant positive correlations between factors representing different dimensions of father involvement [216, 217]. One study also found that a financial provisioning factor was less highly correlated with factors for direct involvement than the latter factors were with one another [216].

Also consistent with the hypothetical model, father's probability of paying for material needs, his time spent with the infant, and his frequency of doing caregiving activities and household chores were all positively correlated with being in a romantic relationship with the mother and with being able to negotiate through relationship conflicts. Traditional marriage practices predict that married fathers should enjoy greater rights and experience more obligations in caring for their children than unmarried fathers. In urban areas, where cohabitation outside of marriage is becoming more accepted [59], co-resident fathers may experience similar rights and obligations to married fathers. In addition, married and cohabiting couples would have had to attain a certain economic stability to be able to form their own independent household. Therefore, these parents may be more able to provide for their children's material needs and may have more control over the balance between work and spending time with children than unmarried and non-cohabiting parents. Qualitative research in South Africa has found that a well-functioning co-parental relationship, involving good communication and sharing of responsibilities, encourages father's involvement with children [213].

In addition, fathers who had not worked in the year prior to the 2-week visit were less likely to have been paying for their infant's material needs, spent less time with their infants and did fewer household chores. These fathers also tended to do direct caregiving activities less frequently, although these differences were not statistically significant. This is consistent with previous research in South Africa and the US showing that fathering is sensitive to economic wellbeing [52, 56, 47]. It has been suggested that some men who perceive they have failed in their role as provider "desert" their other family responsibilities [52, p. 158]. An alternative explanation is that, in communities characterized by limited employment opportunities and a reliance on informal sources of income, dominant ideals of masculinity emphasize independence, toughness, and control over women and children, while de-emphasizing caregiving responsibilities [183].

In traditional Southern African fatherhood ideals, father's were expected to be role models for young men and to take responsibility for deciding when adolescent sons should begin training for initiation into manhood [46]. Because of this traditional expectation, one may expect fathers to have higher levels of involvement with sons than daughters. Among our sample of fathers this did not appear to be the case. In our study, child's sex was not significantly associated with items measuring any of the five modes of paternal influence. Our findings are consistent with other South African research showing that the sex of Xhosa adolescents was not a significant factor affecting the frequency of spending time with fathers, or the amount of money spent by fathers on children's schooling [218]. Similarly, in a longitudinal study of children from birth to 20 years old, child's sex was not associated with father-child contact [219] or with receipt of financial support from fathers [220] following parental union dissolution. Although it would be of interest for future research to examine whether and how gendered expectations of father's parental roles influence the nature and levels of their involvement with children of different sexes, the consistency between our findings and those of previous studies adds to the credibility of our questionnaire.

Replication of our findings among diverse samples of South African fathers will be necessary to more definitively establish the validity of the questionnaire measurements. Because we are interested in father's contributions as they relate to infant's health, future validation research will need to examine whether measurements produced by the questionnaire are associated with child health outcomes. Finally, as discussed previously, qualitative research exploring father's responsibility and material provisioning in more detail could be used to improve the items used to measure these constructs, thereby improving the validity of the measurements.

8.1.4 Limitations

Our IRT modelling of fathers' parenting contributions was subject to some important limitations. First, our sample was smaller than is generally recommended for fitting IRT models [193, 209]. This could explain why some item parameter estimates had large standard errors. In addition, the probability that the chi-square test will incorrectly accept a poorly fitting model increases as sample size decreases [200]. Therefore, had our sample been larger, some of our IRT models may not have been found to have acceptable fit. Nevertheless, in a simulation study involving binary items in CFA and MIMIC models, Yu found that a chi-square p-value cutoff of 0.05 had acceptable Type I error rates with sample sizes smaller than ours [200]. Similar research involving larger samples is necessary to confirm our findings.

Second, we only used item response data from mothers for these analyses. This is limited in that mother's assessments of father's parenting appear to be influenced by the type and quality of their relationship with the father [213]. In other words, our estimates of father's involvement only reflect mothers' perceptions, which are susceptible to bias depending on composition of the sample under study. Similarly, our analyses of agreement between mothers' and fathers' questionnaire response data found relatively poor agreement for items in all modes of paternal influence. For these reasons, it may have been preferable to fit multi-level IRT models simultaneously to response data from mothers and fathers. We were not able to explore this approach because only a minority of fathers participated in our study. Future research on methods for combing fathering questionnaire data from multiple respondents would be needed to address this limitation.

Third, we used latent variable modelling to test the fit of our hypothetical model to the item response data. This approach has the benefit of being informed by theory. On the other hand, it is possible that other latent variable structures would have fit the data as well or better than the one we tested. Therefore, while we conclude that our hypothetical model is consistent with the data, it may not be the only model available for explaining the data. Exploratory factor analysis could be used in the future to explore alternative models.

Fourth, limited sample size and a large proportion of cohort members being lost to follow-up by the 6-month visit prevented us from modelling longitudinal changes in fathers' parenting practices.

Future research would be necessary to determine whether any questionnaire items function significantly differently as children age. A related limitation is that our study only covers the first 6 months of children's lives. Focusing on young children is somewhat justified by the fact that fathers' involvement at younger ages predicts their later involvement [221, 222]. However, researchers conducting large-scale surveys of fathering will likely wish to include a wider range of child age, necessitating evaluation of the questionnaire among other samples.

8.2 The potential to use mothers as proxy respondents in research on fathering

The large percentage of children and fathers living in separate residences, and the related pattern of frequent changes in residence by adults and children, imply that large-scale studies of fathering in South Africa must include built-in approaches for collecting information about non-co-resident fathers [48]. One potential solution would be to use proxy respondents, who are resident members of children's households, to provide data on non-co-resident fathers. It may be possible to use mothers as proxy respondents because South African children are twice as likely to live with their biological mother than their father (*Calculated by the author from South African General Household Survey data* [49]). To evaluate the utility of this approach, we assessed the extent, and nature, of disagreement between mothers' and fathers' responses on the fathering questionnaire. We found that information provided by mothers about fathers' sociodemographic and health characteristics agreed reasonably well with information provided by fathers. However, mothers' and fathers' ratings of fathers' parenting practices agreed poorly. Across conceptually distinct types of parenting practices, there was a consistent tendency for fathers to report their contributions at higher levels than did mothers.

Questionnaire respondents may disagree over the definition of the underlying traits being measured and over the definition of the thresholds between adjacent response options [204]. We found evidence that both of these factors may have contributed to poor parental agreement on father's parenting practices. For items measuring the frequency fathers were doing direct child care activities and household chores we found clear evidence that fathers and mothers disagreed about response thresholds. Most commonly, disagreement was over the thresholds separating the extreme top and bottom response options (i.e.: the threshold separating the "Never" and "Once or twice/Rarely" options and the one separating the "A few times per week" and "Everyday/More than once a day" options, respectively.) At both ends of the scale, mothers tended to be more likely to select the lower category and fathers the higher category.

Our item response data did not fit the distributional assumption of the polychoric correlation. Therefore, to assess parents' agreement over the definition of the trait underlying each item we capitalized on our findings from the IRT models. The IRT models provided evidence that each set of related questionnaire items was measuring a single continuous latent trait. Mothers' and fathers' total scores were modestly correlated for items measuring Accessibility, Direct Caregiving and Material provisioning traits, but only weakly correlated for items measuring Responsibility and Practical Support for Mother traits.

In short, mothers and fathers may have differed both in their interpretation of the fathering items included in the questionnaire (especially items measuring father's responsibility and involvement in household chores) and in the amount or frequency of father's contributions that was sufficient to assign a particular response category. Our results do not allow us to establish the causes of this disagreement. However, two factors that may have contributed are the availability of accepted norms of conduct for fathers and the degree of observability of the parenting practices under question.

Parents' individual understandings about the appropriate types and amounts of fathers' parenting practices are expected to be, at least in part, shaped by cultural and social norms [23]. Collectively, the men and women in our sample reported more concordant beliefs about the importance of fathers' financial provisioning than about the importance of fathers' caregiving and teaching, even though, within individual mother-father pairs, agreement over these beliefs was low. Previous in-depth research into the fatherhood ideals of low-income, Black South Africans has suggested there are clear norms governing fathers' financial responsibility for their children [32, 82]. Cultural expectations about fathers' involvement in other types of child care have been found to be less well defined, possibly leading fathers' non-monetary contributions to be under-reported [32]. The availability of definite expectations about material provisioning by fathers my explain why we observed higher levels of agreement between fathers and mothers on items measuring material provisioning than on items measuring other modes of care.

Another contributing factor may be that mothers are able to report more easily on objective, directly observable fathering behaviours than on those that are subjective, private, or primarily cognitive or emotional [223, p. 1179-80]. That the direct caregiving and accessibility items on our questionnaire are more observable than the responsibility items could, in part, explain why a greater fraction of the former had overall percentages of agreement greater than 60%. Furthermore, among the direct caregiving items, the item measuring the frequency fathers sang to their children had the lowest overall agreement and a significant bias for fathers to report higher levels than mothers. It is possible that singing to children is something that fathers do more often in private than other caregiving items, making it a more difficult item for mothers to report. The fact that a greater percentage of mothers than fathers in our sample agreed with the statement that it is difficult for men to express affectionate feelings toward babies could suggest either that fathers tend to express their affection in private or that mothers tend not to recognize when fathers express it.

Only a single study has previously compared mothers' and fathers' accounts of fathers' involvement with children in South Africa [213]. Although this study was small, the investigators collected data using in-depth interviews and so were able to explore the influence of relationship dynamics on parents' agreement. Another strength of their study is that children were included as a third source of father involvement data. They concluded that mothers who were in romantic, co-residential relationships with their children's fathers tended to report more positively on fathers' financial contributions and contact with their children. These positive reports aligned more closely with fathers' and children's reports. In contrast, mothers in non-residential relationships or who were separated from their children's fathers tended to report lower levels of father involvement than did children and fathers.

Our sub-sample of mother-father pairs included greater percentages of co-residing and married parents than did the complete cohort. Therefore, if Makusha and colleagues' findings can be generalized, we should expect that the levels of agreement observed in our study would be higher than those in a national sample. Although we collected measures of relationship quality, the modest size of our sample prevented us from exploring whether these factors influenced agreement.

Weaknesses of our agreement analyses include the unknown generalizability of the findings (due to our sample not being representative of a wider population) and our inability to make statistical inferences about factors contributing to the observed low levels of agreement. Nevertheless, a strength of our analyses was that we examined agreement separately for items measuring conceptually distinct sets of parenting practices. Future large-scale research on fathering is likely to be aimed at identifying antecedents and consequences of different modes of paternal contribution similar to those used in our study. Therefore it is of value that our findings help to identify similarities and differences in agreement between mothers' and fathers' reports about different types of fathering practices.

A challenge of this type of agreement analysis is that neither source of data can be considered "true". Both mothers' and fathers' reports are based on personal perceptions. In addition, our participants may have purposefully or inadvertently misrepresented their perceptions for various reasons. Ultimately, our findings suggest that a single source of data on father's parenting practices may not be sufficient. Future research in this area should consider including other sources of information. In research involving fathers of older children, the children themselves are a logical source of information. Alternatively, researchers could include data collected through direct observation of fathers' interactions with their children, either during structured laboratory situations or naturalistic observation. Not only would these approaches afford a separate source of data, but they could also be used to assess the quality of father-child interactions, something that is difficult to do using questionnaires. On the other hand, these methods are intensive and it is unlikely that they could be used as the primary data source for population-level fathering research. The ideal would be a study design with direct observation selectively integrated so as to enrich less intensive types of data collection.

Future research could also aim to explore the causes of poor parental agreement and whether more specific instructions and definitions in questions could improve the consistency of the data.

Finally, it would be valuable to separately examine the association between fathering data provided by mothers and fathers and predictor and outcome variables of relevance to intervention designers and policymakers. Poor agreement between the absolute levels of fathers' parenting, as reported by mothers and fathers, may be of less concern if both sources of data produce similar inferences with respect to other variables.

Future studies involving paired data from larger samples could use an IRT approach to model agreement between response data from different sources. Tests of differential item functioning could be used to identify items having different statistical properties for different types of respondents. This information could assist in refining questionnaires. IRT models could also be used to place person locations estimated from different sources of data onto a common scale. In this way, disagreement, for example, over differences in threshold definitions used by different types of observers, could be explicitly accounted for in the models.

8.3 Summary of contributions to South African fathering research

To our knowledge, this is the first study to evaluate a questionnaire suitable for population-level measurement of South African fathers' involvement in caring for infants. Strengths of our study include the fact that the questionnaire was designed using an established conceptual framework, which addresses diverse components of involvement. Using a latent variable modelling approach we were able to demonstrate, using statistical tests, that the empirical findings generally fit with the conceptual model. We established that the questionnaire provides precise estimates of father's Accessibility, Direct Caregiving, and Practical Support for Mother for a modestly large percentage of the population. We also began to establish the validity of these measurements by showing that they are correlated with variables previously demonstrated to influence fathering. That mothers' and fathers' responses on our questionnaire showed poor agreement across a range of types of involvement reinforces and adds a quantitative dimension to previous qualitative research findings. Importantly, these findings suggest that future researchers may need to collect multiple sources of data to obtain reliable and valid measurements of fathers' contributions to children's care.

Chapter 9

Conclusion

In this study, we aimed to provide insight into the ways in which South African fathers contribute to promote the good health of their young children. There is an almost complete lack of quantitative data on the parenting practices of fathers in South Africa. For this reason, we approached our aim in two ways. First, using existing household survey data, we assessed whether residing with a father was associated with four important early childhood health outcomes. Second, we adapted a comprehensive fathering questionnaire and used it to collect primary data on the parenting practices of a sample of fathers of 0-6 month old infants in Cape Town. Our aim was to evaluate the measurement properties of the questionnaire to inform future population-level research on fathering in South Africa. In this chapter we synthesize the findings of the two parts of our study and propose recommendations for future research and intervention design.

9.1 Overall summary of findings

9.1.1 Effects of residing with a father on children's health

Our analysis of cross-sectional household structure data suggests that children whose fathers are resident members of their households do not, on average, have better health outcomes than those whose fathers do not reside with them. However, we observed large variation across neighbourhoods in our effect estimates. This suggests that, in some contexts, children who reside with a father tend to have improved health while, in other contexts, these children tend to have poorer health. Limited indicators of neighbourhood gender equality and employment availability did not account for a significant portion of the contextual variation in the effects of residing with a father.

Although, on the whole, father's co-residence status was not associated with children's health, we observed evidence that among some sub-groups there may be a benefit. In relation to children's immunization completeness and risk of recent illness, there was a trend for residing with a father to be more beneficial when parents were married. In addition, for children's immunization completeness, living with a single mother tended to be detrimental compared to living with multiple adult family members. The probability of being completely immunized seemed to be similarly increased regardless of whether the additional household member was the child's father or another male or female relative.

There is an entrenched history for Black South African households to have fluid residential arrangements and to have members dispersed across different dwellings. Therefore, an important limitation of these analyses is that we lacked information about children's residential histories and about their household membership beyond co-resident members.

9.1.2 Measuring father's contributions to infant's care

In our study of urban fathers' infant care practices, a majority of fathers were spending time with their children and doing a range of routine care activities at least a few times per week at assessments made when infants were 2-weeks, 16-weeks, and 6-months old. Similarly, a majority of fathers were contributing to purchases of children's material needs. Fewer fathers were supporting mothers by regularly doing household chores, and a minority were involved in decisions about their children's health care needs.

Our questionnaire produced precise estimates of fathers' relative positions on three continuous latent traits measuring their levels of direct caregiving, accessibility and practical support for mothers. A set of items measuring fathers' material provisioning were valuable for discriminating between above versus below average levels of provisioning, but could not estimate fathers' positions precisely along a continuous scale. Fathers had limited responsibility for their children's health care needs. Further research is needed to identify alternative items for precisely measuring fathers' levels of responsibility.

As evidence for the validity of measurements produced by the questionnaire, household structure, co-parental relationship characteristics and characteristics of father's employment were confirmed as strong predictors of father's care practices.

Although we observed promising evidence for the precision and validity of estimates of father's child care contributions obtained using our questionnaire, it was clear that mothers' and fathers' questionnaire responses had poor agreement. Therefore, relying on reports from a single observer may not be ideal in studies of fathering in South Africa.

9.2 Fathering practices may explain lack of association between co-residence status and child health

We proposed that data on fathers' actual child care practices, rather than just their residency status, may have helped to explain the observed lack of association between father-child co-residence and children's health outcomes in the SADHS dataset. Using the fathering data collected on the MIHS Fathering Sub-study cohort, we suggest hypotheses to explain the findings of the household structure analyses. However, we first emphasize some important difference between the two datasets, which limit how far we are able to generalize the findings of one to the other.

First, the MIHS followed a convenience sample of urban-dwelling, predominantly Black South Africans in the Western Cape. Whereas, in the SADHS analytic sample, half of the children were living in rural areas, a greater percentage were non-Black, and there was greater variation in parental and household socioeconomic status than among the MIHS sample. These cultural and social characteristics are expected to influence the nature of fathers' parenting practices and may also modify the influence of parenting on children's health.

Second, the MIHS data measure the care given by fathers to 0- to 6-month old infants. Whereas, we used the SADHS data to examine health outcomes of children under the age of five. Fathers' involvement in the care of older children may be quite different from that with infants. For example, in her ethnographic study of labour hostel dwellers in Cape Town, Ramphele observed that fathers' tended to be more involved caring for infants than older children [52].

Third, there have been a number of social and economic changes in South Africa since 1998 when the SADHS was completed. For example, the overall unemployment rate has increased, but, among women, unemployment has declined [63]. Increasing percentages of households live in formal dwellings and have access to basic services (like electricity and flush toilets) [224]. In 1998, the government introduced a cash transfer program for low-income parents, the Child Support Grant, which now reaches a majority of eligible recipients (*Update on child support grant uptake* (2008) as cited in [7]). The percentage of children with non-co-resident fathers appears to have increased over time [225]. The dominant reasons for residential separation may also have shifted. During the 2000s, temporary migrant labour from rural areas became less common, possibly because more migrants are permanently moving to cities [54]. In contrast, marriage rates continued to decline while rates of cohabitation increased only modestly [58, 79]. This implies that increasing percentages of children may be being born to parents who do not live together. The above changes in the material conditions and residential arrangements of many South African households may also have changed the ways in which obligations for children's care are negotiated and divided.

Keeping the above limitations in mind, the MIHS study findings suggest the following pair of hypotheses for why father-child residential separation was not an important factor influencing children's health in the SADHS.

First, although co-resident fathers were, on average, more involved in the child care practices assessed, a significant percentage of non-co-resident fathers were contributing to their children's care. In particular, residential separation had less influence on father's material provisioning than on other modes of care. Financial provisioning by fathers has been shown in previous research in South Africa to be associated with lower risk of child malnutrition [114]. Data are not available with which to assess the relative influence of different modes of paternal care on children's health. However, it is possible that material provisioning may have some of the greatest impact, especially considering this mode of care receives such emphasis in discussions of South African fatherhood ideals [32]. Therefore, if, as in the MIHS, relatively similar percentages of co-resident and non-co-resident fathers in the SADHS were making financial contributions to their children, this could explain the lack of association between co-residence status and child health outcomes.

Second, mothers reported that few fathers were involved in ensuring their infant's health care needs were met. In absolute terms, similar proportions of co-resident and non-co-resident fathers were involved in items related to infant's health care. Young children need to be taken to health clinics to receive routine childhood immunizations. As an important source of health information, attending clinics could also promote positive breastfeeding and hygiene practices, thereby influencing nutritional status and susceptibility to infection. If our data are illustrative of a situation in which many South African fathers have limited involvement in their children's routine health care needs, this could also partially explain why residing with a father is not associated with child health outcomes.

To test these hypotheses requires measurement of fathering practices in a national sample of fathers and estimation of associations between levels of contribution via different modes of care and children's health outcomes. The fathering questionnaire and analytic methods used in this study could form a starting point for this research, noting that some improvements to the questionnaire are warranted. We present recommendations for this future research below.

9.3 Implications and recommendations

In spite of limitations discussed in this and preceding chapters, the findings of this project allow us to make some clear recommendations for future research. Considered together with those of other researchers, our findings also have implications for the design of interventions to strengthen families for child wellbeing.

9.3.1 Recommendations for future research

Further development of a questionnaire for measuring fathering practices, which would be suitable for population-level research in South Africa, requires future research to address the following objectives:

1. Refine and further validate the conceptual model of the modes by which fathers influence their children's wellbeing. In particular, our findings suggest that the ways fathers take responsibility for managing children's care and their material provisioning require further exploration. The emotional and cognitive work of parenting also deserve more explicit attention in the model [23]. Further theoretical work ought to be informed by qualitative data on fatherhood ideals among the diverse social and cultural groups of South Africa - including perceptions about the nature and amounts of contributions expected of fathers. Because the ideals of fatherhood may have limited overlap with fathers' actual conduct [226], future work ought also to be informed by observations of men's care practices. Some of this data already exists but, as is the case with our study, research on South African fathers to date has usually focused on low-to-middle-income Black African men. Research involving men from other ethnic and racial groups and social classes is needed to inform a more inclusive model of South African fatherhood.

2. Evaluate the questionnaire among other samples of respondents and compare the measurement properties observed across samples. In particular, it would be valuable to assess the questionnaire's ability to measure contributions of fathers of slightly older children (6-months to 2-years of age), higher income fathers, fathers living in rural areas, and fathers from other racial and cultural groups. Future evaluations could be strengthened by concurrently collecting qualitative data to explore respondents' understandings of the care practices being assessed and how these relate to their own fatherhood beliefs and expectations. By collecting both qualitative and quantitative data from paired respondents (for example fathers and mothers or fathers and children), future investigators could identify causes of poor agreement in the item response data. The aim could be

to identify refinements to the questionnaire to improve inter-respondent agreement; or to evaluate methods of combining item response data from multiple respondents.

More generally, future research aimed at informing interventions to promote beneficial fathering practices should address the following objectives:

1. Collect data on fathering together with data on child health outcomes in a study statistically powered to detect associations between the two. Ideally, such a study would involve a longitudinal design, such that the temporal ordering of care practices and health outcomes can be clearly established. It would also be important to measure and statistically control for mother's parenting practices because these influence both father's parenting and child wellbeing [223]. Additionally, these types of studies could collect information about household structure and characteristics of the co-parental relationship. This would allow research into how these characteristics shape fathering longitudinally and how they interact with fathering to influence children's health outcomes.

2. Instead of focusing on the care practices of individual parents, examine the dynamics of child care arrangements within the family as a system. Our findings reinforce those of other studies showing that South African children live in a wide variety of family forms, in which fluidity of residential arrangements and physical separation of household members are common features. In our brief review of the literature on traditional Southern African family systems, we highlighted the cultural norm for child care to be viewed as a collective responsibility of extended kin. These features may imply that, at any given point in time, the contributions of isolated caregivers will be less important for children's wellbeing than the totality of care arrangements in the family system and how these are negotiated. Our study provides insight into possible challenges that will need to be overcome in conducting this type of research: how to delineate the boundaries of households and families; from whom to obtain reliable information about the contributions of each family member; how to combine information from different sources while being sensitive to the influence of power dynamics operating within the family; and how to conceptualize the care contributions of people in varying social positions within the family and with varying degrees of connectedness to the child.

3. Evaluate interventions intended to change fathers' parenting practices. Studies such as ours, which use a sample from a single study site, provide insight into the micro-level (individual and family) characteristics influencing fathering. Large-scale studies, or comparisons involving multiple smaller studies set in different contexts, could additionally explain how wider social, cultural and economic conditions shape men's parenting. It is possible that effective interventions will need to target a combination of micro- and macro-level factors.

9.3.2 Implications for designing family-strengthening interventions

Our analysis of the 1998 SADHS data provides further evidence that the nuclear family form is far from the only one in which to raise healthy children in South Africa. Across the groups of children defined by the extended household structure variable, there were no significant differences in the probability of any health outcome except immunization completeness. In fact, a relatively large percentage of children in all groups had experienced negative health outcomes. This suggests that it would be inappropriate to target family-strengthening interventions on the basis of household structure. There were children in all of the household structures we examined who may have benefited from family-strengthening. However, similarly to Richter and Desmond, we found that households comprised of children and a single adult may be less economically secure than households with multiple adult members [80]. Dependence on a single adult may result in increased risk of some adverse child health outcomes, but this may depend on the particular outcome. In our study, these children were only at increased risk for being incompletely immunized. This evidence does not seem sufficient to recommend targeting single-adult households. However, having a single adult member could be considered with other indicators of household risk, such as food insecurity and income instability, when identifying groups for interventions [80].

Our study findings support the inclusion of co-parental relationship strengthening and economic empowerment components in family-strengthening interventions.

There are multiple lines of evidence in our study for the importance of the co-parental relationship. In the SADHS dataset, co-residence of fathers tended to be more strongly associated with beneficial child health outcomes when parents were married. In the MIHS, fathers tended to have greater levels of involvement in children's care when they were in a marital compared to a non-marital relationship with the child's mother. Furthermore, whether married or unmarried, being in an exclusive romantic relationship with the mother was associated with greater father involvement. During discussions with study participants, a distrustful relationship between mother and father was identified as an important barrier to fathers' involvement, particularly for non-co-resident fathers. Relationship strengthening could involve communication and relationship skills training, possibly including reflection on inequitable gender attitudes and beliefs [227]; parenting skills training [228]; relationship counselling; and screening, with appropriate referral, for intimate partner violence, addictions and mental illness [11]. In order to support involvement by non-co-resident and unmarried fathers, programs could be made available to separating and separated parents with the aims of providing information about harmful effects of parental conflict on children, training in positive parenting skills and assistance in negotiating co-parenting and child support arrangements, with an emphasis on meeting the needs of children [229].

Contexts of limited economic opportunity have been implicated in fostering gender-inequitable norms of masculinity [183], and in reducing fathers' material and emotional contributions to their children [47, 52]. Consistent with this, we found that fathers who were not working were significantly less likely to be involved in providing for children's material needs. They also tended to be less likely to be contributing via the other modes of care. The high rate of unemployment in South Africa implies that economic empowerment interventions have the potential to benefit a large percentage of the population. Such interventions could include cash transfers to vulnerable families, micro-credit schemes to support income generating activities, and vocational skills training [230, 228]. It is important that empowerment interventions support women as well as men. Ideally, they should aim to enable more equitable involvement of men and women in labour inside and outside of the home [230]. Careful evaluation will be necessary to ensure that these interventions do not perpetuate patriarchal gender norms in which economic provisioning by men is linked to their power over women and children, as this is likely to result in more harm than benefit [231].

9.4 Concluding remarks

This project aimed to explore how fathers contribute to the care and health of young children in South Africa. It did not definitively establish whether greater positive involvement of fathers in children's care improves children's health outcomes. However, in part due to the contributions made through this project, it should be possible for future research to answer this question. In addition, this project has provided clear evidence to counter two popular perceptions about fathers and fatherhood in South Africa. First, we showed that the pattern for large numbers of fathers to live in separate residences from their children is not, generally, evidence that fathers are abandoning their childrearing responsibilities. Second, we showed that, in general, men are not absent from the work involved in caring for young children. We are not arguing that fathers contribute as much time or effort as mothers do to direct child care. On the basis of our own findings and those of other scholars, we believe the opposite is true. However, we believe that men can be, and are, involved in caring for children in a number of ways. We also believe that, with more research in this area, it ought to be possible to identify ways of achieving more equitable involvement of men in care work, in ways that benefit women, children and men themselves.

References

[1] UNICEF. *Child mortality estimates: South Africa*. URL: http://www.childmortality.org/index.php?r=site/graph&ID=ZAF_South%20Africa (visited on 04/17/2012).

[2] David Sanders, Debbie Bradshaw, and Ngashi Ngongo. “The status of child health in South Africa”. In: *South African Child Gauge 2009/2010*. Ed. by M. Kibel et al. Cape Town: Children’s Institute, University of Cape Town, 2010, pp. 29–40. ISBN: 978-0-9814320-4-5.

[3] Neil McKerrow and Mphele Mulaudzi. “Child Mortality in South Africa: Using Existing Data”. In: *South African health review 2010*. Ed. by Fonn Sharon and Ashnie Padarath. Durban: Health Systems Trust (South Africa), 2010. ISBN: 9781919839691.

[4] Unicef. *Strategy for improved nutrition of children and women in developing countries*. Unicef, 1990.

[5] Nadine Nannan et al. “Levels and differentials in childhood mortality in South Africa, 1977-1998.” In: *J Biosoc Sci* 39.4 (July 2007), pp. 613–32. ISSN: 0021-9320. DOI: 10.1017/S0021932006001702.

[6] Medical Research Council & Measure DHS+ Department of Health. *South African Demographic and Health Survey 1998, Full Report*. Pretoria: National Department of Health, 2002.

[7] Mickey Chopra et al. “Saving the lives of South Africa’s mothers, babies, and children: can the health system deliver?” In: *Lancet* 374.9692 (Sept. 2009), pp. 835–46. ISSN: 1474-547X. DOI: 10.1016/S0140-6736(09)61123-5.

[8] Candy Day et al. *District Health Barometer Year 2008/09*. Durban: Health Systems Trust, May 2010.

[9] Mickey Chopra et al. “Achieving the health Millennium Development Goals for South Africa: challenges and priorities.” In: *Lancet* 374.9694 (Sept. 2009), pp. 1023–31. ISSN: 1474-547X. DOI: 10.1016/S0140-6736(09)61122-3.

[10] Linda M. Richter and Lorraine Sherr. “Strengthening families: a key recommendation of the Joint Learning Initiative on Children and AIDS (JLICA).” In: *AIDS Care* 21 Suppl 1 (2009), pp. 1–2. ISSN: 1360-0451.

[11] Theresa S. Betancourt et al. “Family-centred approaches to the prevention of mother to child transmission of HIV.” In: *Journal of the International AIDS Society* 13 Suppl 2 (2010), S2. ISSN: 1758-2652. DOI: 10.1186/1758-2652-13-S2-S2.

[12] *Male involvement in the prevention of mother-to-child transmission of HIV*. Geneva, Switzerland: World Health Organization, 2012. ISBN: 978 92 4 150367 9.

[13] Matthew R. Dudgeon and Marcia C. Inhorn. "Men's influences on women's reproductive health: medical anthropological perspectives". In: *Social Science & Medicine* 59.7 (2004), pp. 1379–1395.

[14] United Nations. *Report of the International Conference on Population and Development : Cairo, 5-13 September 1994*. New York: United Nations, 1995. ISBN: 9211512891.

[15] Marie-Louise Newell et al. "Mortality of infected and uninfected infants born to HIV-infected mothers in Africa: a pooled analysis." In: *Lancet* 364.9441 (2004), pp. 1236–43. ISSN: 1474-547X. DOI: 10.1016/S0140-6736(04)17140-7.

[16] Adam Aluisio et al. "Male antenatal attendance and HIV testing are associated with decreased infant HIV infection and increased HIV-free survival." In: *Journal of Acquired Immune Deficiency Syndromes* 56.1 (Jan. 2011), pp. 76–82. ISSN: 1944-7884. DOI: 10.1097/QAI.0b013e3181fdb4c4.

[17] Rachel Jewkes and Robert Morrell. "Gender and sexuality: emerging perspectives from the heterosexual epidemic in South Africa and implications for HIV risk and prevention." In: *Journal of the International AIDS Society* 13.6 (2010), pp. 1–11. ISSN: 1758-2652. DOI: 10.1186/1758-2652-13-6.

[18] Rachel Jewkes. "Intimate partner violence: causes and prevention". In: *The Lancet* 359.9315 (2002), pp. 1423–29.

[19] Rachel Jewkes and Naeema Abrahams. "The epidemiology of rape and sexual coercion in South Africa: an overview." In: *Social Science & Medicine* 55.7 (Oct. 2002), pp. 1231–44. ISSN: 0277-9536.

[20] Chris Desmond and Victoria Hosegood. "Men, families and HIV and AIDS". In: *Men in families and family policy in a changing world*. New York: United Nations Division for Social Policy and Development, 2011, pp. 163–201. ISBN: 9789211303063.

[21] Anna Sarkadi et al. "Fathers' involvement and children's developmental outcomes: a systematic review of longitudinal studies." In: *Acta Paediatrica* 97.2 (Feb. 2008), pp. 153–8. ISSN: 0803-5253. DOI: 10.1111/j.1651-2227.2007.00572.x.

[22] Dean Peacock et al. "Men, HIV/AIDS, and human rights". In: *Journal of Acquired Immune Deficiency Syndromes* 51.Suppl 3 (2009), S119. ISSN: 1525-4135.

[23] William Marsiglio, Randal D. Day, and Michael E. Lamb. "Exploring Fatherhood Diversity: Implications for Conceptualizing Father Involvement". In: *Marriage & Family Review* 29.4 (2000), pp. 269–93.

[24] Robert Morrell. "Fathers, fatherhood and masculinity in South Africa". In: *BABA: men and fatherhood in South Africa*. Cape Town: Human Sciences Research Council Press, 2006, pp. 13–25.

[25] Esther Dermott. “Paradoxes of contemporary fatherhood”. In: *Intimate Fatherhood: A Sociological Analysis*. Routledge, 2009, pp. 7–24. ISBN: 0415422612.

[26] Michael E. Lamb et al. “Paternal Behavior in Humans”. In: *American Zoologist* 25.3 (1985), pp. 883–94. ISSN: 00031569. URL: http://www.jstor.org/stable/3883043.

[27] Jane Ribbens McCarthy and Rosalind Edwards. *Key concepts in family studies*. London: SAGE, 2011. ISBN: 9781412920056.

[28] William Marsiglio et al. “Social fatherhood and paternal involvement: Conceptual, data, and policymaking issues”. In: *Report of the Working Group on Conceptualising Male Parenting. Report prepared and presented for the NICHD Conference on Fathering and Male Fertility: Improving Data and Research*. 1997.

[29] Michael E. Lamb et al. “A biosocial perspective on paternal behavior and involvement”. In: *Parenting across the life span: Biosocial dimensions* (1987), pp. 111–42.

[30] Joseph H. Pleck. “Paternal involvement: Levels, sources, and consequences”. In: *The role of the father in child development*. Ed. by Michael E. Lamb. 3rd ed. New York: John Wiley & Sons, 1997, pp. 222–71.

[31] Elizabeth H. Pleck and Joseph H. Pleck. “Fatherhood ideals in the United States: Historical dimensions”. In: *The role of the father in child development*. Ed. by Michael E. Lamb. 3rd ed. New York: John Wiley & Sons, 1997, pp. 33–48.

[32] Catherine M. Montgomery et al. “Men’s involvement in the South African family: engendering change in the AIDS era.” In: *Social Science & Medicine* 62.10 (May 2006), pp. 2411–9. ISSN: 0277-9536. DOI: 10.1016/j.socscimed.2005.10.026.

[33] Naomi Bromberg Bar-Yam and Lori Darby. “Fathers and Breastfeeding: A Review of the Literature”. In: *Journal of Human Lactation* 13.1 (Mar. 1997), pp. 45–50. ISSN: 0890-3344. DOI: 10.1177/089033449701300116.

[34] Marci Lobel. “Conceptualizations, measurement, and effects of prenatal maternal stress on birth outcomes.” In: *Journal of Behavioral Medicine* 17.3 (June 1994), pp. 225–72. ISSN: 0160-7715.

[35] Marinus H. van Ijzendoorn, Carlo Schuengel, and Marian J. Bakermans-Kranenburg. “Disorganized attachment in early childhood: meta-analysis of precursors, concomitants, and sequelae.” In: *Development and Psychopathology* 11.2 (1999), pp. 225–49. ISSN: 0954-5794.

[36] Mark Tomlinson, Peter Cooper, and Lynne Murray. “The mother-infant relationship and infant attachment in a South African peri-urban settlement.” In: *Child Development* 76.5 (2005), pp. 1044–54. ISSN: 0009-3920. DOI: 10.1111/j.1467-8624.2005.00896.x.

[37] W. Henry Mosley and Lincoln C. Chen. “An analytical framework for the study of child survival in developing countries”. In: *Population and development review* 10 (1984), pp. 25–45.

[38] Ann V. Millard. “A causal model of high rates of child mortality.” In: *Social Science & Medicine* 38.2 (Jan. 1994), pp. 253–68. ISSN: 0277-9536.

[39] Gary S. Becker. “A Theory of the Allocation of Time”. In: *The economic journal* 75.299 (1965), pp. 493–517.

[40] David C. Ribar. “What do social scientists know about the benefits of marriage?: A review of quantitative methodologies”. In: *IZA Discussion paper series* 998 (Jan. 2004).

[41] Robert Haveman and Barbara Wolfe. “The determinants of children’s attainments: A review of methods and findings”. In: *Journal of economic literature* 33.4 (1995), pp. 1829–78.

[42] Nancy Folbre. “Household Production in the Philippines: A Non-Neoclassical Approach”. In: *Economic Development and Cultural Change* 32.2 (Jan. 1984), pp. 303–30.

[43] Sean Jones. “Singlehood for security: towards a review of the relative economic status of women and children in woman-led households”. In: *Society in Transition* 30.1 (1999), pp. 13–27.

[44] James S. Coleman. “Social capital in the creation of human capital”. In: *American journal of sociology* (1988), S95–S120.

[45] Margo Russell. “Understanding Black Households: The Problem”. In: *Social Dynamics* 29.2 (Dec. 2003), pp. 5–47. ISSN: 0253-3952. DOI: 10.1080/02533950308628674.

[46] Desmond Lesejane. “Fatherhood from an African cultural perspective”. In: *Baba: men and fatherhood in South Africa*. Ed. by Linda M. Richer and Robert Morrell. Human Sciences Research Council, 2006, pp. 173–182.

[47] William J. Doherty, Edward F. Kouneski, and Martha F. Erickson. “Responsible Fathering: An Overview and Conceptual Framework”. In: *Journal of Marriage and Family* 60.2 (1998), pp. 277–92. ISSN: 00222445. URL: http://www.jstor.org/stable/353848.

[48] Victoria Hosegood and Sangeetha Madhavan. “Understanding Fatherhood and Father Involvement in South Africa: Insights from Surveys and Population Cohorts”. In: *Fathering: A Journal of Theory, Research, and Practice about Men as Fathers* 10.3 (Sept. 2012), pp. 257–73. ISSN: 1537-6680. DOI: 10.3149/fth.1003.257.

[49] *Statistics South Africa Nesstar Data Repository*. URL: http://interactive.statssa.gov.za:8282/webview/ (visited on 05/16/2012).

[50] Colin Murray. “Class, gender and the household: The developmental cycle in Southern Africa”. In: *Development and Change* 18.2 (1987), pp. 235–49.

[51] Debbie Budlender and Francie Lund. “South Africa: A Legacy of Family Disruption”. In: *Development and Change* 42.4 (2011), pp. 925–46. ISSN: 0012-155X.

[52] Mamphela Ramphele. *A bed called home: Life in the migrant labour hostels of Cape Town*. Athens, Ohio: Ohio University Press, 1993.

[53] Andrew Spiegel, Vanessa Watson, and Peter Wilkinson. “Domestic diversity and fluidity among some African households in Greater Cape Town”. In: *Social Dynamics* 22.1 (1996), pp. 7–30.

[54] Dorrit Posel. “Households and labour migration in post-apartheid South Africa”. In: *Studies in Economics and Econometrics* 34.3 (2010), pp. 129–41.

[55] Margo Russell. "Are Urban Black Families Nuclear? A Comparative Study of Black and White South African Family Norms". In: *Social Dynamics* 29.2 (Dec. 2003), pp. 153–76. ISSN: 0253-3952. DOI: 10.1080/02533950308628679.

[56] Nhlanhla D. Mkhize. "African traditions and the social, economic and moral dimensions of fatherhood". In: *Baba: men and fatherhood in South Africa*. Ed. by Linda M. Richer and Robert Morrell. Human Sciences Research Council, 2006, pp. 183–98.

[57] Henrietta L. Moore. "Mothering and social responsibilities in a cross-cultural perspective". In: *Good enough mothering: Feminist perspectives on lone motherhood*. Ed. by Elizabeth Bartolaia Silva. Routledge London, 1996, pp. 58–75.

[58] Victoria Hosegood, Nuala McGrath, and Tom A. Moultrie. "Dispensing with marriage: Marital and partnership trends in rural KwaZulu-Natal, South Africa 2000-2006". In: *Demographic Research* 20 (Mar. 2009), pp. 279–312. ISSN: 1435-9871. DOI: 10.4054/DemRes.2009.20.13.

[59] Elena Moore and Rajen Govender. "Marriage and Cohabitation in South Africa: An Enriching Explanation?" In: *Journal of Comparative Family Studies* 44.5 (2013), pp. 623–39. ISSN: 0047-2328.

[60] Virginia Van der Vliet. "Staying single: A strategy against poverty?" In: *Second carnegie inquiry into poverty and development in Southern Africa*. Vol. 116. Cape Town: Southern Africa Labour and Development Research Unit, 1984. ISBN: 0 7992 0726 8.

[61] Elena Moore. "Transmission and Change in South African Motherhood: Black Mothers in Three-Generational Cape Town Families". In: *Journal of Southern African Studies* 39.1 (Mar. 2013), pp. 151–70. ISSN: 0305-7070. DOI: 10.1080/03057070.2013.764713.

[62] Michel Garenne et al. "Understanding marital and premarital fertility in rural South Africa". In: *Journal of Southern African Studies* 27.2 (2001), pp. 277–90.

[63] *Labour market dynamics in South Africa, 2013*. Pretoria: Statistics South Africa, 2014.

[64] *Encyclopaedia Britannica*. URL: http://www.britannica.com/EBchecked/topic/126829/Coloured (visited on 02/25/2015).

[65] Vonnie C. McLoyd. "Socialization and development in a changing economy: The effects of paternal job and income loss on children." In: *American Psychologist* 44.2 (1989), pp. 293–302.

[66] Mamphela Ramphele and Linda M. Richter. "Migrancy, family dissolution and fatherhood". In: *Baba: men and fatherhood in South Africa*. Human Sciences Research Council, 2006, pp. 73–81. ISBN: 0796920966.

[67] Loring Jones. "Unemployed fathers and their children: Implications for policy and practice". In: *Child and Adolescent Social Work Journal* 8.2 (1991), pp. 101–116.

[68] Olive Shisana et al. *South African National HIV Prevalence, Incidence and Behaviour Survey, 2012*. Cape Town: HSRC Press, 2014.

[69] Debra A. Murphy et al. “Anxiety/stress among mothers living with HIV: effects on parenting skills and child outcomes.” In: *AIDS Care* 22.12 (Dec. 2010), pp. 1449–58. ISSN: 1360-0451. DOI: 10.1080/09540121.2010.487085.

[70] Jamie M. Lachman et al. “Positive parenting for positive parents: HIV/AIDS, poverty, caregiver depression, child behavior, and parenting in South Africa.” In: *AIDS Care* 26.3 (2014), pp. 304–13. ISSN: 1360-0451. DOI: 10.1080/09540121.2013.825368.

[71] Max O. Bachmann and Frikkie L. R. Booysen. “Economic causes and effects of AIDS in South African households.” In: *AIDS* 20.14 (Sept. 2006), pp. 1861–7. ISSN: 0269-9370. DOI: 10.1097/01.aids.0000244205.03382.84.

[72] Muhammad Aarif Adam and Leigh F. Johnson. “Estimation of adult antiretroviral treatment coverage in South Africa.” In: *South African Medical Journal* 99.9 (Sept. 2009), pp. 661–7. ISSN: 0256-9574.

[73] Beverly J. Antle et al. “Challenges of parenting for families living with HIV/AIDS.” In: *Social Work* 46.2 (Apr. 2001), pp. 159–69. ISSN: 0037-8046.

[74] World Health Organization. *Guidelines on HIV and infant feeding principles and recommendations for infant feeding in the context of HIV and a summary of evidence*. Geneva: World Health Organization, 2010. ISBN: 9789241599535.

[75] Laura Porter et al. “HIV status and union dissolution in sub-Saharan Africa: the case of Rakai, Uganda.” In: *Demography* 41.3 (Aug. 2004), pp. 465–82. ISSN: 0070-3370.

[76] Sangeetha Madhavan, Nicholas W. Townsend, and Anita I. Garey. “’Absent Breadwinners’: Father-Child Connections and Paternal Support in Rural South Africa.” In: *Journal of Southern African Studies* 34.3 (Sept. 2008), pp. 647–63. ISSN: 0305-7070. DOI: 10.1080/03057070802259902.

[77] Wendy Sigle-Rushton and Sara McLanahan. *Father absence and child wellbeing: A critical review*. Russell Sage Foundation, 2004.

[78] Michael E. Lamb. “The history of research on father involvement”. In: *Marriage & Family Review* 29.2-3 (2000), pp. 23–42.

[79] Dorrit Posel, Stephanie Rudwick, and Daniela Casale. “Is marriage a dying institution in South Africa? Exploring changes in marriage in the context of ilobolo payments”. In: *Agenda* 25.1 (2011), pp. 102–11.

[80] Linda M. Richter and Chris Desmond. “Targeting AIDS orphans and child-headed households? A perspective from national surveys in South Africa, 1995-2005.” In: *AIDS Care* 20.9 (Oct. 2008), pp. 1019–28. ISSN: 1360-0451. DOI: 10.1080/09540120701842738.

[81] Victoria Hosegood et al. *Fathers and the living arrangements, mobility and survival of young children in rural South Africa*. Marrakech, Morocco: Paper prepared for the XXVI IUSSP International Population Conference, Sept. 2009.

[82] Sharlene Swartz et al. *Teenage tata: voices of young fathers in South Africa*. HSRC Press Cape Town, 2009.

[83] Paul R. Amato. “Children of divorce in the 1990s: an update of the Amato and Keith (1991) meta-analysis.” In: *Journal of Family Psychology* 15.3 (Sept. 2001), pp. 355–70. ISSN: 0893-3200.

[84] Sara McLanahan, Laura Tach, and Daniel Schneider. “The Causal Effects of Father Absence”. In: *Annual Review of Sociology* 39.1 (July 2013), pp. 399–427. ISSN: 0360-0572. DOI: 10.1146/annurev-soc-071312-145704.

[85] Sarah Allen and Kerry Daly. “The effects of father involvement: A summary of the research evidence”. In: *Newsletter of the Father Involvement Initiative -Ontario Network* 1.1-11 (2002).

[86] Paul R. Amato and Joan G. Gilbreth. “Nonresident fathers and children’s well-being: A meta-analysis”. In: *Journal of Marriage and Family* (1999), pp. 557–73. ISSN: 0022-2445.

[87] Thomas G. O’Connor et al. “Distribution of accidents, injuries, and illnesses by family type. ALSPAC Study Team. Avon Longitudinal Study of Pregnancy and Childhood.” In: *Pediatrics* 106.5 (2000), E68. ISSN: 1098-4275.

[88] Kristen Harknett. “Children?”s Elevated Risk of Asthma in Unmarried Families: underlying structural and behavioral mechanisms”. In: *Center for Research on Child Wellbeing Working Paper #2005-01-FF* (2005).

[89] Takeo Fujiwara, Makiko Okuyama, and Kunihiko Takahashi. “Paternal involvement in child-care and unintentional injury of young children: a population-based cohort study in Japan.” In: *International Journal of Epidemiology* 39.2 (Apr. 2010), pp. 588–97. ISSN: 1464-3685. DOI: 10.1093/ije/dyp340.

[90] Olle Lundberg. “The impact of childhood living conditions on illness and mortality in adulthood”. In: *Social science & medicine* 36.8 (1993), pp. 1047–52.

[91] Sarah M. Allen and Kerry J. Daly. *The effects of father involvement: An updated research summary of the evidence*. Centre for Families, Work & Well-Being, University of Guelph, 2007.

[92] Natasha J. Cabrera et al. “Low-income fathers’ involvement in their toddlers’ lives: Biological fathers from the Early Head Start Research and Evaluation Study”. In: *Fathering: A Journal of Theory, Research, and Practice about Men as Fathers* 2.1 (2004), pp. 5–30.

[93] Jacqueline D. Shannon, Catherine S. Tamis-LeMonda, and Natasha J. Cabrera. “Fathering in infancy: Mutuality and stability between 8 and 16 months”. In: *Parenting* 6.2-3 (2006), pp. 167–88.

[94] Victoria Hosegood and Sangeetha Madhavan. “Data availability on men’s involvement in families in sub-Saharan Africa to inform family-centred programmes for children affected by HIV and AIDS.” In: *Journal of the International AIDS Society* 13 Suppl 2 (2010), S5. ISSN: 1758-2652. DOI: 10.1186/1758-2652-13-S2-S5.

[95] Susan P. Walker et al. “Child development: risk factors for adverse outcomes in developing countries”. In: *Lancet* 369.9556 (2007), pp. 145–57.

[96] Solveig Argeseanu Cunningham et al. “Prenatal development in rural South Africa: relationship between birth weight and access to fathers and grandparents.” In: *Population Studies* 64.3 (2010), pp. 229–46. ISSN: 1477-4747. DOI: 10.1080/00324728.2010.510201.

[97] Linda S. Adair, Barry M. Popkin, and David K. Guilkey. “The duration of breast-feeding: how is it affected by biological, sociodemographic, health sector, and food industry factors?” In: *Demography* 30.1 (1993), pp. 63–80. ISSN: 0070-3370.

[98] Anastasia J. Gage. “Familial and socioeconomic influences on children’s well-being: an examination of preschool children in Kenya.” In: *Social Science & Medicine* 45.12 (1997), pp. 1811–28. ISSN: 0277-9536.

[99] Jacinta Bronte-Tinkew and Gordon F. Dejong. “Do household structure and household economic resources predict childhood immunization? Evidence from Jamaica and Trinidad and Tobago”. In: *Population Research and Policy Review* 24.1 (2005), pp. 27–57.

[100] Anastasia J. Gage, A. Elisabeth Sommerfelt, and Andrea L. Piani. “Household structure and childhood immunization in Niger and Nigeria”. In: *Demography* 34.2 (1997), pp. 295–309.

[101] Sia E. Msuya et al. “Low male partner participation in antenatal HIV counselling and testing in northern Tanzania: implications for preventive programs.” In: *AIDS Care* 20.6 (2008), pp. 700–9. ISSN: 1360-0451. DOI: 10.1080/09540120701687059.

[102] Carey Farquhar et al. “Antenatal couple counseling increases uptake of interventions to prevent HIV-1 transmission.” In: *Journal of Acquired Immune Deficiency Syndromes* 37.5 (2004), pp. 1620–6. ISSN: 1525-4135.

[103] Lindiwe Sibeko et al. “Mothers’ infant feeding experiences: constraints and supports for optimal feeding in an HIV-impacted urban community in South Africa.” In: *Public Health Nutrition* 12.11 (2009), pp. 1983–90. ISSN: 1475-2727. DOI: 10.1017/S1368980009005199.

[104] Tanya Doherty et al. “A longitudinal qualitative study of infant-feeding decision making and practices among HIV-positive women in South Africa.” In: *The Journal of Nutrition* 136.9 (2006), pp. 2421–6. ISSN: 0022-3166.

[105] Petrida Ijumba et al. “Social circumstances that drive early introduction of formula milk: an exploratory qualitative study in a peri-urban South African community.” In: *Maternal and Child Nutrition* 10.1 (2014), pp. 102–11. ISSN: 1740-8709. DOI: 10.1111/mcn.12012.

[106] Kammi Schmeer. “Father absence due to migration and child illness in rural Mexico.” In: *Social Science & Medicine* 69.8 (2009), pp. 1281–6. ISSN: 1873-5347. DOI: 10.1016/j.socscimed.2009.07.030.

[107] Eileen Kennedy and Lawrence Haddad. “Are pre-schoolers from female-headed households less malnourished? A comparative analysis of results from Ghana and Kenya”. In: *The journal of development studies* 30.3 (1994), pp. 680–695.

[108] Adelheid Onyango, Katherine Tucker, and Thomas Eisemon. “Household headship and child nutrition: a case study in western Kenya.” In: *Social Science & Medicine* 39.12 (1994), pp. 1633–9. ISSN: 0277-9536.

[109] Catherine S. Molyneux et al. “Intra-household relations and treatment decision-making for childhood illness: a Kenyan case study”. In: *Journal of biosocial science* 34.01 (2002), pp. 109–31. ISSN: 1469-7599.

[110] Aurélien Franckel and Richard Lalou. “Health-seeking behaviour for childhood malaria: household dynamics in rural Senegal.” In: *Journal of Biosocial Science* 41.1 (2009), pp. 1–19. ISSN: 1469-7599. DOI: 10.1017/S0021932008002885.

[111] Amina Abubakar et al. “Socio-cultural determinants of health-seeking behaviour on the Kenyan coast: a qualitative study.” In: *PLoS One* 8.11 (2013), e71998. ISSN: 1932-6203. DOI: 10.1371/journal.pone.0071998.

[112] Israel Olatunji Orubuloye et al. “The impact of family and budget structure on health treatment in Nigeria”. In: *Health transition review* 1.2 (1991), pp. 189–210.

[113] Bronwyn Harris et al. “Inequities in access to health care in South Africa.” In: *Journal of Public Health Policy* 32 Suppl 1 (2011), S102–23. ISSN: 1745-655X. DOI: 10.1057/jphp.2011.35.

[114] Sangeetha Madhavan and Nicholas Townsend. “The social context of children’s nutritional status in rural South Africa.” In: *Scandinavian Journal of Public Health* 35.Suppl 69 (2007), pp. 107–17. ISSN: 1403-4956. DOI: 10.1080/14034950701355700.

[115] Rebecca Sear, Ruth Mace, and Ian A. McGregor. “Maternal grandmothers improve nutritional status and survival of children in rural Gambia.” In: *Proceedings of the Royal Society of London B: Biological Sciences* 267.1453 (2000), pp. 1641–7. ISSN: 0962-8452. DOI: 10.1098/rspb.2000.1190.

[116] Jacinta Bronte-Tinkew and Gordon DeJong. “Children’s nutrition in Jamaica: do household structure and household economic resources matter?” In: *Social Science & Medicine* 58.3 (2004), pp. 499–514. ISSN: 02779536. DOI: 10.1016/j.socscimed.2003.09.017.

[117] Maria Antonieta de B. L. Carvalhaes, Maria Helena D’Aquino Benício, and Aluísio J. D. Barros. “Social support and infant malnutrition: a casecontrol study in an urban area of Southeastern Brazil”. In: *British Journal of Nutrition* 94.03 (2005), p. 383. ISSN: 0007-1145. DOI: 10.1079/BJN20051505.

[118] Tim B. Heaton et al. “Cross-national variation in family influences on child health.” In: *Social Science & Medicine* 60.1 (2005), pp. 97–108. ISSN: 0277-9536. DOI: 10.1016/j.socscimed.2004.04.029.

[119] Bich Huu Tran. “Relationship between paternal involvement and child malnutrition in a rural area of Vietnam.” In: *Food and Nutrition Bulletin* 29.1 (2008), pp. 59–66. ISSN: 0379-5721.

[120] Rebecca Sear et al. “The effects of kin on child mortality in rural Gambia.” In: *Demography* 39.1 (2002), pp. 43–63. ISSN: 0070-3370.

[121] Shelley Clark and Dana Hamplová. "Single motherhood and child mortality in sub-Saharan Africa: a life course perspective." In: *Demography* 50.5 (2013), pp. 1521–49. ISSN: 0070-3370. DOI: 10.1007/s13524-013-0220-6.

[122] Debbie Budlender. "The Debate about Household Headship". In: *Social Dynamics* 29.2 (2003), pp. 48–72. ISSN: 0253-3952. DOI: 10.1080/02533950308628675.

[123] *Measure DHS: DHS Overview*. ICF International. URL: http://www.measuredhs.com/What-We-Do/Survey-Types/DHS.cfm (visited on 01/15/2014).

[124] *Description of the Demographic and Health Surveys: Individual Recode: Data File DHS III*. 1.1. Calverton, MD: ORC Macro, Mar. 2008.

[125] ICF International. "Demographic and Health Survey Interviewers Manual". In: *MEASURE DHS Basic Documentation No. 2*. Calverton, Maryland, USA: ICF International, Oct. 2012.

[126] Statistics South Africa. *The People of South Africa: Population Census, 1996, Census in brief*. Pretoria: Statistics South Africa, 1998.

[127] "Methodology used in census '96". In: *The People of South Africa Population Census 1996: The Count and How it Was Done*. Pretoria: Statistics South Africa, 1998. URL: http://www.statssa.gov.za/census01/Census96/HTML/default.htm.

[128] Coleman Dube. "Census Geography of South Africa". In: *AfricaGIS Conference*. Vol. 31. 2005.

[129] *Census '96 Household Questionnaire*. Pretoria: South African Central Statistical Service, 1996.

[130] *DataFirst*. University of Cape Town. URL: http://www.datafirst.uct.ac.za/ (visited on 12/23/2013).

[131] Katherine L. Frohlich et al. "Understanding place and health: a heuristic for using administrative data." In: *Health & Place* 13.2 (2007), pp. 299–309. ISSN: 1353-8292. DOI: 10.1016/j.healthplace.2006.01.007.

[132] Ana V. Diez Roux. "Investigating neighborhood and area effects on health". In: *American journal of public health* 91.11 (2001), pp. 1783–9. ISSN: 0090-0036.

[133] "Effect of breastfeeding on infant and child mortality due to infectious diseases in less developed countries: a pooled analysis. WHO Collaborative Study Team on the Role of Breastfeeding on the Prevention of Infant Mortality." In: *Lancet* 355.9202 (2000), pp. 451–5. ISSN: 0140-6736.

[134] Lee Baker. "The face of South Africa?'s expanded programme on immunisation (EPI) schedule". In: *SA Pharmaceutical Journal* 77.1 (2010), pp. 18–20.

[135] Debbie Budlender, Ntebaleng Chobokoane, and Yandiswa Mpetsheni. *A survey of time use: How South African women and men spend their time*. Pretoria: Statistics South Africa, 2001.

[136] Moyses Szklo and F. Javier Nieto. *Epidemiology : beyond the basics*. 2nd. Sudbury, Massachusetts: Jones and Bartlett Publishers, 2007. ISBN: 9780763729271.

[137] Sian L. Curtis, Ian Diamond, and John W. McDonald. "Birth interval and family effects on postneonatal mortality in Brazil". In: *Demography* 30.1 (1993), pp. 33–43. ISSN: 0070-3370.

[138] Zoe Matthews and Ian Diamond. "Child immunisation in Ghana: the effects of family, location and social disparity." In: *Journal of Biosocial Science* 29.3 (1997), pp. 327–43. ISSN: 0021-9320.

[139] Jean-Christophe C. Fotso and Barthelemy Kuate-Defo. "Socioeconomic inequalities in early childhood malnutrition and morbidity: modification of the household-level effects by the community SES." In: *Health & Place* 11.3 (2005), pp. 205–25. ISSN: 1353-8292. DOI: 10.1016/j.healthplace.2004.06.004.

[140] Jean-Christophe C. Fotso and Barthelemy Kuate-Defo. "Household and community socioeconomic influences on early childhood malnutrition in Africa." In: *Journal of Biosocial Science* 38.3 (2006), pp. 289–313. ISSN: 0021-9320. DOI: 10.1017/S0021932005026143.

[141] Laurel E. Hatt and Hugh R. Waters. "Determinants of child morbidity in Latin America: a pooled analysis of interactions between parental education and economic status." In: *Social Science & Medicine* 62.2 (2006), pp. 375–86. ISSN: 0277-9536. DOI: 10.1016/j.socscimed.2005.06.007.

[142] Ellen Van de Poel, Owen O'donnell, and Eddy Van Doorslaer. "What explains the rural-urban gap in infant mortality: Household or community characteristics?" In: *Demography* 46.4 (2009), pp. 827–50. ISSN: 0070-3370.

[143] Diddy Antai. "Migration and child immunization in Nigeria: individual- and community-level contexts." In: *BMC Public Health* 10 (2010), p. 116. ISSN: 1471-2458. DOI: 10.1186/1471-2458-10-116.

[144] Cindy-Lee Dennis. "Breastfeeding Initiation and Duration: A 1990-2000 Literature Review". In: *Journal of Obstetric, Gynecologic, & Neonatal Nursing* 31.1 (2002), pp. 12–32.

[145] F. T. Cutts et al. "Evaluation of factors influencing vaccine uptake in Mozambique." In: *International Journal of Epidemiology* 18.2 (1989), pp. 427–33. ISSN: 0300-5771.

[146] Pieter Streefland, A. M. R. Chowdhury, and Pilar Ramos-Jimenez. "Patterns of vaccination acceptance." In: *Soc Sci Med* 49.12 (Dec. 1999), pp. 1705–16. ISSN: 0277-9536.

[147] Jagrati V. Jani et al. "Risk factors for incomplete vaccination and missed opportunity for immunization in rural Mozambique." In: *BMC Public Health* 8.161 (2008). ISSN: 1471-2458. DOI: 10.1186/1471-2458-8-161.

[148] B. J. Selwyn. "The Epidemiology of Acute Respiratory Tract Infection in Young Children: Comparison of Findings from Several Developing Countries". In: *Reviews of Infectious Diseases* 12 (1990), S870–S888. ISSN: 01620886. URL: http://www.jstor.org/stable/4455724.

[149] Cesar G. Victora et al. "Water supply, sanitation and housing in relation to the risk of infant mortality from diarrhoea." In: *Int J Epidemiol* 17.3 (Sept. 1988), pp. 651–4. ISSN: 0300-5771.

[150] "Underlying and proximate determinants of child health: the Cebu Longitudinal Health and Nutrition Study." In: *American Journal of Epidemiology* 133.2 (1991), pp. 185–201. ISSN: 0002-9262.

[151] Anna C. Gorter et al. “Water supply, sanitation and diarrhoeal disease in Nicaragua: results from a case-control study.” In: *International Journal of Epidemiology* 20.2 (1991), pp. 527–33. ISSN: 0300-5771.

[152] Steven A. Esrey. “Water, waste, and well-being: a multicountry study.” In: *American Journal of Epidemiology* 143.6 (1996), pp. 608–23. ISSN: 0002-9262.

[153] Kare Mølbak et al. “Risk factors for diarrheal disease incidence in early childhood: a community cohort study from Guinea-Bissau.” In: *American Journal of Epidemiology* 146.3 (1997), pp. 273–82. ISSN: 0002-9262.

[154] Sharron R. Huttly, S. S. Morris, and V. Pisani. “Prevention of diarrhoea in young children in developing countries.” In: *Bulletin of the World Health Organization* 75.2 (1997), p. 163. ISSN: 0042-9686.

[155] David J. Fein et al. *The determinants of marriage and cohabitation among disadvantaged Americans: Research findings and needs*. Bethesda, MD: Abt Associates, 2003.

[156] William M. Bolstad and Samuel O. Manda. “Investigating child mortality in Malawi using family and community random effects: A Bayesian analysis”. In: *Journal of the American Statistical Association* 96.453 (2001), pp. 12–19.

[157] Carine Van Malderen, Herman Van Oyen, and Niko Speybroeck. “Contributing determinants of overall and wealth-related inequality in under-5 mortality in 13 African countries.” In: *Journal of Epidemiology and Community Health* 67.8 (2013), pp. 667–76. ISSN: 1470-2738. DOI: 10.1136/jech-2012-202195.

[158] Abhishek Singh, Ashish Singh, and Bidhubhusan Mahapatra. “The consequences of unintended pregnancy for maternal and child health in rural India: evidence from prospective data.” In: *Maternal and Child Health Journal* 17.3 (2013), pp. 493–500. ISSN: 1573-6628. DOI: 10.1007/s10995-012-1023-x.

[159] Sangeetha Madhavan, Abigail Harrison, and Christie Sennott. “Management of non-marital fertility in two South African communities.” In: *Culture, Health & Sex* 15.5 (2013), pp. 614–28. ISSN: 1464-5351. DOI: 10.1080/13691058.2013.777475.

[160] Maureen G. Phipps and MaryFran Sowers. “Defining early adolescent childbearing.” In: *American Journal of Public Health* 92.1 (2002), pp. 125–8. ISSN: 0090-0036.

[161] Ian M. Timaeus and Tom A. Moultrie. “Teenage childbearing and dropout from school in South Africa: Evidence from a household panel”. In: *XXVII International Population Conference Abstracts*. Busan, Korea: International Union for the Scientific Study of Population, Aug. 2013, p. 106.

[162] Ishmael Kalule-Sabiti et al. “Family formation and dissolution patterns”. In: *Families and households in post-apartheid South Africa: Socio-demographic perspectives*. Pretoria: Human Sciences Research Council, 2007, pp. 89–112.

[163] Department of Health, Medical Research Council, and OrcMacro. *South Africa Demographic and Health Survey 2003, Full Report*. Pretoria: Department of Health, 2007.

[164] Martha Anker. *Addressing sex and gender in epidemic-prone infectious diseases*. Geneva: World Health Organization, 2007.

[165] Frank L. Mott. "Sons, Daughters and Fathers' Absence: Differentials in Father-Leaving Probabilities and in Home Environments". In: *Journal of Family Issues* 15.1 (1994), pp. 97–128. ISSN: 0192-513X. DOI: 10.1177/019251394015001005.

[166] Joseph L. Mathew. "Inequity in childhood immunization in India: a systematic review". In: *Indian pediatrics* 49.3 (2012), pp. 203–223.

[167] Charles S. Wiysonge et al. "Individual and contextual factors associated with low childhood immunisation coverage in sub-Saharan Africa: a multilevel analysis." In: *PLoS One* 7.5 (2012), e37905. ISSN: 1932-6203. DOI: 10.1371/journal.pone.0037905.

[168] Ross D. Parke. "Father Involvement". In: *Marriage & Family Review* 29.2-3 (2000), pp. 43–58.

[169] Ros Hirschowitz. *Earning and Spending in South Africa: Selected findings and comparisons from the income and expenditure surveys of October 1995 and October 2000*. Pretoria: Statistics South Africa, 2002.

[170] Shea Oscar Rutstein and Kiersten Johnson. *The DHS wealth index. DHS Comparative Reports No. 6*. Cleverton, Maryland: ORC Macro, 2004.

[171] Andrew Gelman and Jennifer Hill. *Data analysis using regression and multilevel/hierarchical models*. New York: Cambridge University Press, 2007. ISBN: 9780521686891.

[172] John A. Nelder and Robert W. M. Wedderburn. "Generalized Linear Models". In: *Journal of the Royal Statistical Society. Series A (General)* 135.3 (1972), p. 370. ISSN: 00359238. DOI: 10.2307/2344614.

[173] Zheng Wu. "Generalized linear models in family studies". In: *Journal of Marriage and Family* 67.4 (2005), pp. 1029–1047.

[174] Benjamin M. Bolker et al. "Generalized linear mixed models: a practical guide for ecology and evolution." In: *Trends in Ecology and Evolution* 24.3 (2009), pp. 127–35. ISSN: 0169-5347. DOI: 10.1016/j.tree.2008.10.008.

[175] German Rodriguez and Noreen Goldman. "Improved estimation procedures for multilevel models with binary response: a case-study". In: *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 164.2 (2001), pp. 339–355.

[176] Ghassan Hamra, Richard Maclehose, and David Richardson. "Markov Chain Monte Carlo: an introduction for epidemiologists." In: *International Journal of Epidemiology* 42.2 (2013), pp. 627–34. ISSN: 1464-3685. DOI: 10.1093/ije/dyt043.

[177] Harvey Goldstein. "The 2-level model". In: *Wiley Series in Probability and Statistics: Multilevel Statistical Models*. 4th. Wiley, 2011, pp. 15–72.

[178] David Spiegelhalter et al. *WinBUGS User Manual, Version 1.4*. MRC Biostatistics Unit & Imperial College London, Jan. 2003.

[179] Terry Elrod. *WriteDatafileR*. University of Alberta, Nov. 2003. URL: http://www.public.iastate.edu/~alicia/stat544/software.htm (visited on 01/15/2013).

[180] Rachel Bray et al. *Growing up in the new South Africa: Childhood and adolescence in post-apartheid Cape Town*. Cape Town: HSRC Press, 2010.

[181] Tanya Doherty et al. "Early cessation of breastfeeding amongst women in South Africa: an area needing urgent attention to improve child health." In: *BMC Pediatrics* 12.105 (2012). ISSN: 1471-2431. DOI: 10.1186/1471-2431-12-105.

[182] I. S. Rogers, P. M. Emmett, and J. Golding. "The incidence and duration of breast feeding". In: *Early human development* 49 (1997), S45–S74.

[183] Philippe Bourgois. "In Search of Masculinity: Violence, Respect and Sexuality among Puerto Rican Crack Dealers in East Harlem". In: *British Journal of Criminology* 36.3 (1996), pp. 412–427.

[184] Jonathan Bendor and Piotr Swistak. "The Evolution of Norms". In: *American Journal of Sociology* 106.6 (2001), pp. 1493–1545. ISSN: 00029602. URL: http://www.jstor.org/stable/10.1086/321298.

[185] J. Ties Boerma et al. "Accuracy and completeness of mothers' recall of diarrhoea occurrence in pre-school children in demographic and health surveys." In: *International Journal of Epidemiology* 20.4 (1991), pp. 1073–80. ISSN: 0300-5771.

[186] Sharon R. Huttly et al. "Do mothers overestimate breast feeding duration? An example of recall bias from a study in southern Brazil." In: *American Journal of Epidemiology* 132.3 (1990), pp. 572–5. ISSN: 0002-9262.

[187] Emille van Heyningen. "Appendix C - Planning District C". In: *Planning Districts Socio-Economic Analysis 2007*. Strategic Development Information and GIS Department, City of Cape Town, Feb. 2007, pp. 29–36.

[188] Busi Kunene et al. *Involving men in maternity care South Africa*. University of the Witwatersrand, Population Council & Family Health International, Oct. 2004.

[189] Jacinta Bronte-Tinkew, Kristin A. Moore, and Tamara Halle. *DADS: The Developing a Daddy Survey and the Collaborative Work of the DADS Working Group*. Education Statistics Services Institute (ESSI) of the National Center for Education Statistics (NCES), Jan. 2002.

[190] Murray A. Straus et al. "The Revised Conflict Tactics Scales (CTS2): Development and Preliminary Psychometric Data". In: *Journal of Family Issues* 17.3 (1996), pp. 283–316. ISSN: 0192-513X. DOI: 10.1177/019251396017003001.

[191] Alan Agresti. *Categorical data analysis*. Hoboken, NJ: Wiley, 2013. ISBN: 9780470463635.

[192] William J. Conover. *Practical nonparametric statistics*. New York: Wiley, 1999. ISBN: 9780471160687.

[193] R. J. De Ayala. *The theory and practice of item response theory*. New York: Guilford Press, 2009. ISBN: 9781593858698.

[194] Tenko Raykov and George A. Marcoulides. “Validity”. In: *Introduction to psychometric theory*. Taylor & Francis, 2010, pp. 183–222.

[195] Tenko Raykov and George A. Marcoulides. “Introduction to item response theory”. In: *Introduction to psychometric theory*. Taylor & Francis, 2010, pp. 247–267.

[196] Bengt O. Muthén and Linda K. Muthén. *IRT in Mplus*. URL: http://www.statmodel.com/irtanalysis.shtml (visited on 12/08/2014).

[197] Linda K. Muthén and Bengt O. Muthén. *Mplus User’s Guide*. 7th ed. Los Angeles, CA: Muthén & Muthén, 2012.

[198] Tenko Raykov and George A. Marcoulides. “Introduction to latent variable modeling and confirmatory factor analysis”. In: *Introduction to psychometric theory*. Taylor & Francis, 2010, pp. 61–113.

[199] Tenko Raykov and George A. Marcoulides. “Fundamentals and Models of Item Response Theory”. In: *Introduction to psychometric theory*. Taylor & Francis, 2010, pp. 269–304.

[200] Ching-Yun Yu. “Evaluating Cutoff Criteria of Model Fit Indices for Latent Variable Models with Binary and Continuous Outcomes”. PhD thesis. Los Angeles, CA, 2002.

[201] Tihomir Asparouhov and Bengt O. Muthén. *Weighted least squares estimation with missing data*. URL: http://www.statmodel.com/download/GstrucMissingRevision.pdf (visited on 12/12/2014).

[202] Karl G. Jöreskog and Arthur S. Goldberger. “Estimation of a model with multiple indicators and multiple causes of a single latent variable”. In: *Journal of the American Statistical Association* 70.351a (1975), pp. 631–639.

[203] R. J. De Ayala. “Differential item functioning”. In: *The theory and practice of item response theory*. New York: Guilford Press, 2009, pp. 323–345. ISBN: 9781593858698.

[204] John Uebersax. *Statistical Methods for Rater and Diagnostic Agreement*. URL: http://www.john-uebersax.com/stat/agree.htm (visited on 09/18/2014).

[205] John Uebersax. *Introduction to the Tetrachoric and Polychoric Correlation Coefficients*. URL: http://www.john-uebersax.com/stat/tetra.htm (visited on 12/18/2014).

[206] John Fox. *Polycor*. Apr. 2010. URL: http://cran.r-project.org/web/packages/polycor/index.html (visited on 04/15/2014).

[207] Keith Dunnigan. “Tests of marginal homogeneity and special cases.” In: *Pharmaceutical Statistics* 12.4 (2013), pp. 213–6. ISSN: 1539-1612. DOI: 10.1002/pst.1573.

[208] Adrian Frith. *Census 2011*. URL: http://census2011.adrianfrith.com/place/199018 (visited on 12/12/2012).

[209] Christine DeMars. *Item response theory*. Oxford; New York: Oxford University Press, 2010. ISBN: 9780195377033.

[210] R. J. De Ayala. "Models for nominal polytomous data". In: *The theory and practice of item response theory*. New York: Guilford Press, 2009, pp. 237–274. ISBN: 9781593858698.

[211] Rob Palkovitz. "Reconstructing 'Involvement': Expanding Conceptualizations of Men?'s Caring in Contemporary Families". In: *Generative fathering: Beyond deficit perspectives*. Ed. by Allan J. Hawkins and David C. Dollahite. Thousand Oaks, CA: Sage, 1997, pp. 200–16.

[212] John Ditekemena et al. "Determinants of male involvement in maternal and child health services in sub-Saharan Africa: a review." In: *Reproductive Health* 9.32 (2012). ISSN: 1742-4755. DOI: 10.1186/1742-4755-9-32.

[213] Tawanda Makusha, Linda Richter, and Deevia Bhana. "Children?'s experiences of support received from men in rural KwaZulu-Natal". In: *Africa Development* 37.3 (2013), pp. 127–52.

[214] Sanford L. Braver, Pamela J. Fitzpatrick, and R. Curtis Bay. "Noncustodial Parent's Report of Child Support Payments". In: *Family Relations* 40.2 (1991), pp. 180–5. ISSN: 0197-6664. DOI: 10.2307/585480.

[215] Tihomir Asparouhov and Bengt Muthén. "Multiple-Group Factor Analysis Alignment". In: *Structural Equation Modeling: A Multidisciplinary Journal* 21.4 (2014), pp. 495–508. ISSN: 1070-5511. DOI: 10.1080/10705511.2014.919210.

[216] Alan J. Hawkins et al. "The Inventory of Father Involvement: A pilot study of a new measure of father involvement". In: *The Journal of Men's Studies* 10.2 (2002), pp. 183–196.

[217] Sarah J. Schoppe-Sullivan, Brent A. McBride, and Moon-Ho Ringo H. R. Ho. "Unidimensional versus multidimensional perspectives on father involvement". In: *Fathering: A Journal of Theory, Research, and Practice about Men as Fathers* 2.2 (2004), pp. 147–163.

[218] K. G. Anderson et al. "Paternal Care by Genetic Fathers and Stepfathers II:: Reports by Xhosa High School Students". In: *Evolution and Human Behavior* 20.6 (1999), pp. 433–51.

[219] S. Madhavan, L. Richter, and S. Norris. "Father Contact Following Union Dissolution for Low-Income Children in Urban South Africa". In: *Journal of Family Issues* (2014), pp. 1–23. ISSN: 0192-513X. DOI: 10.1177/0192513x14532255.

[220] Sangeetha Madhavan et al. "Fathers' Financial Support of Children in a Low Income Community in South Africa." In: *Journal of Family and Economic Issues* 35.4 (2014), pp. 452–63. ISSN: 1058-0476. DOI: 10.1007/s10834-013-9385-9.

[221] Michael E. Lamb et al. "The determinants of paternal involvement in primiparous Swedish families". In: *International Journal of Behavioral Development* 11.4 (1988), pp. 433–449.

[222] Natasha J. Cabrera, Jay Fagan, and Danielle Farrie. "Explaining the long reach of fathers' prenatal involvement on later paternal engagement." In: *Journal of Marriage and Family* 70.5 (2008), pp. 1094–2013. ISSN: 0022-2445. DOI: 10.1111/j.1741-3737.2008.00551.x.

[223] William Marsiglio et al. “Scholarship on fatherhood in the 1990s and beyond”. In: *Journal of Marriage and Family* 62.4 (2000), pp. 1173–91.

[224] Statistics South Africa. *Census 2011 Methodology and Highlights of key results*. Pretoria: Statistics South Africa, 2012.

[225] Dorrit Posel and Richard Devey. “The demographics of fathers in South Africa: an analysis of survey data, 1993–2002”. In: *Baba: men and fatherhood in South Africa*. Ed. by Linda M. Richter and Robert Morrell. Cape Town: HSRC Press, 2006, pp. 38–52. ISBN: 0796920966.

[226] Ralph LaRossa. “Fatherhood and social change”. In: *Family relations* 37.4 (1988), pp. 451–457.

[227] Rachel Jewkes, Mzikazi Nduna, and Nwabisa Jama. *Stepping Stones: a training manual for sexual and reproductive health communication and relationship skills*. 3rd. South Africa: Medical Research Council, 2010.

[228] Linda M. Richter et al. “Strengthening families to support children affected by HIV and AIDS”. In: *AIDS Care* 21.sup1 (2009), pp. 3–12. ISSN: 0954-0121. DOI: 10.1080/09540120902923121.

[229] Megan Morris and W. Kim Halford. “Family Mediation: A Guide for Family Therapists”. In: *Australia and New Zealand Journal of Family Therapy* 35.4 (2014), pp. 479–92. ISSN: 0814-723X. DOI: 10.1002/anzf.1078.

[230] Linda M. Richter, Julie Manegold, and Riashnee Pather. *Family and community interventions for children affected by AIDS*. Cape Town: HSRC Publishers, 2004.

[231] Elena Ghanotakis, Dean Peacock, and Rose Wilcher. “The importance of addressing gender inequality in efforts to end vertical transmission of HIV”. In: *Journal of the International AIDS Society* 15.4(Suppl 2) (2012), pp. 17385–95. ISSN: 1758-2652. DOI: 10.7448/IAS.15.4.17385.

[232] “Derived household income”. In: *1996 Census Community Profile databases metadata*. Pretoria: Statistics South Africa, 1999.

[233] Deon Filmer and Lant H. Pritchett. “Estimating Wealth Effects Without Expenditure DataOr Tears: An Application To Educational Enrollments In States Of India*”. In: *Demography* 38.1 (2001), pp. 115–132. ISSN: 0070-3370.

[234] John W. Graham. “Missing data analysis: making it work in the real world.” In: *Annual Review of Psychology* 60 (2009), pp. 549–76. ISSN: 0066-4308. DOI: 10.1146/annurev.psych.58.110405.085530.

Appendix A

Research Objective 1 Appendices

A.1 Detailed description of analytic variables

Table A.1: Description of variables used for statistical analyses including, where applicable, levels of categorical variables and derivation from original SADHS variables

Variable	**Levels**[§]	**Derivation**
Exposure		
Father's co-residence status	**Non-co-resident** Co-resident	Derived from three binary variables ascertained using the following questions in the SADHS Household schedule: Is [the child's] natural father alive? Does [the child's] natural father live in this household?[33] Does [the father] usually live here?[34] If all three questions were "Yes", children's fathers were coded as "Co-resident" on our derived analytic variable. If the first was "Yes" but second or third were "No", a code of "Non-co-resident" was assigned on the derived variable. If any of the three were missing, a "missing" value was assigned on the derived variable.
Outcomes		

[33]Interviewers were instructed that "natural father" means "the biological father of the child."

[34]This variable was queried using the father's number in the household roster to identify his record in the household member dataset.

Variable	**Levels§**	**Derivation**
Breastfed for 6 months or longer	**No** Yes Not applicable	A count variable in the SADHS dataset measures the child's duration of breastfeeding in months. This information was ascertained by three questions in SADHS women's questionnaire: Did you ever breastfeed [the child]?; Are you still breastfeeding [the child]?; and For how many months did you breastfeed [the child]? A dummy value of "94" identifies children who had never been breastfed. Children still breastfeeding at the time of the survey were assigned a breastfeeding duration equal to their age in months. To derive our binary analytic variable we categorized the original count variable. First, we calculated child's age in months as the difference between the interview date and child's birth date (both recorded as century month codes [124, p.5]). We coded children younger than six months old as "not applicable" and excluded them from analyses of this outcome. Among the remaining children, those with breastfeeding durations of six months or longer were coded "Yes", and children who were never breastfed or had breastfeeding durations of less than six months were coded "No".

Variable	Levels[§]	Derivation
Completely immunized for age group	**No** Yes	A series of nine variables in the SADHS dataset measure children's receipt of each dose of the routine childhood immunizations recommended by the South African Expanded Programme on Immunization (EPI-SA): polio, diptheria-pertussis-tetanus, and measles.[35] Based on the EPI-SA schedule in place from 1995 to 1999 [134], we identified five age groups in which children immunized according to schedule ought to have received distinct combinations of immunization doses (depicted in Table 3.1 on page 32).[36] Column three of Table 3.1 gives the lower limits used in calculating age groups. Column four gives the implied ranges in the lower age group cut-offs, taking into account our uncertainty about children's ages. We selected age groups such that, for each lower limit, the lowest value in our range of uncertainty is just greater than the recommended age of receipt for the batch of immunization doses that define that age group. In other words, all children within a particular age group should have had adequate opportunity to receive all of the immunization doses appropriate for that group. Children who had received all of the immunizations doses appropriate for their age group were coded as "Yes", and all others were coded as "No".[37]

[35]Hepatitis B was added to the South African EPI in 1995 (whereas, all other dose recommendations in Table 3.1 were in place prior to 1995), therefore four-year-old children in the 1998 SADHS dataset may not have had the opportunity to receive this vaccine. In addition, according to the 1998 SADHS full report, "...hepatitis B vaccination had not been adopted as a standard for the whole country at the time of the survey...." Department of Health [6, p. 121] For these reasons, we did not consider Hepatitis B doses when deriving our immunization completeness outcome variable.

[36]Children's birth dates and interview dates are recorded to the nearest month in the SADHS dataset. Therefore there is uncertainty of ± 1 month in calculating children's ages, making it necessary to use generous lower limits for the age windows.

[37]We treated the following levels of the original variables as equivalent indicators that a particular vaccine dose had been received: 1=yes, vaccination date on card; 2=yes, reported by mother, 3=yes; vaccination marked on card (but date missing). The purpose of doing this was to avoid excluding from our analyses the 4% of children whose health cards were reported missing, and the 22% whose health cards were not seen by interviewers.

Variable	Levels§	Derivation
Had recent episode of ARI	**No** Yes	Derived from variables relating to two questions in the SADHS woman's questionnaire: Has (the child) been ill or feverish with a cough at any time in the last 2 weeks?; and When (the child) was ill with a cough, did he/she breathe with difficulty or faster than usual with short, fast breaths? If both questions were answered "Yes", we coded children as "Yes" on our variable, as per the standard approach for studying period prevalence of acute respiratory infection using DHS data [6], Whereas, if either question was answered "No", we coded children as "No".
Had recent episode of diarrhoea	**No** Yes	This variable comes directly from the SADHS dataset and was ascertained using the following question in the woman's questionnaire: Has (the child) had diarrhoea in the last 2 weeks?
Potential effect modifiers of father's co-residence status		
Mother is currently married	**No** Yes	A dummy variable indicating whether the mother is currently married. Derived from the current marital status variable in the SADHS dataset. The implicit reference category includes all of the following marital statuses: never married, living like married, widowed, separated, and divorced. Note that it was not possible to ascertain whether the mother's husband was also the child's father. If the mother was married and the father was co-resident, we assumed that the father was the mother's husband. However, if the father was non-co-resident we did not make this assumption.

Variable	Levels§	Derivation
Extended household structure	**Co-resident father** Non-co-resident father, ⩾1 adult male relative Non-co-resident father, ⩾1 adult female relative, no males Non-co-resident father, only mother, no other adult relatives	The "co-resident father" category of this variable is identical to that of the primary exposure variable. The three remaining household structure categories are subdivisions of the "children with non-co-resident fathers" category of the primary exposure, with the addition of children whose biological fathers were reported to be dead at the time of the survey[38]. We classify adult household members as those 18 years or older based on evidence from the South African Time Use Survey, year 2000, about the relative time spent engaged in economic work and in household maintenance (which includes care work) by people in different age groups; although, on average, 10-19 year olds do spend time in both types of work (particularly girls doing household maintenance), the average amounts of time spend by 20-39 year olds (of both sexes, and in both types of work) is much greater [135, p. 38]. For this reason, we assume the most obvious benefit to children of having co-resident relatives will be from those relatives who are 18 years or older.
Child and mother covariates		

[38]We felt it would be reasonable to include children with dead fathers in analyses of the extended household structure variable because the primary focus is no longer on the co-residence statuses of biological fathers.

Variable	Levels§	Derivation
Birth order & preceding birth interval	1st born 2-4th born, birth interval <24 months **2-4th born, birth interval 24-47 months** 2-4th born, birth interval >47 months 5+ born, birth interval <24 months 5+ born, birth interval 24-47 months 5+ born, birth interval >47 months	We derived a four-level categorical variable from the original count of the child's position in her/his mother's birth history. We also derived a three-level variable from the number of months between the child's date of birth and the date of birth of her/his next oldest sibling. Our exploratory analyses suggested that there may be an important interaction between birth order and preceding birth interval. Because first born children do not have a preceding birth interval, a convenient way to model the interaction between these variables is to combine them into the single variable shown here [143, p. 3].
Place of delivery	Home **Public medical facility** Private medical facility	Derived by collapsing the more granular categories provided in the SADHS dataset into the "major categories" defined in the dataset documentation. Children reported to have been born in an "other" place of delivery were treated as having missing data for this variable.

Variable	Levels[§]	Derivation
Antenatal care provider	**Nurse/midwife (with or without a doctor)** Doctor only Traditional birth attendant, other care provider, or no care	Derived from five binary variables indicating whether the mother received antenatal care from each of the following providers or no antenatal care: nurse/midwife, doctor, traditional birth attendant, other care provider. It is possible for mothers to have received care from more than one provider but very few reported both a medical and a non-medical care provider, thus making it reasonable to derive a single variable with mutually exclusive categories from the original non-exclusive binary variables. The 14 children whose mothers received care from a nurse or doctor and a traditional birth attendant or other provider were assigned a missing value for this variable. We acknowledge that seeking care from a traditional birth attendant and having received no care are different phenomena, however too few women reported these antenatal care arrangements for them to be treated as separate analytic categories.
Mother's desired timing to become pregnant with the child	**Then** Later Did not want any more children	Used directly as provided in the SADHS dataset.
Mother's population group	**Black** Non-black	Derived from a four-level variable indicating the mother's self identified administrative population grouping. The 'non-Black' category was formed by collapsing the 'Asian/Indian', 'Coloured', and 'White' categories of the original variable. Although White people were privileged above all other population groups during Apartheid, we chose to group them with Coloured and Asian/Indian people in this variable because of the relatively small numbers in these groups in the SADHS dataset.

Variable	Levels[§]	Derivation
Mother's highest completed level of education	No education or incomplete primary **Complete primary or incomplete secondary** Complete secondary or higher	Derived by collapsing pairs of categories of the original six-level variable in the SADHS dataset. The pairs of categories making up each category of the derived variable can be identified from the labels.
Mother's age at her first child birth	<18 years old **18-29 years old** >29 years old	Derived by creating three categories from the continuous variable in the SADHS dataset. Cut-points for the categories are as indicated by the category labels.
Mother's age at index child's birth	Count of years, treated as continuous, standardized	Derived by calculating the difference between the index child's date of birth and the mother's date of birth (both recorded as century codes in the SADHS dataset) and rounding to the nearest completed year. We standardized the continuous variable by subtracting from each child's value the mean maternal age for the sample of children and dividing by the standard deviation. As such, the zero-value of the standardized variable corresponding to the global mean of 26.7 years, and a 1-unit increase is equivalent to a 6.9 year increase of the unscaled variable.

Variable	Levels§	Derivation
Mother's childhood place of residence and whether she migrated since childhood	**Spent childhood in rural area and did not migrate by time of survey** Spent childhood in urban area and did not migrate by time of survey Spent childhood in rural area and migrated to urban area by time of survey Spent childhood in urban area and migrated to rural area by time of survey	Derived by creating a category for each combination of the levels of two existing binary variables in the SADHS dataset: mother's childhood place of residence (where city and town were treated together as 'urban' vs. countryside), and type of place of residence at the time of the interview (urban vs. rural). We define 'migration' as a move from a rural to an urban place of residence since childhood or *vice versa*. Because of the potential significance of urbanization as distinct from urban-to-rural migration, we chose *a priori* to treat these as separate categories in the derived variable.

Variable	Levels[§]	Derivation
Child's age	Count of months, treated as continuous, standardized	Derived by calculating the difference in months between the interview date and the child's date of birth (both recorded as century codes in the SADHS dataset). We included this as a continuous variable in our models because exploratory analyses suggested it is approximately linearly associated with the outcomes. We standardized the continuous variable by subtracting from each child's value the mean age for the sample of children and dividing by the standard deviation. The zero-value of the standardized variable corresponds to the mean of the original, 28.0, and a 1-unit increase of the standardized variable corresponds to a 17.3 months increase on the original scale.
Child's sex	**Female** Male	Used directly as provided in the SADHS dataset.
Season of interview	**Summer** Autumn Winter	Derived from a variable indicating the month the mother completed the woman's questionnaire. Seasons were defined as: Summer - January, February, March; Autumn - April, May; Winter - June, July, August, September
Neighbourhood covariates		
Type of neighbourhood	**Rural** Urban	Used directly as provided in the SADHS dataset.

Variable	**Levels**[§]	**Derivation**
Percentage of female neighbourhood residents having completed high school education or higher	Continuous, standardized[39]	Derived using 1996 Census South Africa Community Profiles data. By cross-tabulating highest education level by EA number we obtained the percentage of residents in each EA having completed each level of education. We calculated percentage having completed high school or higher education by combining the following levels into a single category: "matric only", "matric and certificate", "matric and diploma", "matric and Bachelors degree", "Matric and Bachelors and Diploma", "Matric and Bachelors and Honours", "Matric and Masters degree", "Matric and Doctors degree", and "Other qualification". We restricted the tabulation to individuals in the 20-24 year age group or older, to ensure that all individuals considered had sufficient time to complete high school (intended to happen at 18 years of age in South Africa). To estimate percentages for female residents only we stratified the cross tabulation by gender and only exported the results for females. Descriptive statistics showed the raw variable to be positively skewed. To make the distribution more normal, we took the natural logarithm of the raw values. (Before doing so, we set all values less than 1.00% equal to 1.00.)

[39] In exploratory regression models we tested quintiles of the continuous neighbourhood variables, to allow for non-linear associations. This resulted in regression coefficient interval estimates becoming very wide. For this reason, we only present findings of models including continuous neighbourhood variables. We standardized each variable by subtracting the relevant mean value for the complete set of neighbourhoods in the analytic dataset and dividing by the standard deviation.

Variable	Levels[§]	Derivation
Ratio of percentage female to percentage male neighbourhood residents having completed high school education or higher	Continuous, standardized	Derived similarly to the “percentage of female neighbourhood residents with completed high school education or higher” variable, except that we additionally calculated the ratio of females-to-males having completed each level of education. To make it possible to perform the ratio calculation for neighbourhoods where 0% of male residents have completed high school education or higher, we added 0.001 to the percentage value for male residents. Descriptive statistics showed the raw variable to be positively skewed. To make the distribution more normal, we top-coded all values greater than 3.00 by setting them at 3.00. Approximately 95% of EAs in the analytic dataset had values lower than 3.00, but a few had much larger values. We assumed that values of $\geqslant$3.00 in the ratio of women-to-men having completed high school education or higher represented ‘large’ values and so could be treated as equivalent in statistical models.
Unemployment rate among adult male neighbourhood residents	Continuous, standardized	In deriving this variable, we used the expanded definition for the ‘unemployment rate’ as the percentage of people aged 15 years old or older “who did not work at the time of the census, but were looking for work” [126, p. 2]. This involved calculating the number of people reported to be “unemployed, looking for work” as a percentage of the sum of employed and unemployed people (i.e.: the ‘economically active population’). Cross-tabulating unemployment rate with EA identifier produces the rate for each EA. Estimates were weighted using the census person weights. We restricted the cross-tabulation to people aged 15 years old or older because our definition of unemployment is only relevant for these individuals. We stratified the table by gender to yield a separate estimate of the unemployment rate for the male population of each EA.

Variable	**Levels[§]**	**Derivation**
Percentage of households in neighbourhood having a female head	Continuous, standardized	Derived by cross tabulating the "gender of head of household" variable with EA identifier to produce a figure for the number of female-headed households in each EA. Percentages were calculated using the total number of households in the EA[40], excluding institutions and hostels. Estimates were weighted using the census household weights.
Percentage of households in neighbourhood having annual incomes <R6000	Continuous, standardized	Cross-tabulating the "derived household income" variable[41] by EA identifier produces a count of the number of households in each income category in each EA. Counts were weighted using census household weights. We defined 'lower-income households' as those having an annual income of less than 6000 Rands. Investigators analyzing data from the 1995 South African Income and Expenditure Survey calculated 7112 Rands to be the upper limit for the lowest quintile of annual household incomes nationally [169, p. 28]. The "R2401-6000" income range in the census dataset is the highest one falling entirely within the national lowest income quintile. Therefore, we calculated the number of lower-income households in each EA as the sum of households in the "R2401-6000" income range or lower. We expressed this number as a percentage of all households, excluding institutions and hostels.
Child and mother-level covariates used for descriptive statistics only		

[40]In the 1996 census, the household head is the person identified as such by the members of the household, apparently according to their own definition, "usually [as] the person who assumes responsibility for decision-making in the household." [127]

[41]The household income variable provided in the 1996 census dataset is a categorical variable derived "by adding together all recorded individual incomes of household members, plus the household's additional income and remittances received" and categorizing the resulting continuous variable into income ranges [232]. Individual incomes were recorded as ranges on the census questionnaire. For this reason an approximate income had to be estimated for each household member from their reported income range (usually as the logarithmic mean of the top and bottom of the income interval). Because of the assumptions made in deriving this variable, Statistics SA cautions against using it as an absolute measure of total household income [232]. However, it may still have value as an index of the relative percentage of lower-income households for making comparisons across neighbourhoods.

Variable	Levels[§]	Derivation
Mother is currently working	No Yes	Used directly as provided in the SADHS dataset. ‘Currently working’ is defined broadly to include work that is “paid in cash or in kind”, including being self-employed or working “on the family farm or in the family business.”

Variable	**Levels**[§]	**Derivation**
Quintile of household wealth index	Quintile: 1 (lowest) 2 3 4 5 (highest)	The DHS surveys include a series of questions about household dwelling structure and ownership of durable assets. Taking a linear, weighted sum of these variables produces a single, continuous 'asset index'[42] [170]. This index is assumed to be a proxy for household wealth or "long-run economic status" [233, p. 116]. Principal Components Analysis (PCA) is used to derive the weight for each categorical variable [233]. We recalculated the asset index after using the expectation-maximization (EM) technique[43] to impute missing asset data (instead of the mean-substitution technique used originally). Except for the different imputation method, we followed the derivation procedure described in the DHS wealth index report[44] [170]. The absolute value of the asset index score has no real-world interpretation but is used as a reflection of relative wealth within the population under study. To provide more meaningful descriptive statistics, we assigned households to quintiles based on their value of the wealth index. Quintiles were calculated from the distribution of wealth index values across the complete, weighted population of household members [170, p. 9-10].

[42] Following is the complete set of variables included in the calculation: a series of binary variables indicating that the household has each of the following: electricity, a radio, a television, a refrigerator, a personal computer, a washing machine, a telephone, a bicycle, a motorcycle, a car, a donkey or a horse, and sheep or cattle; another set of binary variables indicating whether the household uses each of the following fuels for cooking and heating: electricity, gas, paraffin, wood, coal, and animal dung; four categorical variables indicating main source of drinking water, type of toilet facility, main material of floor, and main material of walls; and a continuous variable measuring crowding (calculated as the number of usual household members divided by the number of rooms for sleeping).

[43] EM imputation produces maximum likelihood estimates for values of missing data by iteratively performing a regression for each variable with all other variables in the model used as predictors. At each iteration, the covariance matrix for the set of variables is calculated. Final imputed values are chosen at the point where further iterations do not significantly change the covariance matrix [234]. We performed the imputation step using the PROC MI procedure in SAS software version 9.3 (SAS Institute Inc., Cary, NC, USA). Our EM model included all variables used to calculate the wealth index and an additional set of variables that showed a clearly different distribution in household with missing asset data compared to those with complete data (age and sex of household head, month of interview; Province; whether the neighbourhood is in a large city, a small city, a town or the countryside; and unique identifiers for EA, interviewer, data entry person, field supervisor, field editor, and office editor).

[44] We performed the prinicpal components analysis using the PROC FACTOR procedure in SAS. In our analysis, the first principal component explained 16.9% of the common variance in the asset variables.

Variable	**Levels**[§]	**Derivation**
Province	Western Cape Eastern Cape Northern Cape Free State KwaZulu Natal North West Gauteng Mpumalanga Northern Province (Limpopo)	The Province in which the mother and child are living at the time of the survey. Used directly as provided in the SADHS dataset.

[§]Categories used as reference levels in statistical models are bolded. For potential confounders the most prevalent category in the analytic sample was set as the reference, except for the 'birth order & preceding birth interval' variable. For the latter, the reference category is the intersection of the two most prevalent categories of the original 'birth order' and 'preceding birth interval' variables.

A.2 Kaplan-Meier curves for time-to-breastfeeding cessation

Using the SAS LIFETEST procedure, we calculated Kaplan-Meier estimates of the percentage of children still breastfeeding between birth and 59 months (i.e.: under 5 years old) in our analytic sample. Children who were still being breastfed at the time of the survey were right-censored at that age. Separate survival functions (and 95% Hall-Wellner bands) were estimated for children with and without co-resident fathers to allow for a comparison of the survival probabilities between the two groups of children at different ages. We found that significantly fewer children with co-resident fathers were still being breastfed between 2 months and 18 months of age (Figure A.1).

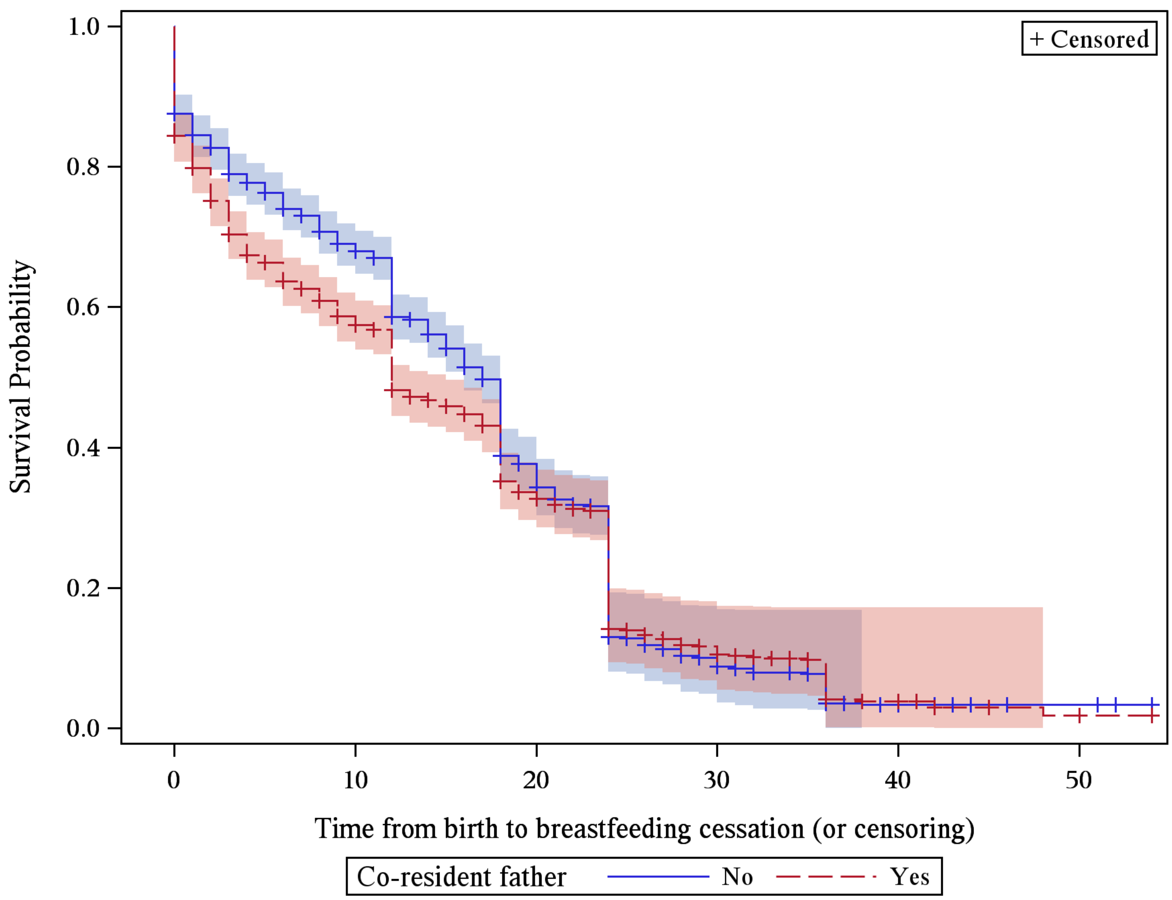


Figure A.1: Plots of Kaplan-Meier product limit estimates (and 95% Hall-Wellner bands) of proportion of children still being breastfed stratified by father's co-residence status

A.3 Procedure for linking child and household member datasets from the 1998 SADHS

In this section we provide details of two alternative strategies for linking children's records across the child and household member datasets of the SADHS. First, we describe the more conservative strategy. Next, we describe the strategy we ultimately used, which improves the number of records linked. Last, we present single-variable descriptive statistics to compare the distributions of covariates of interests in the datasets generated by the two linkage strategies.

Before using either linkage strategy, we prepared the datasets as follows:

- Child dataset (containing a record for each child under-5): restricted to records of children who were alive at the time of the survey, and who were reported to usually live with their mothers. There were 4437 records in this dataset.
- Household member dataset (containing a record for each member of each sampled household): restricted to records of household members who are under 5 years old, who have living mothers, and whose mothers are members of their household. There were 4413 records in this dataset.

Restricting to children who live with their mothers was based on both practical and theoretical considerations. Practically speaking, household characteristics are only known for children who are usual residents of the surveyed households. In the child dataset, children who are usual household residents can only be identified by restricting to those who usually live with their mothers and further restricting to mothers who are usual residents of the sampled households. Another practical consideration is that mothers may be able to report more accurately on recent episodes of infection for children who live with them. Theoretically speaking, children who reside with their mothers may tend to have quite different life circumstances than children who do not. For example, Richter and Desmond [80] demonstrate clear differences in the levels of economic 'vulnerability' of child-only and skip-generation (i.e.: households in which adults are all older than 60 years) compared to households in which children live with their parents. Although it would be equally, if not more, important to examine the effects of residing with a father for children who do not reside with their mother, the proportion of children who do not reside with their mother is low in this dataset (360/4797 = 7.5%), making it difficult to produce statistical generalizations about these children. Also note that it seems to be rare for children to live with their father but not their mother in South Africa [80, p. 1026]. Among children under 5 residing in SADHS households, 9% live with their father but not their mother (this includes children whose mothers are alive and those whose mothers are dead).

Because there is no unique child identifier variable available in the SADHS, our linkage strategies relied on matching pairs of records based on their having identical values on a set of variables common to the child and household member datasets. The variables we used to match records are: EA number, household number, a unique identifier for each woman interviewed (hereafter refer to as a unique 'mother identifier' because of our focus on women with children), age in years of each child, and sex of each child. The first linkage procedure we tested conservatively required a match on all five variables in order for records to be linked. However, we found two challenges with this procedure:

1. The set of common variables cannot distinguish records of identical twins (n=47 pairs) and any other children of the same sex born within one year of each other to the same mother (n=2 pairs); and

2. This approach precludes matching of children whose ages and/or sexes were accidentally recorded differently in the household member and children's datasets.

In the household member dataset twin's records are identical because they have the same household characteristics and the same biological father (therefore, the same exposure status). In contrast, in the child dataset differences in twin's records are possible but a variable is available which identifies twin's records. This means that if the records of twins in the child dataset can be matched to identical pairs of records in the household member dataset, the order in which the records are linked should be unimportant [45]. Therefore to overcome the first challenge identified above, we added the following step to the conservative linking procedure: using the twin variable in the child recode dataset, we excluded from the linking procedure records of children who are not twins but were born within one year of one another to the same mother (n=4). We merged the remaining records using the set of five common variables. Figure A.2 on the next page is a flow-chart depicting the conservative linking strategy.

To overcome the second challenge, necessitates using an alternative linking procedure. This second procedure also used the set of five common variables, but did not require records to match on all five variables, provided no duplicate matches were found using a sub-set of the common variables. At a minimum, records had to match on EA number, household number, and mother's identifier to be linked. The alternative strategy was implemented in four steps as depicted in figure A.3 on page 228. In step 1 of figure A.3 on page 228, we isolate and attempt to match records of the child and household members datasets having unique combinations of **EA number, household number, and mother identifier** (i.e.: those children who have no co-resident biological siblings). The remaining records (i.e.: records of children having one or more co-resident biological sibling) pass to step 2. In step 2, we isolate and attempt to match records having unique combinations of EA number, household number, mother number, and **child's sex** (i.e.: those children who have no same-sex, co-resident biological siblings). All remaining records (i.e.: records of children having one or more same-sex, co-resident biological sibling) pass to step 3. Step 3 isolates and attempts to match records having unique combinations of EA number, household number, mother identifier, child's sex and **child's age in years** (i.e.: those children who have no same-age, same-sex, co-resident biological siblings). The remaining records pass to step 4. In this last step we are left with records for which there are no other common variables to distinguish them. However, as described in the preceding paragraph, it seems reasonable to treat twins' records in the household member dataset as interchangeable. Therefore, we restrict the remaining records from the child dataset to those of twins. These pairs of twins' records were then matched with identical pairs

[45] All of the variables on which twins may differ, including their breastfeeding, immunization or infectious outcomes, are recorded in the child dataset. Therefore, there is no possibility that the values of these variables could be accidentally switched during linking.

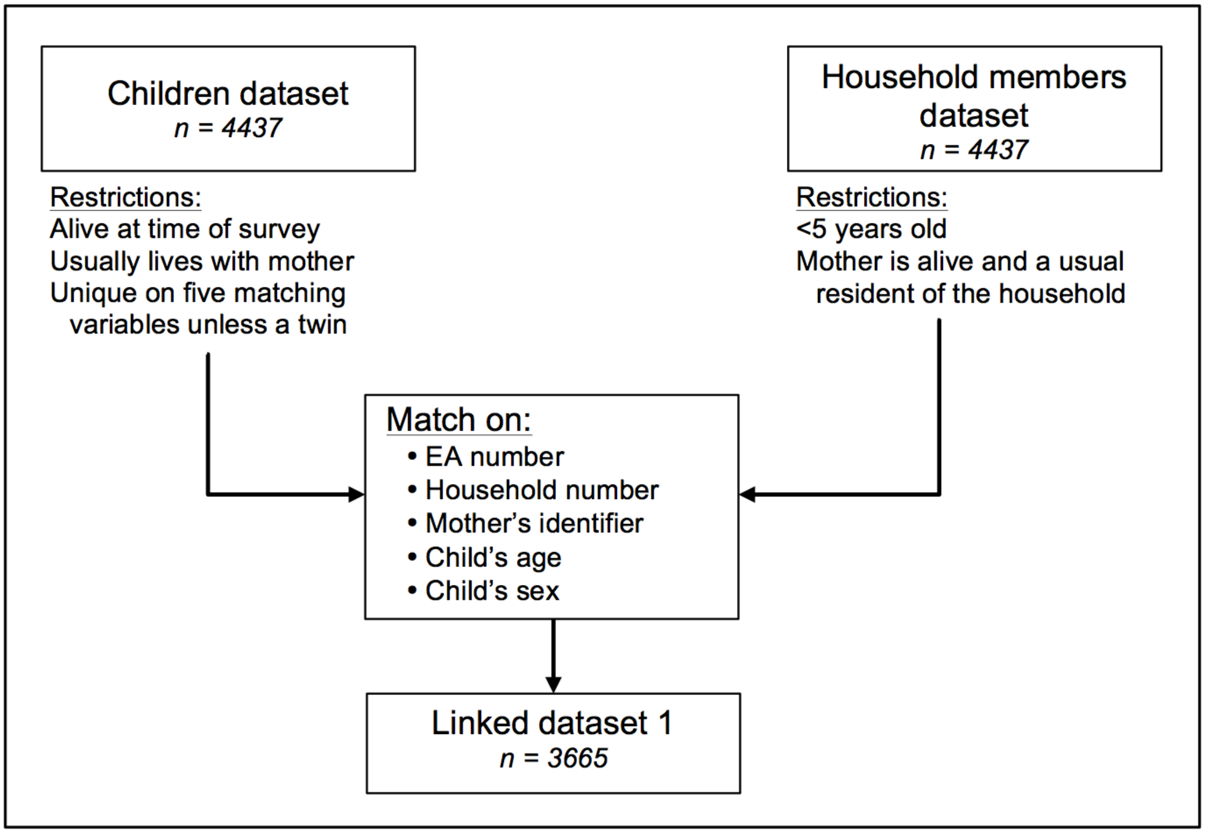


Figure A.2: Conservative, one-step procedure for matching records in the child and household members datasets of the 1998 SADHS.

of records remaining from the household member dataset. Appending the records matched at each step yields the final linked dataset.

Matching procedure one generated linked records for 3665 children, meaning that approximately 17% of records in the original datasets could not be matched using this approach. Whereas, the final linked dataset generated by procedure two contained records for 4010 children, with around 10% of the original going unmatched.

The less conservative linking procedure generated 273 records (273/4010 = 6.8%) having discrepancies between the values of the age variables recorded in the child and household member datasets; 80 records (80/4010 = 2.0%) having discrepant values of sex; and 12 records (12/4010 = 0.3%) having discrepant values of both age and sex. This could suggest that this procedure generated inaccurate linkages. However, it is plausible for slightly different ages to be recorded for the same child in the household member and child datasets because different questions were used to collect the data in these two variables. If this were the case, we would expect most age discrepancies to be only one year. In the linked dataset produced by procedure two, 249 of the records with discrepant age values (249/273 = 91%) have a discrepancy of only one year. It is less clear whether to accept linked records with age discrepancies greater than one year, and/or with discrepancies in the child's sex variable. We wondered whether these could have occurred more often in households with many children, or when the respon-

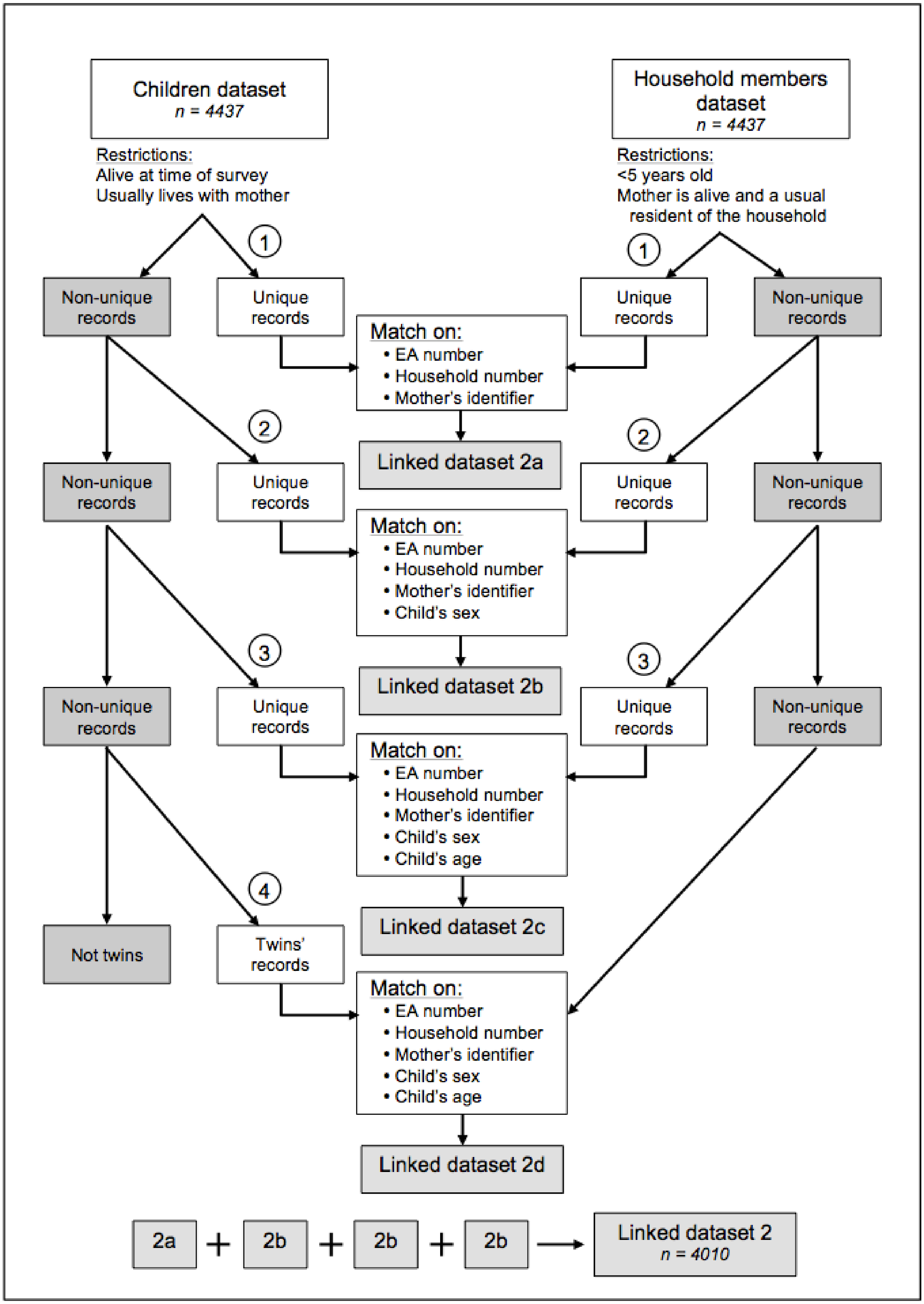


Figure A.3: Less conservative, multi-step procedure for matching records in the child and household members datasets of the 1998 SADHS.

dent to the household questionnaire was unrelated to the child. To understand whether records with age discrepancies > 1 year are systematically different from the other records in the linked dataset, we prepared single-variable descriptive statistics of household characteristics for both sets of records (results not shown). Because there are only 20 records with age discrepancies > 1 year, statistical tests for differences between these records and the rest of the dataset produce no significant results. Visually, there are some differences between the groups. For example, among the group of children with discrepant records, a lower percentage live in households where the household heads is their mother (10.0% vs. 19.5%) or their mother's spouse (25.0% vs. 34.2%), and a higher percentage live in households where the head is their mother's parent (45.0% vs. 29.4%) or sibling (10.0% vs. 2.7%). However, as suggested by the statistical tests, these differences could be due to chance. We assume that the majority of records with discrepancies in child's age and/or sex are not the result of improper data linkage. For this reason, we completed our analyses using the dataset generated by the second merging procedure.

A.4 Complete results for regressions of child health outcomes on father's co-residence status

In this section we present supplementary regression model results for each outcome. In the following four tables, 'Unadjusted' estimates are from simple logistic regression models. 'Model 1' is an ordinary logistic regression model adjusted for all covariates listed. 'Model 2' is a 2-level logistic regression, which models variation in the intercept across neighbourhoods and includes the same covariates as Model 1. 'Model 3' is a 3-level extension of model 2, which additionally models variation in the intercept across households.

Table A.2: Estimated odds ratios (ORs) and 95% Credible Intervals (CIs) for having been **breastfed for six months or longer**.

	Unadjusted		**Model 1**		**Model 2**		**Model 3**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Co-resident father	0.61	0.52 - 0.71	0.88	0.72 - 1.05	0.88	0.71 - 1.09	0.88	0.63 – 1.21
Birth order & preceding birth interval								
1st born	0.73	0.58 - 0.91	0.72	0.54 - 0.95	0.68	0.49 - 0.92	0.60	0.37 - 0.91
2-4 born, <24 months	0.90	0.61 - 1.28	0.93	0.62 - 1.35	0.93	0.58 - 1.42	1.08	0.56 - 1.93
2-4 born, 24-47 months	REF		REF		REF		REF	
2-4 born, >47 months	0.80	0.62 – 1.00	0.90	0.69 - 1.17	0.88	0.65 - 1.18	0.87	0.55 - 1.31
5+ born, <24 months	1.02	0.59 - 1.71	0.69	0.37 - 1.18	0.64	0.32 - 1.15	0.68	0.24 - 1.55
5+ born, 24-47 months	1.75	1.19 – 2.50	1.09	0.69 - 1.67	1.09	0.66 - 1.71	1.18	0.56 - 2.23
5+ born, >47 months	1.55	1.05 - 2.26	1.22	0.75 - 1.93	1.18	0.68 - 1.92	1.19	0.53 - 2.35
Place of delivery								
Public medical facility	REF		REF		REF		REF	
Home	2.02	1.57 – 2.60	1.30	0.98 - 1.68	1.32	0.96 - 1.78	1.43	0.90 - 2.20
Private medical facility	0.29	0.22 - 0.37	0.73	0.52 - 0.99	0.72	0.48 - 1.02	0.58	0.31 - 0.98
Antenatal care provider								
Nurse/ midwife (+/- doctor)	REF		REF		REF		REF	
Doctor	0.32	0.26 - 0.39	0.65	0.51 - 0.82	0.64	0.48 - 0.84	0.53	0.33 - 0.78
TBA, Other, no care	0.63	0.41 - 0.95	0.87	0.54 - 1.33	0.93	0.55 - 1.48	0.99	0.43 - 1.98

Continued on next page

	Unadjusted		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Time mother wanted pregnancy								
Then	REF		REF		REF		REF	
Later	1.40	1.17 - 1.65	1.23	1.01 – 1.50	1.19	0.94 - 1.48	1.34	0.95 - 1.85
No more	1.37	1.10 – 1.70	0.98	0.76 - 1.23	0.99	0.74 - 1.30	1.01	0.67 - 1.49
Mother's population group								
Black/African	REF		REF		REF		REF	
Non-Black/African	0.31	0.26 - 0.36	0.55	0.44 - 0.68	0.47	0.34 - 0.61	0.32	0.19 - 0.49
Mother's highest completed education level								
Less than primary	1.88	1.53 - 2.29	1.45	1.15 – 1.80	1.42	1.09 - 1.82	1.65	1.10 - 2.38
Primary or incomplete secondary	REF		REF		REF		REF	
Secondary or higher	0.56	0.46 - 0.68	0.93	0.74 - 1.15	0.89	0.68 - 1.14	0.83	0.56 - 1.20
Mother's childhood place of residence, whether she migrated								
Rural area, did not migrate	REF		REF		REF		REF	
Urban area, did not migrate	0.30	0.25 - 0.35	0.55	0.44 - 0.68	0.54	0.40 - 0.71	0.40	0.25 - 0.59
Rural area, migrated to urban	0.55	0.43 - 0.69	0.71	0.55 - 0.91	0.75	0.54 - 1.03	0.64	0.38 - 0.99
Urban area, migrated to rural	0.43	0.30 – 0.60	0.68	0.46 - 0.99	0.75	0.47 - 1.16	0.67	0.32 - 1.23

Continued on next page

	Unadjusted		Model 1		Model 2		Model 3	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Mother's age at first child birth								
<18	1.58	1.30 - 1.91	1.16	0.93 - 1.43	1.16	0.91 - 1.48	1.33	0.91 - 1.90
18-29	REF		REF		REF		REF	
>29	0.50	0.32 - 0.76	0.78	0.45 - 1.26	0.69	0.36 - 1.20	0.51	0.18 - 1.12
1SD increase in mother's age at index child's birth	0.99	0.91 - 1.07	0.93	0.80 - 1.08	0.91	0.77 - 1.08	0.90	0.70 - 1.14
Varying coefficients					**Estimate**	**95% CI**	**Estimate**	**95% CI**
Neighbourhood intercepts (SD)					0.90	0.72 - 1.09	1.14	0.83 - 1.48
Household intercepts (SD)							1.90	1.38 - 2.48

Note: TBA=Traditional Birth Attendant; REF=Reference category; SD=Standard Deviation; Model 1 - ordinary logistic regression adjusted for all covariates listed; Model 2 - 2-level logistic regression, neighbourhood varying intercept, same covariates as Model 1; Model 3 - 3-level extension of model 2, including household varying intercept.

Table A.3: Estimated odds ratios (ORs) and 95% Credible Intervals (CIs) for being **completely immunized**.

	Unadjusted		**Model 1**		**Model 2**		**Model 3**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Co-resident father	1.11	0.96 - 1.27	1.11	0.94 – 1.30	1.12	0.92 - 1.34	1.20	0.89 - 1.59
Birth order & preceding birth interval								
1st born	1.22	0.99 – 1.50	1.08	0.84 - 1.37	1.07	0.81 - 1.40	1.22	0.81 - 1.78
2-4 born, <24 months	1.06	0.75 - 1.44	1.01	0.70 - 1.40	1.05	0.70 - 1.50	1.13	0.64 - 1.86
2-4 born, 24-47 months	REF		REF		REF		REF	
2-4 born, >47 months	1.16	0.93 - 1.43	0.97	0.76 - 1.21	0.96	0.73 - 1.24	1.01	0.68 - 1.44
5+ born, <24 months	0.44	0.27 - 0.67	0.49	0.29 - 0.78	0.59	0.33 - 0.98	0.55	0.22 - 1.16
5+ born, 24-47 months	0.67	0.50 - 0.88	0.77	0.53 - 1.07	0.82	0.55 - 1.18	0.82	0.44 - 1.40
5+ born, >47 months	0.97	0.69 - 1.32	0.97	0.64 - 1.41	1.01	0.64 - 1.52	1.04	0.52 - 1.90
Place of delivery								
Public medical facility	REF		REF		REF		REF	
Home	0.47	0.39 - 0.57	0.59	0.48 - 0.72	0.60	0.47 - 0.75	0.48	0.33 - 0.67
Private medical facility	1.14	0.86 - 1.49	0.92	0.66 - 1.24	0.90	0.61 - 1.27	0.84	0.47 - 1.39
Antenatal care provider								
Nurse/ midwife (+/- doctor)	REF		REF		REF		REF	
Doctor	1.14	0.94 - 1.38	0.83	0.65 - 1.05	0.80	0.61 - 1.04	0.74	0.49 - 1.08
TBA, Other, no care	0.69	0.47 - 0.96	0.67	0.46 - 0.97	0.68	0.43 - 1.02	0.63	0.31 - 1.15

Continued on next page

	Unadjusted		Model 1		Model 2		Model 3	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Time mother wanted pregnancy								
Then	REF		REF		REF		REF	
Later	1.14	0.97 - 1.33	1.15	0.96 - 1.37	1.12	0.92 - 1.36	1.24	0.91 - 1.64
No more	0.80	0.66 - 0.96	0.89	0.72 - 1.09	0.87	0.69 - 1.09	0.81	0.56 - 1.12
1 SD increase in child's age (months)	0.74	0.69 - 0.79	0.73	0.67 - 0.78	0.69	0.64 - 0.75	0.59	0.51 - 0.66
Mother's population group								
Black/African	REF		REF		REF		REF	
Non-Black/African	1.77	1.46 - 2.13	1.56	1.24 - 1.94	1.64	1.23 - 2.14	2.11	1.37 - 3.15
Mother's highest completed education level								
Less than primary	0.67	0.57 - 0.79	0.82	0.68 - 0.98	0.77	0.63 - 0.95	0.71	0.50 - 0.96
Primary or incomplete secondary	REF		REF		REF		REF	
Secondary or higher	1.26	1.03 - 1.51	1.09	0.88 - 1.34	1.09	0.85 - 1.37	1.14	0.79 - 1.61

Continued on next page

	Unadjusted		Model 1		Model 2		Model 3	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Mother's childhood place of residence, whether she migrated								
Rural area, did not migrate	REF		REF		REF		REF	
Urban area, did not migrate	1.61	1.36 - 1.88	1.18	0.96 - 1.43	1.22	0.94 - 1.57	1.33	0.89 - 1.93
Rural area, migrated to urban	1.29	1.04 - 1.59	1.05	0.83 - 1.31	1.10	0.82 - 1.45	1.15	0.73 - 1.74
Urban area, migrated to rural	2.11	1.43 - 3.04	1.70	1.13 - 2.51	1.73	1.08 - 2.64	2.18	1.06 - 4.08
Mother's age at first child birth								
<18	0.83	0.70 - 0.97	0.94	0.78 - 1.12	0.91	0.74 - 1.11	0.96	0.70 - 1.30
18-29	REF		REF		REF		REF	
>29	1.05	0.68 - 1.58	0.83	0.50 - 1.31	0.91	0.51 - 1.50	0.87	0.35 - 1.82
1 SD increase in mother's age at index child's birth	0.95	0.88 - 1.02	1.11	0.97 - 1.27	1.10	0.95 - 1.26	1.16	0.93 - 1.43
Varying coefficients					**Estimate**	**95% CI**	**Estimate**	**95% CI**
Neighbourhood intercepts (SD)					0.80	0.66 - 0.95	1.04	0.80 - 1.32
Household intercepts (SD)							1.88	1.47 - 2.32

Note: TBA=Traditional Birth Attendant; REF=Reference category; SD=Standard Deviation; Model 1 - ordinary logistic regression adjusted for all covariates listed; Model 2 - 2-level logistic regression, neighbourhood varying intercept, same covariates as Model 1; Model 3 - 3-level extension of model 2, including household varying intercept.

Table A.4: Estimated odds ratios (ORs) and 95% Credible Intervals (CIs) for having had a **recent Acute Respiratory Infection (ARI)**.

	Unadjusted		**Model 1**		**Model 2**		**Model 3**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Co-resident father	1.04	0.88 - 1.22	1.14	0.94 - 1.37	1.18	0.96 - 1.45	1.35	0.93 - 1.90
Birth order & preceding birth interval								
1st born	1.22	0.94 - 1.56	1.15	0.86 - 1.52	1.17	0.85 - 1.59	1.19	0.72 - 1.86
2-4 born, <24 months	1.33	0.89 - 1.91	1.30	0.86 - 1.86	1.36	0.88 - 2.03	1.67	0.83 - 3.00
2-4 born, 24-47 months	REF		REF		REF		REF	
2-4 born, >47 months	1.25	0.96 – 1.60	1.23	0.93 – 1.60	1.25	0.92 - 1.66	1.29	0.80 - 2.01
5+ born, <24 months	1.21	0.65 – 2.00	1.45	0.75 - 2.46	1.50	0.74 - 2.65	2.33	0.72 - 5.70
5+ born, 24-47 months	1.12	0.77 - 1.59	1.22	0.78 - 1.82	1.20	0.75 - 1.83	1.23	0.55 - 2.37
5+ born, >47 months	1.36	0.92 - 1.93	1.47	0.91 - 2.24	1.55	0.92 - 2.42	1.79	0.76 - 3.59
Place of delivery								
Public medical facility	REF		REF		REF		REF	
Home	0.92	0.72 - 1.14	0.97	0.76 - 1.23	1.02	0.77 - 1.32	1.02	0.65 - 1.55
Private medical facility	0.79	0.55 - 1.06	0.83	0.56 - 1.17	0.81	0.53 - 1.19	0.71	0.34 - 1.30
Antenatal care provider								
Nurse/ midwife (+/- doctor)	REF		REF		REF		REF	
Doctor	0.96	0.76 - 1.19	1.03	0.78 - 1.32	1.01	0.75 - 1.32	1.09	0.66 - 1.71
TBA, Other, no care	0.74	0.43 - 1.14	0.73	0.42 - 1.14	0.68	0.38 - 1.09	0.51	0.20 - 1.04

Continued on next page

	Unadjusted		Model 1		Model 2		Model 3	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Time mother wanted pregnancy								
Then	REF		REF		REF		REF	
Later	1.10	0.91 - 1.31	1.05	0.85 - 1.27	1.05	0.84 - 1.30	1.15	0.80 - 1.63
No more	1.11	0.88 - 1.38	1.10	0.85 - 1.39	1.11	0.85 - 1.43	1.20	0.76 - 1.83
Child's sex								
Female	REF		REF		REF		REF	
Male	0.98	0.83 - 1.15	0.99	0.84 - 1.16	1.00	0.83 - 1.19	1.05	0.79 - 1.38
1 SD increase in child's age (months)	0.83	0.76 – 0.90	0.83	0.76 – 0.90	0.81	0.73 - 0.88	0.67	0.57 - 0.78
Season								
Summer	REF		REF		REF		REF	
Autumn	1.02	0.86 - 1.22	1.01	0.84 - 1.21	1.03	0.81 - 1.30	1.03	0.68 - 1.48
Winter	1.30	0.97 - 1.71	1.29	0.94 - 1.71	1.38	0.95 - 1.95	1.73	0.89 - 3.07
Mother's population group								
Black/African	REF		REF		REF		REF	
Non-Black/African	1.08	0.88 - 1.31	1.11	0.87 - 1.39	1.13	0.85 - 1.48	1.26	0.76 - 1.97

Continued on next page

	Unadjusted		Model 1		Model 2		Model 3	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Mother's highest completed education level								
Less than primary	0.87	0.71 - 1.05	0.89	0.72 – 1.10	0.87	0.68 - 1.08	0.78	0.51 - 1.14
Primary or incomplete secondary	REF		REF		REF		REF	
Secondary or higher	0.82	0.65 - 1.01	0.87	0.68 - 1.09	0.86	0.65 - 1.10	0.81	0.52 - 1.21
Mother's age at first child birth								
<18	1.18	0.98 - 1.41	1.13	0.91 - 1.38	1.15	0.91 - 1.43	1.33	0.90 - 1.92
18-29	REF		REF		REF		REF	
>29	0.63	0.33 - 1.05	0.72	0.36 - 1.26	0.68	0.32 - 1.23	0.62	0.17 - 1.55
1 SD increase in mother's age at index child's birth	0.94	0.87 - 1.02	0.94	0.80 - 1.09	0.93	0.79 - 1.10	0.91	0.69 - 1.18
Varying coefficients					**Estimate**	**95% CI**	**Estimate**	**95% CI**
Neighbourhood intercepts (SD)					0.73	0.56 - 0.90	0.99	0.63 - 1.35
Household intercepts (SD)							2.39	1.84 - 3.02

Note: TBA=Traditional Birth Attendant; REF=Reference category; SD=Standard Deviation; Model 1 - ordinary logistic regression adjusted for all covariates listed; Model 2 - 2-level logistic regression, neighbourhood varying intercept, same covariates as Model 1; Model 3 - 3-level extension of model 2, including household varying intercept.

Table A.5: Estimated odds ratios (ORs) and 95% Credible Intervals (CIs) for having had **recent diarrhoea**.

	Unadjusted		**Model 1**		**Model 2**		**Model 3**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Co-resident father	0.88	0.73 - 1.07	1.21	0.97 - 1.49	1.23	0.98 - 1.54	1.30	0.93 - 1.77
Birth order & preceding birth interval								
1st born	1.35	0.99 - 1.80	1.32	0.93 - 1.84	1.32	0.91 - 1.86	1.37	0.84 - 2.14
2-4 born, <24 months	1.36	0.84 - 2.05	1.34	0.81 - 2.07	1.33	0.80 - 2.09	1.32	0.65 - 2.36
2-4 born, 24-47 months	REF		REF		REF		REF	
2-4 born, >47 months	1.27	0.93 - 1.71	1.33	0.95 - 1.83	1.32	0.93 - 1.83	1.30	0.80 - 2.01
5+ born, <24 months	1.87	0.98 - 3.16	2.06	1.02 - 3.67	2.11	1.00 - 3.89	2.39	0.83 - 5.35
5+ born, 24-47 months	1.58	1.03 - 2.30	1.40	0.84 - 2.19	1.40	0.82 - 2.22	1.32	0.62 - 2.44
5+ born, >47 months	1.99	1.29 - 2.91	2.02	1.19 - 3.24	2.04	1.17 - 3.32	2.13	0.97 - 4.12
Place of delivery								
Public medical facility	REF		REF		REF		REF	
Home	1.37	1.07 - 1.73	1.35	1.03 - 1.74	1.42	1.06 - 1.85	1.65	1.10 - 2.42
Private medical facility	0.44	0.25 - 0.67	0.60	0.34 - 0.97	0.61	0.33 - 1.02	0.49	0.22 - 0.93
Antenatal care provider								
Nurse/ midwife (+/- doctor)	REF		REF		REF		REF	
Doctor	0.68	0.51 - 0.88	1.09	0.77 - 1.47	1.09	0.77 - 1.50	1.21	0.74 - 1.87
TBA, Other, no care	0.60	0.31 - 1.01	0.55	0.28 - 0.94	0.52	0.25 - 0.91	0.46	0.17 - 0.95

Continued on next page

	Unadjusted		Model 1		Model 2		Model 3	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Time mother wanted pregnancy								
Then	REF		REF		REF		REF	
Later	1.41	1.14 - 1.73	1.33	1.05 - 1.67	1.35	1.05 - 1.72	1.57	1.11 - 2.19
No more	1.66	1.28 - 2.10	1.48	1.11 - 1.92	1.51	1.12 - 1.99	1.66	1.10 - 2.43
Child's sex								
Female	REF		REF		REF		REF	
Male	1.30	1.07 - 1.57	1.33	1.09 - 1.6	1.35	1.10 - 1.64	1.55	1.16 - 2.05
1 SD increase in child's age (months)	0.61	0.55 - 0.68	0.61	0.54 - 0.67	0.59	0.53 - 0.66	0.49	0.40 - 0.57
Season								
Summer	REF		REF		REF		REF	
Autumn	1.00	0.81 - 1.21	0.99	0.8 - 1.22	0.99	0.77 - 1.26	0.97	0.68 - 1.34
Winter	0.51	0.32 - 0.76	0.58	0.36 - 0.87	0.59	0.35 - 0.93	0.48	0.22 - 0.85
Mother's population group								
Black/African	REF		REF		REF		REF	
Non-Black/African	0.63	0.48 - 0.81	0.86	0.63 - 1.14	0.85	0.61 - 1.16	0.86	0.54 - 1.31

Continued on next page

	Unadjusted		Model 1		Model 2		Model 3	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Mother's highest completed education level								
Less than primary	1.18	0.95 - 1.45	1.17	0.91 - 1.47	1.18	0.91 - 1.51	1.27	0.87 - 1.80
Primary or incomplete secondary	REF		REF		REF		REF	
Secondary or higher	0.71	0.54 - 0.91	0.86	0.63 - 1.13	0.88	0.64 - 1.17	0.83	0.53 - 1.23
Mother's age at first child birth								
<18	1.24	1.00 - 1.53	1.04	0.81 - 1.32	1.08	0.83 - 1.38	1.18	0.82 - 1.66
18-29	REF		REF		REF		REF	
>29	0.67	0.31 - 1.19	0.83	0.36 - 1.57	0.83	0.34 - 1.61	0.73	0.21 - 1.73
1 SD increase in mother's age at index child's birth	0.97	0.88 - 1.07	0.90	0.75 - 1.07	0.90	0.74 - 1.08	0.92	0.71 - 1.18
Varying coefficients					**Estimate**	**95% CI**	**Estimate**	**95% CI**
Neighbourhood intercepts (SD)					0.58	0.38 - 0.77	0.64	0.27 - 0.97
Household intercepts (SD)							1.74	1.19 - 2.36

Note: TBA=Traditional Birth Attendant; REF=Reference category; SD=Standard Deviation; Model 1 - ordinary logistic regression adjusted for all covariates listed; Model 2 - 2-level logistic regression, neighbourhood varying intercept, same covariates as Model 1; Model 3 - 3-level extension of model 2, including household varying intercept.

A.5 Complete descriptive statistics and regression findings for extended household structure analyses

In this section we present more detailed descriptive statistics comparing children in each category of the extended household structure variable (Table A.6 on the following page). We also present the complete set of effect estimates from the neighbourhood varying-intercept multilevel logistic regression models with extended household structure as the primary predictor (Table A.7 on page 250).

The three sections of Table A.6 on the following page show descriptive statistics for outcomes, potential confounders, and additional covariates of interest, respectively. Comparing the distribution of potential confounders across the categories of household structure, it appears that children with additional adult relatives (of either sex) were similar to one another on a number of variables but distinct from children in the other two groups. Conversely, children who reside with their mothers only were similar on some variables to those having two co-resident biological parents. On other variables they were distinct from children in all three of the other households structures. There were interesting socioeconomic differences between the four groups. Greater percentages of children with two co-resident parents or with co-resident mothers only had working mothers compared to the other two groups. Children with two co-resident parents tended to live in households with higher wealth scores than children in the other categories, while children with no additional co-resident male relatives (i.e.: with co-resident female relatives only, or with co-resident mothers only) tended to live in households with lower wealth scores. Children with non-co-resident fathers but one or more co-resident male relative tended to live in households with intermediate wealth scores. Recall that for these analyses we included children with dead fathers. Interestingly, it appears that these children were fairly evenly represented across the three non-co-resident father household structures, accounting for around 6% of children in each group.

Table A.6: Population-weighted descriptive statistics comparing children with co-resident fathers to those with non-co-resident fathers, the latter stratified by whether they reside with other adult relatives; children aged 0-4 years, 1998 SADHS..

		Non-co-resident father		
	Co-resident father	**$\geqslant$ 1 male relative**	**Female relatives only**	**Mother only**
n (%)	1638 (43.9)	1156 (27.8)	572 (13.7)	543 (13.1)
OUTCOMES	%	%	%	%
Breastfed 6 months or longer				
No	30.4	22.6	20.3	19.0
Yes	56.2	62.8	63.0	69.8
Don't know	0.7	0.5	0.7	0.6
Missing	1.6	1.0	2.3	1.8
N/A (<6 months old)	11.2	13.2	13.7	8.8
Completely immunized				
No	30.4	30.7	32.3	38.4
Yes	65.7	66.2	64.4	57.9
Don't know	3.7	2.9	3.3	3.2
Missing	0.2	0.2	0.0	0.5
Recent ARI				
No	77.0	78.5	78.0	80.2
Yes	21.6	20.7	20.4	18.7
Don't know	0.8	0.2	0.2	0.1
Missing	0.6	0.6	1.4	1.0

Continued on next page

	Co-resident father	Non-co-resident father		
		⩾ 1 male relative	Female relatives only	Mother only
Recent Diarrhoea				
No	86.3	84.3	82.4	87.1
Yes	12.7	15.0	16.1	12.4
Don't know	0.2	0.3	0.1	0.0
Missing	0.8	0.4	1.5	0.6
POTENTIAL CONFOUNDERS	%	%	%	%
Preceding birth interval & birth order				
1st born	19.4	52.1	49.6	13.8
<24 months, 2-4th born	7.8	4.4	6.2	5.2
24-47 months, 2-4th born	21.2	12.2	11.8	24.4
>47 months, 2-4th born	32.2	20.0	21.1	29.2
<24 months, 5+ born	2.8	1.2	1.5	4.5
24-47 months, 5+ born	9.2	4.8	4.0	11.9
>47 months, 5+ born	7.3	5.2	5.7	11.0
Missing	0.2	0.2	0.1	0.0
Place of delivery				
Home	11.6	12.9	18.8	20.7
Public Medical	70.2	82.5	77.0	74.7
Private Medical	17.3	3.9	2.6	2.7
Missing	0.9	0.7	1.5	1.9

Continued on next page

		Non-co-resident father		
	Co-resident father	**$\geqslant$ 1 male relative**	**Female relatives only**	**Mother only**
Antenatal care provider				
Nurse/midwife (+/- doctor)	67.2	83.5	83.6	92.2
Doctor only	27.0	13.5	11.3	4.6
TBA, Other, No antenatal care	4.5	2.5	4.3	2.1
Missing	1.4	0.5	0.8	1.1
When mother wanted child's birth				
At that time	62.3	31.6	33.1	49.4
Later	22.4	49.1	47.5	30.0
No more	15.1	19.0	18.9	20.4
Missing	0.2	0.3	0.5	0.2
Season				
Summer	54.8	66.2	60.4	58.6
Autumn	30.7	28.0	32.7	34.3
Winter	14.6	5.8	7.0	7.1
Child's sex				
Female	51.7	48.7	49.0	54.8
Male	48.3	51.3	51.0	45.2
Child's age in months; *Median (IQR)*	29 (31)	23 (30)	24 (29)	29 (30)

Continued on next page

	Co-resident father	Non-co-resident father		
		⩾ 1 male relative	**Female relatives only**	**Mother only**
Mother's population group				
Black	70.6	87.1	92.6	93.6
Non-black	28.8	12.6	7.0	5.5
Coloured	*11.3*	*11.6*	*6.5*	*4.5*
White	*12.5*	*0.4*	*0.1*	*0.8*
Asian/Indian	*5.0*	*0.6*	*0.4*	*0.2*
Missing	0.6	0.4	0.4	0.9
Mother's educational attainment				
None or incomplete primary	26.8	20.7	25.5	40.8
Completed primary or some secondary	47.1	56.0	54.4	46.1
Completed secondary or higher than secondary	26.0	23.3	20.1	13.1
Mother's age at index child's birth in years; *Median (IQR)*	28 (9)	22 (9)	22 (9)	28 (8)
Mother's age at first child birth				
<18 years	22.0	29.4	29.4	23.0
18-29 years	74.0	68.4	68.9	73.4
>29 years	4.0	2.2	1.7	3.6

Continued on next page

	Co-resident father	Non-co-resident father		
		⩾ 1 male relative	Female relatives only	Mother only
Mother's childhood place of residence and whether she migrated				
Rural area, did not migrate	35.1	50.0	61.1	64.2
Urban area, did not migrate	42.2	32.1	21.7	18.5
Rural area, migrated to urban	18.5	12.9	11.6	12.8
Urban area, migrated rural	3.4	3.6	3.9	3.4
Missing	0.8	1.3	1.7	1.1
ADDITIONAL VARIABLES	%	%	%	%
Child's father is dead				
No	100.0	91.3	90.1	90.9
Yes	0.0	5.5	7.7	7.5
Don't know	0.0	1.4	1.3	0.6
Missing	0.0	1.7	0.9	1.1
Mother is currently working				
No	66.4	77.6	82.2	72.4
Yes	33.3	22.2	16.4	26.8
Missing	0.2	0.2	1.4	0.8

Continued on next page

		Non-co-resident father		
	Co-resident father	**$\geqslant$ 1 male relative**	**Female relatives only**	**Mother only**
Household wealth index (quintile)				
1 (Lowest)	16.0	20.2	37.9	37.0
2	19.8	26.3	27.9	30.2
3	19.3	22.4	18.3	19.7
4	18.6	21.3	12.6	10.6
5 (Highest)	26.2	9.8	3.3	2.5
Province				
Western Cape	11.6	9.3	4.4	4.6
Eastern Cape	11.1	16.0	17.5	19.3
Northern Cape	2.4	2.4	2.1	1.6
Free State	6.7	4.7	3.4	4.3
KwaZulu Natal	19.1	18.7	27.3	25.2
North West	6.9	8.5	8.2	6.0
Gauteng	25.3	14.2	9.5	8.5
Mpumalanga	6.7	8.6	8.1	7.2
Northern Province (Limpopo)	10.1	17.7	19.5	23.2
Type of neighbourhood				
Urban	61.0	45.5	33.8	31.3
Rural	39.0	54.5	66.2	68.7

Note: ARI=Acute Respiratory Infection; TBA=Traditional Birth Attendant; IQR=InterQuartile Range.

Table A.7: Adjusted odds ratios (OR) and neighbourhood-level varying intercept standard deviations (95% credible intervals) estimated using multi-level logistic regressions comparing children living with different combinations of adult relatives; children aged 0-4 years, 1998 SADHS.

	Breastfed ≥6 months		**Completely immunized**		**Recent ARI**		**Recent diarrhoea**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Household structure								
Co-resident father	REF		REF		REF		REF	
Non-co-resident father								
⩾ 1 male relative	1.12	(0.86 - 1.42)	0.92	(0.73 - 1.14)	0.85	(0.67 - 1.07)	0.83	(0.63 - 1.07)
Female relatives only	1.03	(0.74 - 1.40)	0.89	(0.68 - 1.14)	0.86	(0.64 - 1.14)	0.85	(0.61 - 1.15)
Mother only	1.08	(0.79 - 1.45)	0.79	(0.61 - 1.00)	0.82	(0.60 - 1.09)	0.84	(0.60 - 1.14)
Birth order & preceding birth interval								
1st born	0.68	(0.49 - 0.91)	1.06	(0.80 - 1.38)	1.21	(0.88 - 1.63)	1.32	(0.91 - 1.86)
2-4 born, <24 months	0.98	(0.62 - 1.47)	0.96	(0.65 - 1.36)	1.40	(0.91 - 2.05)	1.46	(0.88 - 2.26)
2-4 born, 24-47 months	REF		REF		REF		REF	
2-4 born, >47 months	0.92	(0.68 - 1.21)	0.93	(0.71 - 1.19)	1.27	(0.94 - 1.69)	1.38	(0.97 - 1.92)
5+ born, <24 months	0.59	(0.30 - 1.06)	0.56	(0.32 - 0.92)	1.42	(0.71 - 2.47)	2.24	(1.09 - 4.03)
5+ born, 24-47 months	1.17	(0.71 - 1.84)	0.75	(0.51 - 1.07)	1.22	(0.76 - 1.84)	1.59	(0.94 - 2.48)
5+ born, >47 months	1.25	(0.74 - 2.02)	0.99	(0.64 - 1.47)	1.47	(0.89 - 2.29)	2.02	(1.15 - 3.29)
Place of delivery								
Public medical facility	REF		REF		REF		REF	
Home	1.35	(0.99 - 1.81)	0.64	(0.50 - 0.79)	1.03	(0.79 - 1.32)	1.41	(1.06 - 1.84)
Private medical facility	0.71	(0.48 - 1.01)	0.89	(0.62 - 1.25)	0.84	(0.54 - 1.23)	0.65	(0.36 - 1.06)

Continued on next page

	Breastfed ≥6 months		Completely immunized		Recent ARI		Recent diarrhoea	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Antenatal care provider								
Nurse/ midwife (+/- doctor)	REF		REF		REF		REF	
Doctor	0.65	(0.49 - 0.85)	0.85	(0.65 - 1.09)	0.97	(0.72 - 1.27)	1.04	(0.73 - 1.42)
TBA, Other, no care	0.88	(0.52 - 1.41)	0.67	(0.43 - 0.99)	0.63	(0.36 - 1.01)	0.53	(0.27 - 0.91)
Time mother wanted pregnancy								
Then	REF		REF		REF		REF	
Later	1.28	(1.01 - 1.59)	1.11	(0.91 - 1.34)	1.05	(0.84 - 1.28)	1.30	(1.02 - 1.65)
No more	1.06	(0.80 - 1.39)	0.83	(0.66 - 1.03)	1.08	(0.82 - 1.38)	1.43	(1.07 - 1.87)
Child's sex								
Female					REF		REF	
Male					1.00	(0.84 - 1.19)	1.33	(1.09 - 1.61)
1 SD increase in child's age (months)			0.68	(0.63 - 0.74)	0.81	(0.74 - 0.88)	0.59	(0.53 - 0.65)
Season								
Summer					REF		REF	
Autumn					1.05	(0.82 - 1.30)	0.98	(0.76 - 1.23)
Winter					1.39	(0.95 - 1.97)	0.61	(0.36 - 0.94)
Mother's population group								
Black/African	REF		REF		REF		REF	
Non-Black/African	0.46	(0.34 - 0.60)	1.53	(1.16 - 1.98)	1.07	(0.81 - 1.40)	0.84	(0.60 - 1.14)

Continued on next page

	Breastfed ≥6 months		Completely immunized		Recent ARI		Recent diarrhoea	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Mother's highest completed education level								
Less than primary	1.45	(1.12 - 1.85)	0.76	(0.61 - 0.93)	0.86	(0.68 - 1.07)	1.19	(0.92 - 1.52)
Primary or incomplete secondary	REF		REF		REF		REF	
Secondary or higher	0.90	(0.69 - 1.14)	1.08	(0.85 - 1.35)	0.85	(0.66 - 1.08)	0.89	(0.65 - 1.19)
Mother's childhood place of residence, whether she migrated								
Rural area, did not migrate	REF		REF					
Urban area, did not migrate	0.55	(0.41 - 0.72)	1.18	(0.92 - 1.51)				
Rural area, migrated to urban	0.76	(0.54 - 1.03)	1.12	(0.83 - 1.46)				
Urban area, migrated to rural	0.77	(0.48 - 1.18)	1.74	(1.10 - 2.66)				
Mother's age at first child birth								
<18	1.14	(0.88 - 1.44)	0.87	(0.71 - 1.06)	1.14	(0.91 - 1.42)	1.06	(0.82 - 1.34)
18-29	REF		REF		REF		REF	
>29	0.68	(0.36 - 1.17)	0.99	(0.56 - 1.65)	0.73	(0.35 - 1.31)	0.96	(0.41 - 1.79)

Continued on next page

	Breastfed ≥6 months		Completely immunized		Recent ARI		Recent diarrhoea	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
1 SD increase in mother's age at index child's birth	0.89	(0.76 - 1.04)	1.11	(0.96 - 1.27)	0.94	(0.80 - 1.10)	0.86	(0.72 - 1.02)
Varying coefficients	**Estimate**	**95% CI**	**Estimate**	**95% CI**	**Estimate**	**95% CI**	**Estimate**	**95% CI**
Neighbourhood intercepts (SD)	0.93	(0.75 - 1.11)	0.80	(0.65 - 0.94)	0.73	(0.56 - 0.90)	0.56	(0.37 - 0.74)

Note: CI=Credible Interval; ARI=Acute Respiratory Infection; TBA=Traditional Birth Attendant; SD=Standard Deviation.

Appendix B

Research Objective 2 Appendices

B.1 MIHS Fathering Sub-Study: Invitation letter for fathers

- TITLE OF THE RESEARCH PROJECT: Mother Infant Health Study
- REFERENCE NUMBER: S12/01/009
- PRINCIPAL INVESTIGATOR: Dr. Monika Esser
- ADDRESS: Department of Pathology, Immunology Unit, 9th Floor, Core Laboratory, Tygerberg Hospital
- CONTACT NUMBER: XXXXXXXXXX / XXXXXXXXXX

Dear Sir,

You are invited to take part in a research study. The study asks: "How do fathers help to keep their babies healthy?" This letter explains what will happen during the study. It also explains how you can be involved. Please read this letter carefully so that you understand what the study is about. It is entirely your choice to take part in the study. Also, if you choose to take part at the start, you can stop taking part at any time.

This study has been approved by the Health Research Ethics Committee at Stellenbosch University. The study will follow the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.

Thank you for taking the time to read this letter.

Sincerely,

Dr. Monika Esser.

Principal Investigator

What is this research study about?

- This study is about why some babies are more likely to need to go into the hospital for infection than other babies.
- By taking part you can help us to learn how fathers are helping to keep their babies healthy.
- The study is being completed at the Children's Infectious Diseases Clinical Research Unit, or KID-CRU, at Tygerberg Hospital.

- The study will involve around 300 babies and their mothers and fathers.

Why have you been invited to take part in this study?

- You are being invited to take part because your baby and your baby's mother are taking part in the study.
- We would like you, the father, to take part too.

What will happen next?

- There are two ways you can take part in this study:

1. You can come to study visits at KID-CRU with your baby and your baby's mother, or
2. You can let a member of our research team talk to you on the phone.

- If you want to take part in study visits at KID-CRU, you will need to come with your baby and your baby's mother to their first study visit. This first visit will be when your baby is around 2 weeks old.
- If you would prefer to take part over the telephone then we will call you when your baby is around 2 weeks old. We will ask your baby's mother for your telephone number.
- We will see you in the clinic or call you on the telephone a total of four times.
- The first time we would like to talk to you, is when your baby will be 2 weeks old. The second will be when your baby is 16 weeks old. The third time will be when your baby is 6 months old, and the last time when your baby is 1 year old.
- Each time we talk with you we will ask you if you still want to take part in the study. We will give you a chance to ask any questions you have about the study. We will then ask you a questionnaire about yourself.
- The calls will be in your choice of Xhosa, Afrikaans or English.

What types of questions will be asked in the questionnaire?

We will ask you questions about the following topics:

- Your education
- Your job
- Your health
- How you have been helping to support your baby and your baby's mother

- How good your relationship is with your baby's mother
- How good your relationship was with your own father when you were a boy

Are there any risks involved in your taking part in this research?

- We do not think there is anything in this study that could harm you. We will not give you any medications or do any medical tests on you in this study.
- Some of the questions we ask may seem sensitive or personal. You do not have to answer any question if you do not want to.

Will you benefit from taking part in this research?

- We do not think taking part in this study will help you. However, in the future, other babies and fathers may benefit from what we learn in this study.

How will your identity be protected?

- The questionnaire will be anonymous. No information that identifies you (like your name or telephone number) will be kept on any study records.

Will you be paid to take part in this study and are there any costs involved?

- You will not be paid to take part in this study.
- The only cost for you to take part in the study is the time to come to KID-CRU or to talk with us on the telephone.
- We will pay for the cost of you, your baby, and your baby's mother's transport to and from KID-CRU for your study visits.
- You will also be offered a small amount (around R10.00) of cell phone airtime at each visit so that you are able to contact the study team if you need to change the time or telephone number for us to contact you.

If you do not want to take part what can you do?

- If you do not want to take part in this study you there are two ways you can let us know:

1. You can tell us at the clinic when you come with your child that you do not want to take part.
2. When we phone you, you can let the interviewer know that you do not want us to phone you again.

- If you do either of these things we will not contact you again.

What can you do if you need more information?

- You can contact Dr. Monika Esser at XXXXXXXXXX if you have questions that are not answered in this letter.
- You can contact the Stellenbosch University Health Research Ethics Committee at XXXXXXXXXX if you have any complaints about the study or about how you are treated by the study staff.

B.2 MIHS Fathering Sub-study: Informed consent script for fathers

Hello. My name is [NAME]. I'm a member of the Mother Infant Health Study research team. I'm speaking to you on behalf of the study doctor, Dr. Monika Esser.

May I please speak with [FATHER'S NAME]?

You should have recently gotten a letter about the Mother Infant Health Study, a study about why some babies are more likely to get sick than others, and about how fathers are helping to keep their babies healthy.

Did you read and understand this letter? [YES] / [NO]

[IF NO, SWITCH TO READING THE INVITATION LETTER] / [IF YES, CONTINUE WITH BRIEF INFORMED CONSENT SCRIPT]

As you read in the letter, your baby and your baby's mother are taking part in the Mother Infant Health Study. We would like to ask you if you would like to take part in the study too.

We would like you to take part in four interviews for this study. If you agree, I will contact you again next week to complete the first interview. We will contact you again in about 3 months time to complete the second interview. The third interview will be in about six months time from now and the final interview will be in about 1 year from now.

During the interviews we will ask questions about your schooling, what type of work you do, and your health. We will ask some questions about how you have been helping to support your baby and your baby's mother, and about your relationship with your baby's mother. We will also ask about how well you knew your own father when you were a boy.

It is entirely your choice if you want to take part in the interviews. Also you can refuse to answer any of the questions. The answers you give are anonymous, and no information that identifies you – such as your name, address, or phone number - will be kept on any study records.

Do you have any questions about the interview?

Do you agree to participate in this interview? [YES] / [NO]

[IF "NO", THANK THE FATHER AND END THE CALL] / [IF "YES", COMPLETE THE REST OF THE SCRIPT]

[*I*F MOTHER HAS AGREED FOR FATHER TO ATTEND KID-CRU WITH HER ASK]

There are two ways for you to complete the interview. You can come with your baby and baby's mother to KID-CRU and do the interview in-person. The other option, is to do the interview over the phone. Which option is better for you? [IN-PERSON INTERVIEW] / [TELEPHONE INTERVIEW]

- *If in-person interview is preferred, remind father of the date, time, and place for pick-up for the study visit.*

[IF TELEPHONE INTERVIEW IS PREFERRED OR IF MOTHER DOES NOT WANT FATHER TO ATTEND KID-CRU WITH HER ASK]

Would it be okay for me to call you on [DATE OF INTERVIEW]? When would be the best time for us to call you? And what is the telephone number we can use to contact you?

- *On face sheet, record time and date to call back.*
- *Confirm telephone number is the same as recorded on the face sheet. If different, record the new number.*
- *Thank the father and end the call.*

B.3 Items included in the fathering questionnaire

Table B.1 lists the complete set of items included in the MIHS fathering questionnaire, arranged into sections by the mode of paternal influence being measured. The table also shows a key for the original response options on the questionnaire and after we recoded the responses for our analyses (where applicable). Similarly, table B.2 on page 263 lists the items designed to measure fathers' and mothers' fatherhood beliefs. The final table in this section (Table B.3 on page 264) lists the item response options represented by each response key.

Table B.1: MIHS Fathering Questionnaire items arranged by the mode of paternal influence they are hypothesized to measure, along with associated response key on questionnaire and after recoding for analysis

Mode & Items	**Original response key**	**Recoded response key**
ACCESSIBILITY		
Number of nights per week stayed in same house as child	Count	–
Frequency spent >=1 hr. with child	ORD 1	RC-ORD 1
Frequency spent >=1 hr. with child, workday mornings	BIN YN	–
Frequency spent >=1 hr. with child, workday afternoons	BIN YN	–
Frequency spent >=1 hr. with child, workday evenings	BIN YN	–
Frequency spent >=1 hr. alone with child, workdays	BIN YN	–
Frequency spent >=1 hr. with child, non-workday mornings	BIN YN	–
Frequency spent >=1 hr. with child, non-workday afternoons	BIN YN	–
Frequency spent >=1 hr. with child, non-workday evenings	BIN YN	–
Frequency spent >=1 hr. alone with child, non-workdays	BIN YN	–
Frequency looked after child while mother did other things	ORD 2	Rev ORD 2
DIRECT CAREGIVING		
Frequency held child	ORD 3	RC-ORD 3
Frequency soothed child	ORD 3	RC-ORD 3
Frequency bathed child	ORD 3	RC-ORD 3
Frequency changed child's diaper	ORD 3	RC-ORD 3

Continued on next page

Mode & Items	**Original response key**	**Recoded response key**
Frequency got up when child woke up during the night	ORD 3	RC-ORD 3
Frequency dressed child	ORD 3	RC-ORD 3
Frequency put child to sleep	ORD 3	RC-ORD 3
Frequency took child for a walk	ORD 3	RC-ORD 3
Frequency talked to child	ORD 3	RC-ORD 3
Frequency sang songs or nursery rhymes to child	ORD 3	RC-ORD 3
RESPONSIBILITY		
Frequency father talked to mother about child	Rev ORD 2	–
Who makes most of the important decisions about child's care	NOM 1	RC-BIN YN
Who decided what child's name would be	NOM 1	RC-BIN YN
Who decided when child would start eating solid foods	NOM 1 (+NA)	RC-BIN YN (+NA)
Who decides when child needs to be taken to the clinic/doctor	NOM 1	RC-BIN YN
Who usually takes child to clinic/doctor	NOM 2	RC-BIN YN
Who usually cares for child when s/he is ill	NOM 2	RC-BIN YN

Continued on next page

Mode & Items	**Original response key**	**Recoded response key**
MATERIAL PROVISIONING		
How do father and mother share expenses for child	NOM 3	RC-BIN YN
In past month, who mainly paid for child care items like diapers	NOM 3 (+NA)	RC-BIN YN
In past month, who mainly paid for clothing for child	NOM 3 (+NA)	RC-BIN YN
In past month, who mainly paid for toys or presents for child	NOM 3 (+NA)	RC-BIN YN (+NA)
In past month, who mainly paid for medicines for child	NOM 3 (+NA)	RC-BIN YN (+NA)
In past month, who mainly paid for food for the household	NOM 3 (+NA)	RC-BIN YN
PRACTICAL SUPPORT FOR MOTHER		
Frequency cooked a meal for the members of the household	ORD 2	Rev ORD 2
Frequency repaired something in the house that was damaged or broken	ORD 2	Rev ORD 2
Frequency washed dishes or cooking pots	ORD 2	Rev ORD 2
Frequency cleaned or tidied the house	ORD 2	Rev ORD 2
Frequency washed clothes for members of the household	ORD 2	Rev ORD 2

Abbreviations: ORD - Ordinal; BIN YN - Binary (Yes/No); NOM - Nominal; NA - Not applicable; RC - recoded; Rev = reverse ordered

Table B.2: MIHS questionnaire items assessing fatherhood beliefs, along with associated response key on questionnaire and after recoding for analysis

Fatherhood Belief Item	**Original response key**	**Recoded response key**
It is less important for a father to spend time with his children than it is for him to provide financially for them	ORD 4	Rev ORD 4
One of the most important things a father can do for his children is to give their mother encouragement and emotional support	ORD 4	Rev ORD 4
A father should be as heavily involved as the mother in the care of their children (doing things like dressing and cleaning the children and changing their nappies)	ORD 4	Rev ORD 4
The father more than the mother should be the one to teach their children "right" from "wrong"	ORD 4	Rev ORD 4
A father must make sure his children are safe and protected	ORD 4	Rev ORD 4
It is difficult for men to express affectionate feelings toward babies. (By "expressing affectionate feelings" I mean doing things like kissing and hugging the baby.)	ORD 4	Rev ORD 4

Abbreviations: ORD - Ordinal; Rev = reverse ordered

Table B.3: MIHS Fathering Questionnaire response keys and associated response options

Key	**Response options**
ORD 1	1=6 or 7 days each week; 2=4 or 5 days each week; 3=2 or 3 days each week; 4=One day each week; 5=One day each two weeks; 6=Never
ORD 2	1=Every day or almost every day; 2=A few times a week; 3=Once or twice; 4=Never
ORD 3	1=More than once a day; 2=About once a day; 3=A few times a week; 4=A few times a month; 5=Rarely; 6=Not at all
ORD 4	1=Strongly Agree; 2=Mildly Agree; 3=Mildly Disagree; 4=Strongly Disagree
NOM 1	1=Mother; 2=Father and mother together; 3=Father; 4=Someone else
NOM 2	1=Mother; 2=Father; 3=Father and mother together; 4=Sometimes father, sometimes mother; 5=Someone else
NOM 3	1=Mother; 2=Father; 3=Mother and father equally; 4=Someone else
RC-ORD 1	1=Never; 2=One day each week/each two weeks; 3=2-5 days each week; 4=6-7 days each week
RC-ORD 2	1=Not at all; 2=Rarely/a few times per month; 3=A few times per week/about once per day; 4=More than once per day
RC-BIN YN	0=Mother/Someone else; 1=Father/Father and mother together/Sometimes father, sometimes mother

B.4 MIHS Fathering Sub-study: Fathering questionnaire for father, 2-week visit

1. Interview method? [1=Face-to-face interview 2=Telephone interview]
2. What is your birth date? Date: [DD/MON/YYYY] or [777=Don't know] (*If birth date is known, skip to Q4*)
3. How old are you? Age (in years):___
4. Which racial group do you belong to? (*choose only 1*) [1=Black African 2=Coloured 3=Indian/Asian 4=White 5=Other (specify)]
5. When you were a child, what language did you speak most often at home? (*choose only 1*) [1=Afrikaans 2=English 3=Xhosa 4=Zulu 5=Other African 6=Other Non-African]
6. Have you ever attended school? [1=Yes 2=No] *(If "No", skip to Q9*)
7. What is the highest level completed? [0=less than 1 year 1=sub A/grade 1 2=sub B/grade 2 3=standard 1/grade 3 4=standard 2/grade 4 5=standard 3/grade 5 6=standard 4/grade 6 7=standard 5/grade 7 8=standard 6/grade 8 9=standard 7/grade 9 10=standard 8/grade 10 11=standard 9/grade 11 12=standard 10/grade 12 13=Further studies incomplete 14=Diploma or other post-school completed 15=Further degree completed]
8. Are you currently attending school? [1=Yes 2=No]
9. Did you work for pay in the last 7 days? [1=Yes 2=No] (*"Yes", skip to Q11*)
10. Have you done any work in the past 12 months? [1=Yes 2=No] (*If "No", skip to Q17*)
11. During the last 12 months, how many months did you work? Number of months:___
12. During the last 12 months, how many days a week did you usually work? Number days per week:___
13. How much do you usually earn for this work? Amount in Rands:___ (*Specify timing*) [1=Per hour 2=Per day 3=Per week 4=Per month 5=Per year]
14. In your main job are you: Working for someone else for pay? (Including paid domestic workers, gardeners or security guards); An employer (employing one or more employees)?; Or working for yourself (not employing any employees)? [1=Working for someone else for pay 2=An employer 3=Working for yourself] (*If "An employer" or "Working for yourself", skip to Q16*)
15. Are you employed on the basis of a written contract or a verbal agreement? [1=Written contract 2=Verbal agreement 77=Don't know]

16. In your own words, what is your occupation? (That is, what type of work do you mainly do in your job?) Occupation (in man's own words):___
17. Do you currently receive a disability grant? [1=Yes 2=No]
18. Do you currently receive a child support grant? [1=Yes 2=No]
19. Do you currently receive a foster child grant? [1=Yes 2=No]
20. Do you currently receive a care dependency grant? [1=Yes 2=No]
21. Do you currently receive a social relief of distress grant? [1=Yes 2=No]
22. Do you currently receive a war veteran grant? [1=Yes 2=No]
23. Do you currently receive an old age grant? [1=Yes 2=No]
24. In general, compared to other men of your age, how is your health at the moment? [1=Excellent 2=Good 3=Fair 4=Poor]
25. Do you have any long-term illness, health problem or handicap that limits your daily activities or the work you can do? [1=Yes 2=No 77=Refused to answer]
26. Have you ever had an HIV test? [1=Yes 2=No 77=Refused to answer] (*If "No", skip to Q30*)
27. Was your most recent test positive or negative? [1=Positive 2=Negative 77=Refused to answer] (*If "Negative", skip to Q29*)
28. Do you take daily antiretroviral (or "ARV") medication for HIV infection? [1=Yes 2=No 77=Refused to answer]
29. Have you told (CHILD)'s mother the result of your test? [1=Yes 2=No 77=Refused to answer]
30. In the last month how often did you have a drink containing alcohol? [1=Never 2=Maybe once in the month 3=About once a week 4=Every day or almost every day 77=Refused to answer] (*If "Never", skip to Q32*)
31. In the last month how many times did you have 6 or more drinks in one sitting? [1=Never 2=Maybe once in the month 3=About once a week 4=Every day or almost every day 77=Refused to answer]
32. In the last month have you used any street drugs (like Tic)? [1=Yes 2=No 77=Refused to answer]
33. Including the baby in this study, how many children of your own do you have? Number of children:___ (*If number is 1 then skip to Q36*)
34. Do you have children with more than one woman? [1=Yes 2=No 77=Don't know/Refused]

35. How old were you when your first child was born? Age (in years):___

Now I would like to ask you some questions about your relationship with the mother of your baby in this study.

36. For how many years have you known (CHILD)'s mother? Years:___ *(Record to the nearest completed year*)

37. Thinking about the time 9 months ago, how would you describe your relationship with (CHILD)'s mother then. (I am talking about the time when (CHILD)'s mother became pregnant with (CHILD).) [1=Married 2=Together as an exclusive couple (not married) (By "exclusive" I mean you were not in a relationship or having sex with someone other than (CHILD)'s mother) 3=Together as couple but not exclusive 4=Casual partners (having sex but not exclusive) 5=Other (specify):___ 77=Refused to answer]

38. Between then and NOW, has your relationship with (CHILD)'s mother changed? [1=Yes 2=No] (*If "No", skip to Q40*)

39. How would you describe your relationship with (CHILD's MOTHER) NOW? [1=Married 2=Together as an exclusive couple (not married) (By "exclusive" I mean you were not in a relationship or having sex with someone other than (CHILD)'s mother) 3=Together as couple but not exclusive 4=Casual partners (having sex but not exclusive) 5=We are friends (but not having sex) 6=We only see each other about (CHILD) 7=We no longer see each other 8=Other (specify):___ 77=Refused to answer]

40. Were you and (CHILD)'s mother living together 9 months ago? (At the time when she became pregnant with (CHILD).) [1=Yes 2=No]

41. Do you and (CHILD's MOTHER) live together in the same household NOW? [1=Yes 2=No]

42. Do you live in the same household as (CHILD) NOW? [1=Yes 2=No]

43. When did you find out that (CHILD)'s mother was pregnant with (CHILD)? Was it during her pregnancy or after (CHILD)'s birth? [1=During the pregnancy 2=After (CHILD)'s birth (*If "After (CHILD)'s birth", skip to Q51*)

Did you do any of the following BEFORE (CHILD) was born?

44. Go to the clinic or doctor with (CHILD)'s mother? [1=Yes 2=No]

45. Discuss how (CHILD)'s mothers pregnancy was going with her? [1=Yes 2=No]

46. Give (CHILD)'s mother money or buy things for the baby? [1=Yes 2=No]

47. Feel (CHILD) move inside (CHILD)'s mother's stomach [1=Yes 2=No]

48. Did you do any other things to help (CHILD)'s mother prepare for (CHILD's) birth? [1=Yes 2=No]

49. (*If Q48 is "Yes"*) What types of things did you do? Record in man's own words:___ (*Check Questions 44 to 48. If one or more has a "Yes" response then skip to Q51*)

50. What was the reason you did not do any of these activities? Record in man's own words:___

51. Thinking of (CHILD's) birth, were you at the clinic/hospital (either in the waiting room or in the delivery room) when (he/she) was born? [1=Yes 2=No]

52. Did you travel with (CHILD) and (CHILD's) mother home from the clinic/hospital after (CHILD) was born? [1=Yes 2=No]

53. Thinking about the time since (CHILD)'s birth, have there been any nights when you and (CHILD) did not stay together in the same house? (*If the man works night shifts, ask if there have been any days when he did not stay in the same house as (CHILD).*) [1=Yes 2=No] (*If "No", skip to Q57*)

54. Since (CHILD)'s birth, how many nights did you stay in a different house from (CHILD)? (*If the man works night shifts, ask how many days he stayed in a different house from (CHILD).*) Number of nights:___

55. Did you spent this time away from the house where (CHILD) lives for your work? [1=Yes 2=No] *(If "Yes", skip to Q57*)

56. What were the reasons why you spent some nights staying in a different house from (CHILD)? Record in man's own words:___

57. In an average week, how many days do you spend one hour or more with (CHILD)? Is it… [1=Six or Seven days each week 2=Four or Five days each week 3=Two or Three days each week 4=One day each week 5=One day each two weeks 6=Never] (*If "Never", skip to Q66*)

Thinking about the days WHEN YOU WORK:

58. Do you usually spend an hour or more with (CHILD) in the MORNING? [1=Yes 2=No 3=N/A: Father does not work] (*If "N/A: father does not work", skip to Q62*)

59. Still thinking about days WHEN YOU WORK, do you usually spend an hour or more with (CHILD) in the AFTERNOON? [1=Yes 2=No]

60. And do you usually spend an hour or more with (CHILD) in the EVENING? [1=Yes 2=No]

61. On days WHEN YOU WORK, do you usually spend a full hour or more alone with (CHILD)? (By "alone" I mean there is no body else in the room with you and (CHILD).) [1=Yes 2=No]

Now, thinking about days when you DO NOT WORK:

62. Do you usually spend an hour or more with (CHILD) in the MORNING? [1=Yes 2=No]
63. Still thinking about days when you DO NOT WORK, do you usually spend an hour or more with (CHILD) in the AFTERNOON? [1=Yes 2=No]
64. Do you usually spend an hour or more with (CHILD) in the EVENING? [1=Yes 2=No]
65. On days when YOU DO NOT WORK, do you usually spend a full hour or more alone with (CHILD)? (By "alone" I mean there is no body else in the room with you and (CHILD).) [1=Yes 2=No]
66. Since (CHILD) was born, how often have you looked after (CHILD) while (CHILD)'s mother did other things? Was it… [1=Every day or almost every day 2=A few times a week 3=Once or twice 4=Never 77=Refused to answer]

Some fathers are unable to spend much time with their infants. I'm going to read you a list of reasons some fathers have given us. For each one, please tell me if this has ever been a reason for why you were not able to spend time with (CHILD).

67. You live too far away to spend more time with (him/her) [1=Yes 2=No]
68. Your work stops you from being able to spend more time with (him/her) [1=Yes 2=No]
69. Poor health stops you from being able to spend more time with (him/her) [1=Yes 2=No]
70. You don't have enough time [1=Yes 2=No]
71. You are not good with babies [1=Yes 2=No]
72. You don't know (CHILD)'s mother well [1=Yes 2=No]
73. You don't know if (CHILD) is your child [1=Yes 2=No]
74. (CHILD)'s mother won't let you spend more time (him/her) [1=Yes 2=No]
75. You are not interested in spending more time with (CHILD) [1=Yes 2=No]

Thinking about the days when you are with (CHILD), how often since (he/she) was born have you done any of the following with (him/her)? Was it "more than once a day"; "about once a day"; "a few times a week"; "a few times a month"; "rarely"; or "not at all"?

76. Held (CHILD)?
77. Soothed (CHILD) when (he/she) was upset?
78. Washed or bathed (CHILD)?
79. Changed (CHILD)'s nappie? [7=N/A: (CHILD) does not wear nappies]

80. Got up with (CHILD) when (he/she) woke up during the night?
81. Dressed (CHILD)
82. Put (CHILD) to sleep
83. Took (CHILD) for a walk
84. Talked to (CHILD)
85. Sang songs or nursery rhymes to (him/her)?

Since (CHILD) was born have you ever done any of the following with (him/her):

86. Have you had relatives/family members visit you? [1=Yes 2=No 3=N/A: No family to visit]
87. Have you taken (CHILD) with you to visit relatives/family members? [1=Yes 2=No 3=N/A: No family to visit]
88. Have you visited friends with (CHILD)? [1=Yes 2=No 3=Not applicable]
89. Have you taken (CHILD) shopping with you? [1=Yes 2=No 3=Not applicable]
90. Have you taken (CHILD) with you to a religious service or religious event? [1=Yes 2=No 3=N/A: Not religious]
91. Since (CHILD) was born, how often have you talked with (CHILD)'s mother about (CHILD)? [1=Never 2=Once or twice 3=A few times a month 4=A few times a week 5=Every day or almost every day]
92. How do important decisions about (CHILD)'s care get made? [1=You make most of the important decisions 2=You and (CHILD)'s mother make most of the important decisions together 3=(CHILD)'s mother makes most of the important decisions 4=Someone else makes most of the important decisions (If someone else) Specify who:___]

Who made each of the following decisions about (CHILD)'s care? Was it "you who decided"; "you and (CHILD)'s mother who decided together"; "(CHILD)'s mother who decided"; or "someone else who decided"?

93. Deciding what (CHILD)'s name would be?
94. Deciding when (CHILD) would start eating solid foods? [5=N/A: (CHILD) is not eating solid foods yet]
95. Deciding when (CHILD) needs to be taken to the clinic or doctor?

96. When (CHILD) needs to be taken to the medical clinic or doctor, who usually takes (him/her)? Is it… [1=You who usually takes (him/her) 2=(CHILD)'s mother who usually takes (him/her) 3=You and (CHILD)'s mother who usually take (him/her) together 4=Sometimes you who takes (him/her) and sometimes (CHILD)'s mother who takes (him/her) 5=Someone who else usually takes (him/her) (If someone else) Specify who:___]

97. When (CHILD) is ill, who usually cares for (him/her)? (By "care" I mean things like giving (him/her) medicine, soothing (him/her), and putting (him/her) to sleep). Is it… [1=You who usually cares for (him/her) 2=(CHILD)'s mother who usually cares for (him/her) 3=You and (CHILD)'s mother who usually care for (him/her) together 4=Sometimes you who cares for (him/her) and sometimes (CHILD)'s mother who cares for (him/her) 5=Someone else who usually cares for (him/her) (If someone else) Specify who:___]

98. How do you and (CHILD)'s mother share expenses for (CHILD)? [1=You and (CHILD)'s mother share half/half 2=You pay most 3=She pays most 4=Someone else pays most (If someone else) Specify who:___]

Since child was born, who has mainly paid for each of the following items for (CHILD)? Was it "mainly you"; "mainly (CHILD)'s mother"; both you and (CHILD)'s mother equally"; or "mainly someone else"?

99. Child care items like nappies and wet-wipes? [5=Not applicable]

100. Clothing? [5=Not applicable]

101. Toys or presents? [5=Not applicable]

102. Medicines? [5=Not applicable]

103. Food for the household? [5=Not applicable]

Since (CHILD) was born, how often have you done the following activities in the house where (CHILD) lives? Was it "every day or almost every day"; "a few times a week"; "once or twice"; or "never"?

104. Cooked a meal for the members of the household?

105. Repaired something in the house that was damaged or broken?

106. Washed the dishes or cooking pots?

107. Cleaned or tidied the house?

108. Washed clothes for members of the household?

Thinking of your experience as a father for (CHILD) since (CHILD) was born, please rate how good a job you think you did as a father on each of the items listed below.

109. Giving (CHILD)'s mother encouragement and emotional support [1=Excellent 2=Very good 3=Good 4=Fair 5=Poor 6=Very poor 77=Refused to answer]

110. Cooperating with (CHILD)'s mother in raising (CHILD) [1=Excellent 2=Very good 3=Good 4=Fair 5=Poor 6=Very poor 77=Refused to answer]

111. Providing (CHILD)'s basic needs (food, clothing, shelter, and health care) [1=Excellent 2=Very good 3=Good 4=Fair 5=Poor 6=Very poor 77=Refused to answer]

112. Accepting responsibility for the financial support of (CHILD) [1=Excellent 2=Very good 3=Good 4=Fair 5=Poor 6=Very poor 77=Refused to answer]

113. Thinking of the coming years, how much do YOU want to be involved in raising (CHILD)? Would you say… [1=A lot 2=A little 3=Not very much 4=Not at all]

114. And, how much do you think (CHILD's) mother wants you to be involved in raising (CHILD)? Would you say… [1=A lot 2=A little 3=Not very much 4=Not at all 77=Don't know]

Read the paragraph to the father then ask him to answer each question :

No matter how well a couple gets along, there are times when they disagree or fight. Couples also have many different ways of trying to settle their differences. I am going to ask you about a few things that might have happened when you and (CHILD)'s mother disagreed. How many times did you do each of the following things in the past 3 months, and how many times did (CHILD)'s mother do them in the past 3 months:

[1=Once in the past three months 2=Twice in the past three months 3=Three to Five times in the past three months 4=Six to Ten times in the past three months 5=Eleven to 20 times in the past three months 6=More than 20 times in the past three months 7=Not in the past three months but this did happen before 8=This has never happened]

(Ask the father to guess the number of times, then select the corresponding response. If the father does not know, prompt him using the pre-defined response.)

115. You showed (CHILD)'s mother you cared even though you disagreed

116. (CHILD)'s mother showed care for you even though you disagreed

117. You explained your side of a disagreement to (CHILD)'s mother

118. (CHILD)'s mother explained her side of a disagreement to you

119. You insulted or swore at (CHILD)'s mother

120. (CHILD)'s mother did this to you

121. You showed respect for (CHILD)'s mother's feelings about an issue

122. (CHILD)'s mother showed respect for your feelings about an issue

123. You punched or hit (CHILD)'s mother with something that could hurt

124. (CHILD)'s mother did this to you

125. You said you were sure you could work out a problem

126. (CHILD)'s mother was sure you could work it out

127. You suggested a compromise to a disagreement

128. (CHILD)'s mother did this to you

129. You threatened to hit or throw something at (CHILD)'s mother

130. (CHILD)'s mother did this to you

131. You agreed to try a solution to a disagreement (CHILD)'s mother suggested

132. (CHILD)'s mother agreed to try a solution you suggested

I would like to ask you some questions about your experiences with your father.

133. Was your biological father alive when you were a child? (By "child" I mean when you were between 2 years old and 12 years old) [1=Yes 2=No] (*If "No", skip to Q138*)

134. In general, how often did you see your biological father when you were a child? [1=Every day or almost every day 2=A few times a week 3=A few times a month 4=A few times a year 5=Less than a few times a year but I did see him rarely 6=I never saw him as a child]

135. Now thinking about when you were a teenager, was your biological father alive? (By "teenager" I mean when you were between 13 years old and 21 years old) [1=Yes 2=No] (*If "No", skip the next question - Q136*)

136. In general, how often did you see your biological father when you were a teenager? [1=Every day or almost every day 2=A few times a week 3=A few times a month 4=A few times a year 5=Less than a few times a year but I did see him rarely 6=I never saw him as a teenager]

(*Check Q134. If response is "I never saw him as a child", skip to Q138*)

137. Overall, how would you describe the general quality of your relationship with your biological father while you were growing up? (that is, when you were between 2 years old and 21 years old?) [1=Excellent 2=Good 3=Fair 4=Poor]

138. Was there another man in your life who was like a father to you when you were growing up? (that is, between when you were 2 years old and 21 years old?) [1=Yes 2=No] (*If "No", skip to Q142*)

139. Who was this person? Record in man's own words:___

140. What did this person do that made him "like a father" to you? Record in man's own words:___

141. Overall, how would you describe the general quality of your relationship with the man who was like a father to you while you were growing up? (that is, when you were between 2 years old and 21 years old?) [1=Excellent 2=Good 3=Fair 4=Poor]

Now I would like to ask you some questions about your experiences with your mother.

142. Was your biological (or birth) mother alive when you were a child? (By "child" I mean when you were between 2 years old and 12 years old) [1=Yes 2=No] (*If "No", skip to Q147*)

143. In general, how often did you see your biological (or birth) mother when you were a child? [1=Every day or almost every day 2=A few times a week 3=A few times a month 4=A few times a year 5=Less than a few times a year but I did see her rarely 6=I never saw her as a child]

144. Now thinking about when you were a teenager, was your biological mother alive? (By "teenager" I mean when you were between 13 years old and 21 years old) [1=Yes 2=No] *(If "No", skip next question - Q145*)

145. In general, how often did you see your biological mother when you were a teenager? [1=Every day or almost every day 2=A few times a week 3=A few times a month 4=A few times a year 5=Less than a few times a year but I did see her rarely 6=I never saw her as a teenager]

(*Check Q143. If response is "I never saw her as a child", skip to Q147*)

146. Overall, how would you describe the general quality of your relationship with your biological mother while you were growing up? (that is, when you were between 2 years old and 21 years old?) [1=Excellent 2=Good 3=Fair 4=Poor]

147. Was there another woman in your life who was like a mother to you when you were growing up? (that is, between when you were 2 years old and 21 years old?) [1=Yes 2=No] (*If "No", skip to Q151*)

148. Who was this person? Record in man's own words:___

149. What did this person do that made her "like a mother" to you? Record in man's own words:___

150. Overall, how would you describe the general quality of your relationship with the woman who was like a mother to you while you were growing up? (that is, when you were between 2 years old and 21 years old?) [1=Excellent 2=Good 3=Fair 4=Poor]

How much do you agree or disagree with each of the following statements:

151. It is less important for a father to spend time with his children than it is for him to provide financially for them. [1=Strongly agree 2=Mildly agree 3=Mildly disagree 4=Strongly disagree 77=Don't know]

152. One of the most important things a father can do for his children is to give their mother encouragement and emotional support [1=Strongly agree 2=Mildly agree 3=Mildly disagree 4=Strongly disagree 77=Don't know]

153. A father should be as heavily involved as the mother in the care of their children (doing things like dressing and cleaning the children and changing their nappies) [1=Strongly agree 2=Mildly agree 3=Mildly disagree 4=Strongly disagree 77=Don't know]

154. The father more than the mother should be the one to teach their children "right" from "wrong" [1=Strongly agree 2=Mildly agree 3=Mildly disagree 4=Strongly disagree 77=Don't know]

155. A father must make sure his children are safe and protected [1=Strongly agree 2=Mildly agree 3=Mildly disagree 4=Strongly disagree 77=Don't know]

156. It is difficult for men to express affectionate feelings toward babies. (By "expressing affectionate feelings" I mean doing things like kissing and hugging the baby.) [1=Strongly agree 2=Mildly agree 3=Mildly disagree 4=Strongly disagree 77=Don't know]

That is the end of the questionnaire. Thank you for taking the time to complete it with me. We would like to contact you again for the next questionnaire in about 3 and a half months time.

B.5 Reasons for father's non-participation in the MIHS fathering sub-study

Table B.4: Frequency distribution of reasons for father's non-participation; MIHS Fathering sub-study, 2012-13.

Reason for non-participation	*n*	%
Mother did not want father to participate	21	19.6
Mother did not have father's telephone number	5	4.7
Unable to make contact with father	16	15.0
Father did not want to participate:		
No reason given	19	17.8
Was not interested in the study	1	0.9
Denied paternity of the infant	7	6.5
Too busy to participate	12	11.2
Refused because he was not living in Cape Town	1	0.9
Father continued to delay enrolment	9	8.4
Father enrolled but continued to delay first study visit	16	15.0
Total	107	100.0

B.6 Description of cohort with complete follow-up to 6 months

Table B.5 presents descriptive statistics for sociodemographic and health variables reported by mothers at enrolment and 2 weeks for the cohort who had complete follow-up to 6 months. P-values are from Pearson chi-square tests and Wilcoxon rank-sum tests, and demonstrate that there were no significant differences between this group and the complete cohort at the 2-week visit.

Table B.5: Descriptive statistics for cohort with complete follow-up to 6 months (N=109), maternal report at enrolment and 2-week visit: MIHS Fathering Sub-study, 2012-13

	n	%	p-value
FATHER'S CHARACTERISTICS			
Age (years)			0.950
18-19	0	0.0	
20-24	16	14.7	
25-29	28	25.7	
30-34	28	25.7	
35-39	17	15.6	
40-44	12	11.0	
45+	1	0.9	
Don't know	7	6.4	
Population group			0.691
Black	97	89.0	
Coloured	12	11.0	
First language			0.869
Afrikaans	12	11.0	
Xhosa	71	65.1	
Other African	23	21.1	
Other non-African	3	2.8	
Educational attainment			0.974
Completed primary or less	7	6.4	
1 year of secondary	5	4.6	
2 years of secondary	12	11.0	
3 years of secondary	13	11.9	
4 years of secondary	17	15.6	
Completed secondary	34	31.2	
Some post-secondary	6	5.5	
Don't know/Missing	15	13.8	

Continued on next page

	n	%	p-value
Employment status			0.840
Worked in last week	88	80.7	
No work in last week, worked in last year	7	6.4	
No work in last year	13	11.9	
Days worked per week, median (IQR)	5	(5-6)	0.662
Don't know/Missing	18	16.5	
Months worked last year, median (IQR)	12	(8-12)	0.676
Don't know/Missing	16	14.7	
Median monthly earnings, thousand Rands (IQR)	2.8	(2.0-4.0)	0.992
Don't know/Missing	49	45.0	
Has long-standing, work-limiting illness	7	6.4	0.955
HIV status			0.964
Infected	19	17.4	
Uninfected	43	39.5	
Not tested	33	30.3	
Don't know/Refused	14	12.8	
Number of children			0.801
1	31	28.4	
2	42	38.5	
3+	35	32.1	
Has children with other women			0.915
Yes	47	43.1	
No	29	26.6	
N.A. (only 1 child)	31	28.4	
Residing with study infant at 2-wk visit	63	57.8	0.977

Continued on next page

	n	%	p-value
MOTHER'S CHARACTERISTICS			
Mother's age (years)			0.963
18-19	10	9.2	
20-24	34	31.2	
25-29	31	28.4	
30-34	20	18.4	
35-39	10	9.2	
40-44	4	3.7	
45+	0	0.0	
Mother's educational attainment			0.983
Completed primary or less	6	5.5	
1 year of secondary	5	4.6	
2 years of secondary	9	8.3	
3 years of secondary	17	15.6	
4 years of secondary	31	28.4	
Completed secondary/some post-secondary	41	37.6	
Mother is HIV-infected	57	52.3	0.932
Mother worked in year prior to delivery	49	45.0	0.712
Mother's median monthly income, thousand Rands (IQR)	1.0	(0.3-2.2)	0.940
CHILD CHARACTERISTICS			
Sex			0.874
Female	58	53.2	
Male	51	46.8	
Pregnancy was planned	29	26.6	0.506
RELATIONSHIP CHARACTERISTICS			
Living with mother at conception	61	56.0	0.897
Relationship with mother at 2-wk visit			0.973
Married	31	28.4	
Exclusive couple (not married)	62	56.9	
Non-exclusive or casual relationship	3	2.8	
No longer seeing mother/only seeing mother about the infant	12	11.0	

Continued on next page

	n	%	p-value
Time known mother at 2-wk visit			0.746
≤1 year	15	13.8	
2-4 years	44	40.4	
≥5 years	49	45.0	
Father used negotiation to resolve conflict, past 3 mo.§	93	85.3	0.777
Father insulted or threatened mother, past 3 mo.	21	19.3	0.117
Father hit mother, past 3 mo.	6	6.4	0.076
INFANT'S HOUSEHOLD CHARACTERISTICS			
Number of children			0.678
1	32	29.4	
2-3	43	39.5	
4+	34	31.2	
Living with grandparents	25	22.9	0.985
Living with mother's adult siblings	24	22.0	0.805

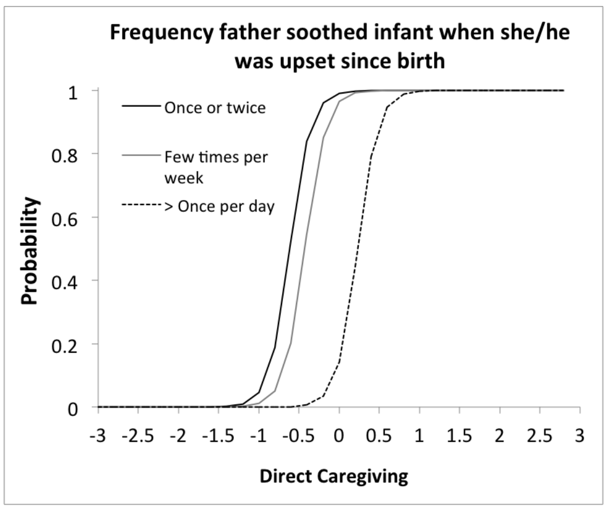
Note: IQR=InterQuartile Range; wk=week; mo.=months. P-values are from Pearson's chi-squared tests (categorical variables) and Wilcoxon rank-sum tests (continuous variables) comparing characteristics of participants who completed all three study visits to the total cohort at the 2-week visit.

B.7 Additional IRT findings

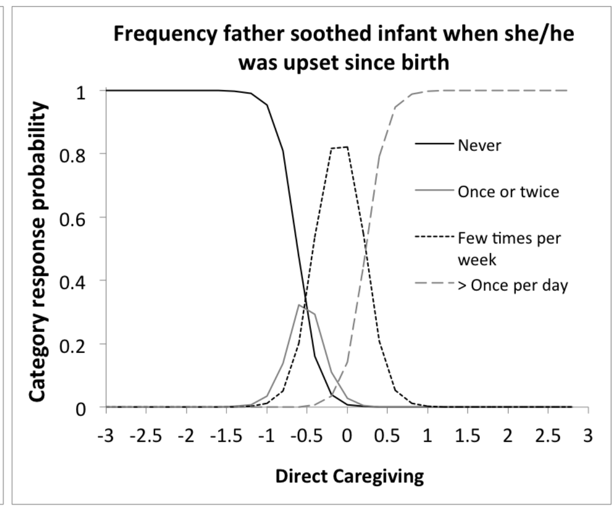
In this section we present additional findings from our IRT analyses. The findings are separated into subsections by the latent trait being modelled.

B.7.1 Additional findings: Direct Caregiving trait

Figures B.1 to B.6 depict the Category Characteristic Curves and Category Response Curves for the *Soothed*, *Sleep*, *Talked*, *Night*, *Walk*, and *Diaper* items included in the model for the Direct Caregiving trait.

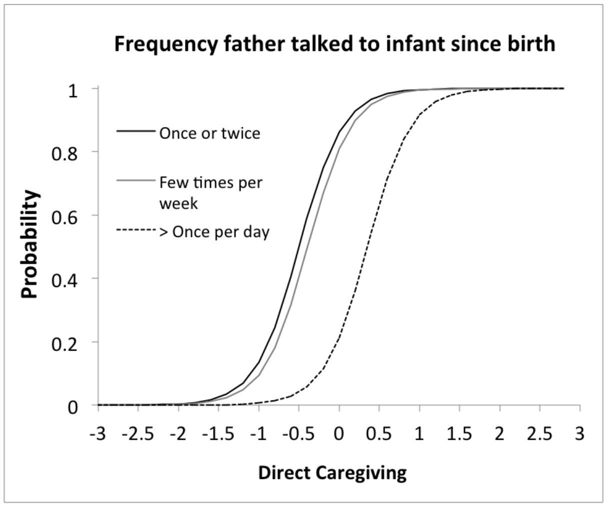


(a)

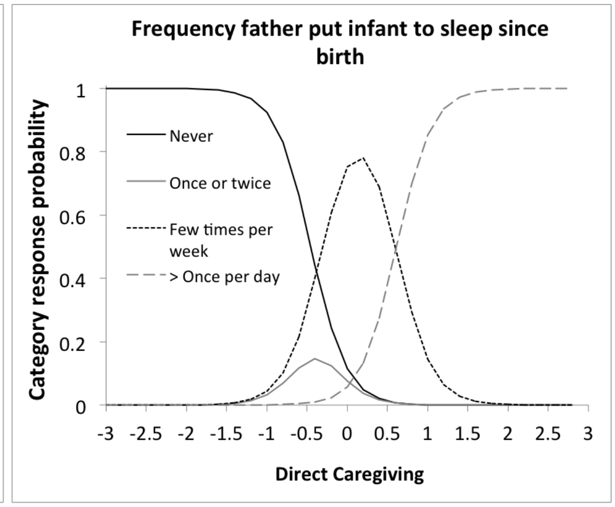


(b)

Figure B.1: Category characteristic curves (a) and Category Response Curves (b) for *Soothed* item in the IRT model for the Direct Caregiving trait.

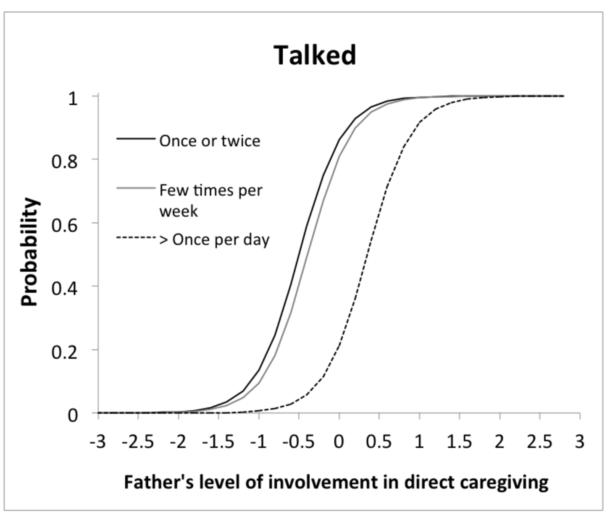


(a)

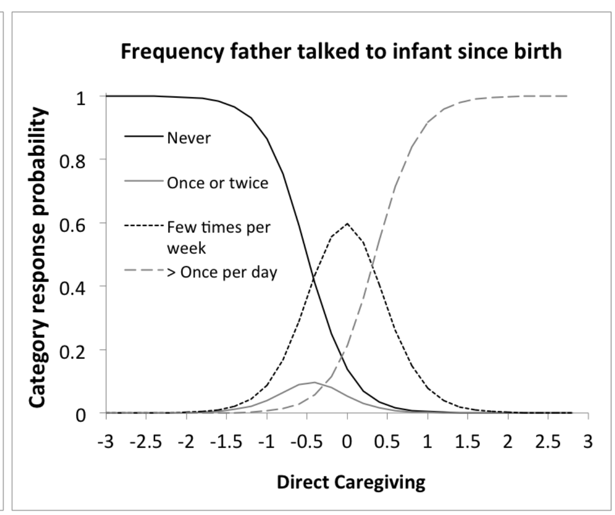


(b)

Figure B.2: Category characteristic curves (a) and Category Response Curves (b) for *Sleep* item in the IRT model for the Direct Caregiving trait.

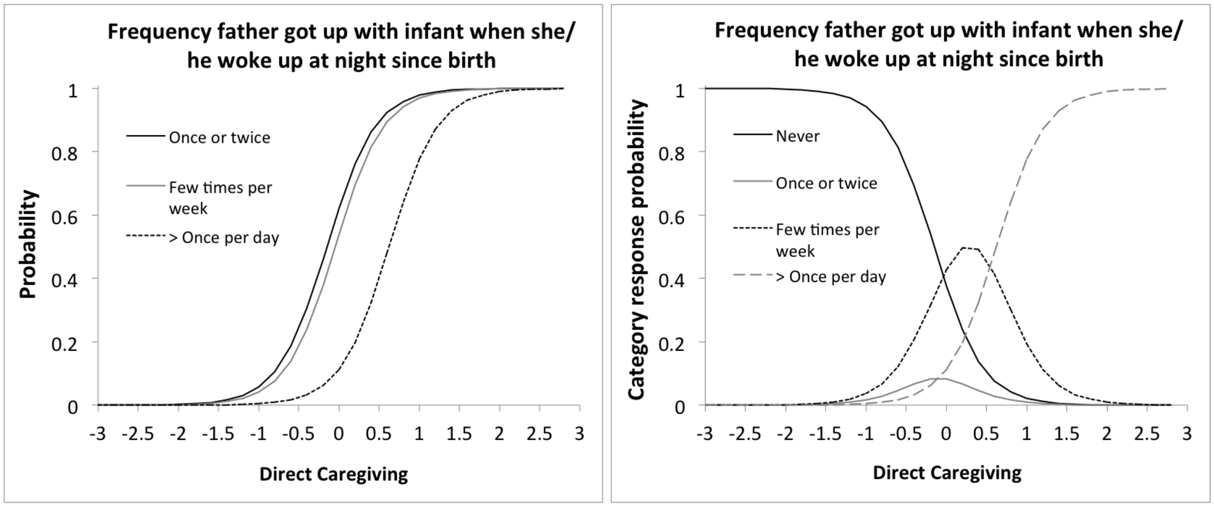


(a)



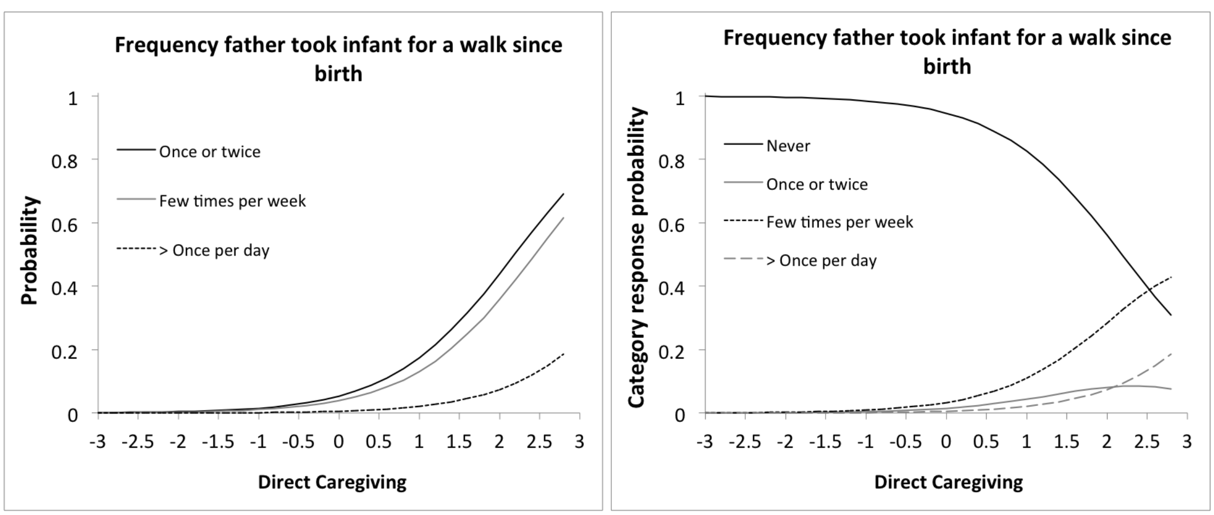
(b)

Figure B.3: Category characteristic curves (a) and Category Response Curves (b) for *Talked* item in the IRT model for the Direct Caregiving trait.



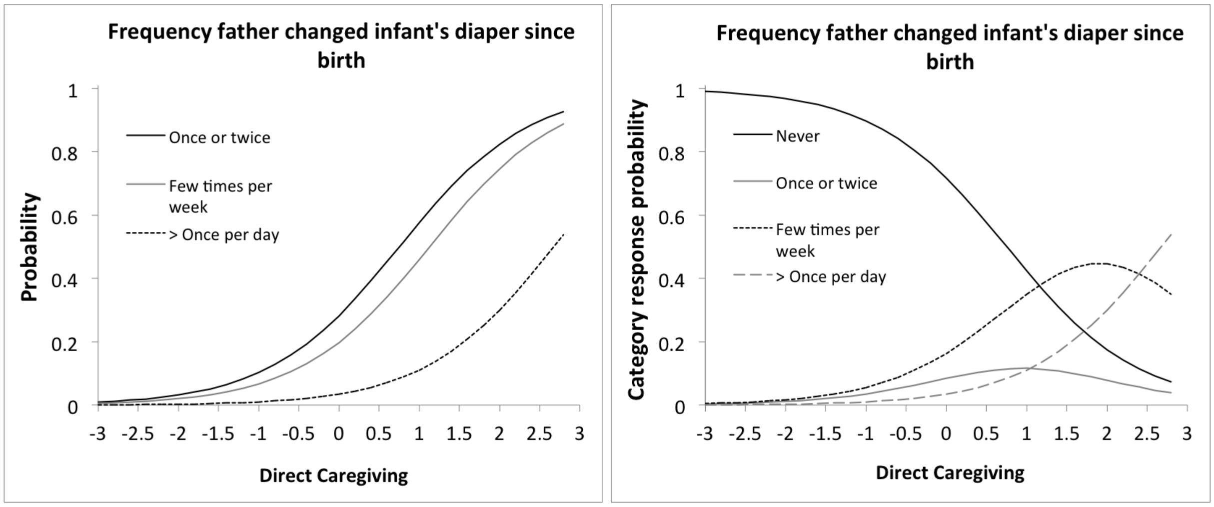
(a) (b)

Figure B.4: Category characteristic curves (a) and Category Response Curves (b) for *Night* item in the IRT model for the Direct Caregiving trait.



(a) (b)

Figure B.5: Category characteristic curves (a) and Category Response Curves (b) for *Walk* item in the IRT model for the Direct Caregiving trait.

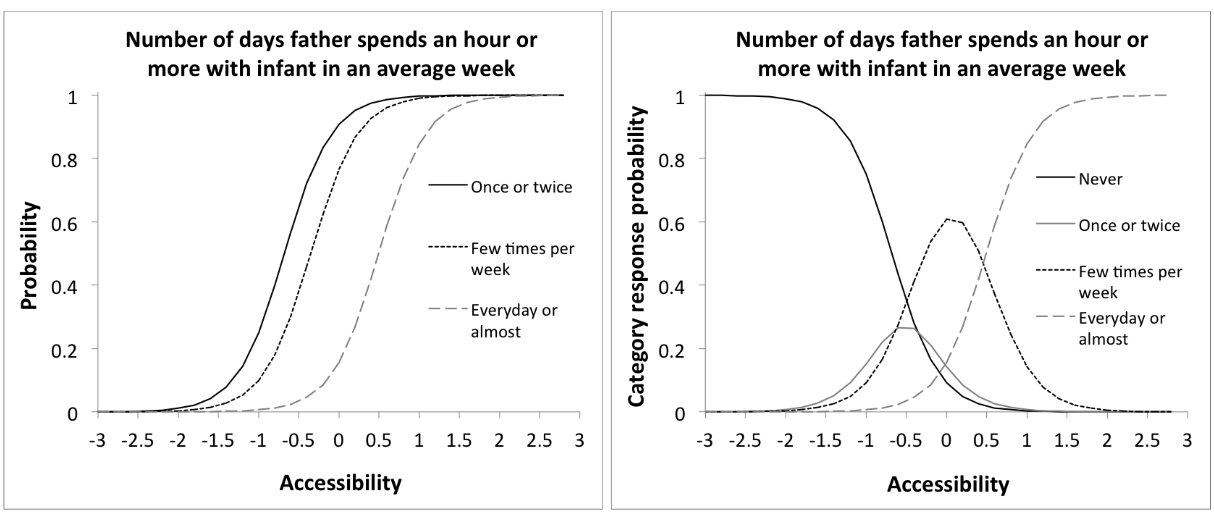


(a) (b)

Figure B.6: Category characteristic curves (a) and Category Response Curves (b) for *Diaper* item in the IRT model for the Direct Caregiving trait.

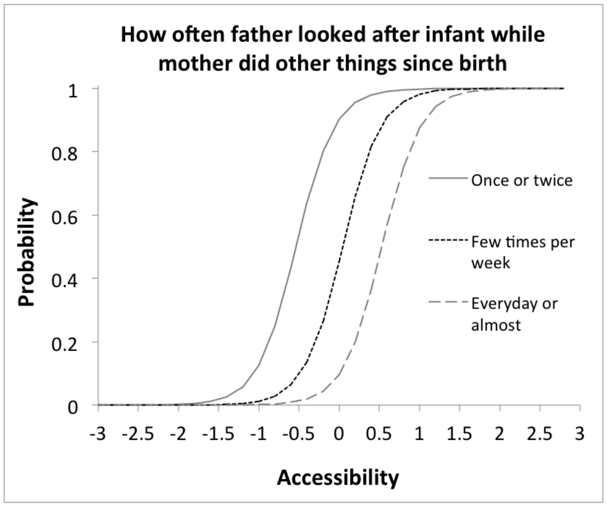
B.7.2 Additional findings: Accessibility trait

Category Characteristic Curves and Category Response Curves for the *Spent hr.* and *Looked after alone* items in the Accessibility trait IRT model are shown in figures B.7 (page 283) and B.8 (page 284), respectively.

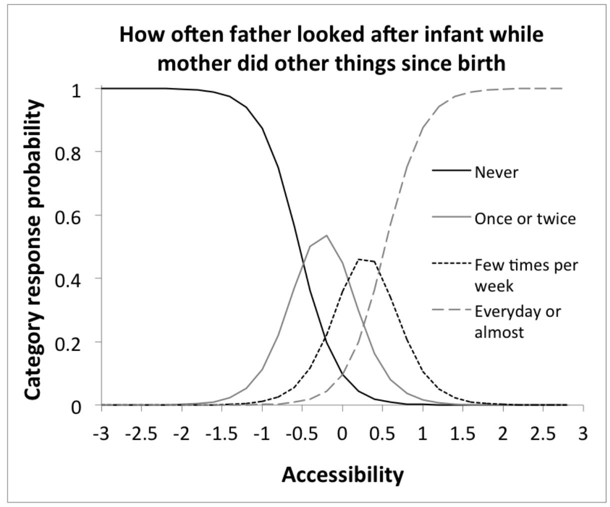


(a) (b)

Figure B.7: Category characteristic curves (a) and Category Response Curves (b) for item measuring the number of days the father spends an hour or more with the infant in an average week (*Spent hr.*) in the IRT model for the Accessibility trait.



(a)



(b)

Figure B.8: Category characteristic curves (a) and Category Response Curves (b) for *Looked after alone* item in the IRT model for the Accessibility trait.

B.7.3 Additional findings: Responsibility trait

Figure B.9 depicts the percentage distributions of mothers' responses to the dichotomized Responsibility items, measured at 2 weeks.

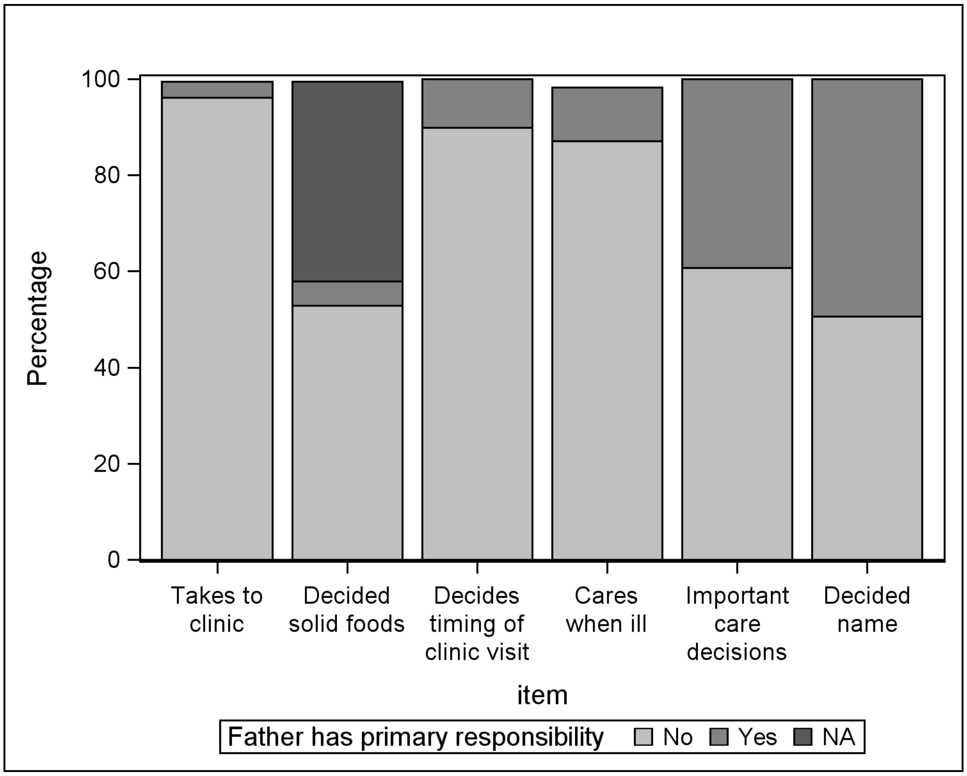


Figure B.9: Percentage distribution of whether father had primary responsibility for child's care by item, maternal report at 2-week visit (n=178); MIHS Fathering Sub-study, 2012-13

B.7.4 Additional findings: Material Provisioning trait

Figure B.10 depicts the percentage distributions of mothers' responses to the dichotomized Material Provisioning items, measured at 2 weeks.

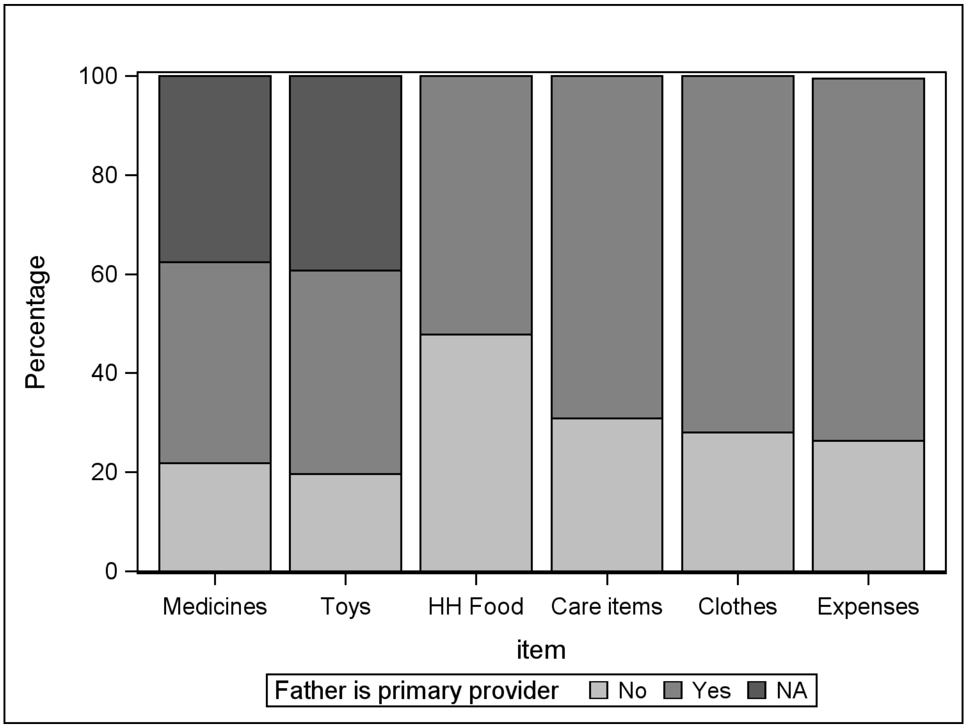
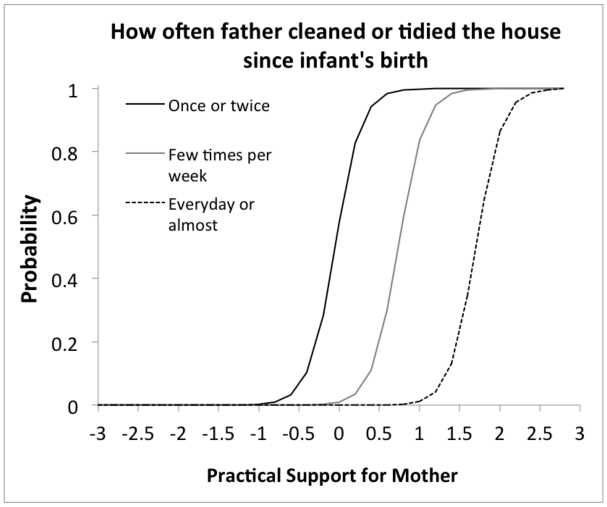


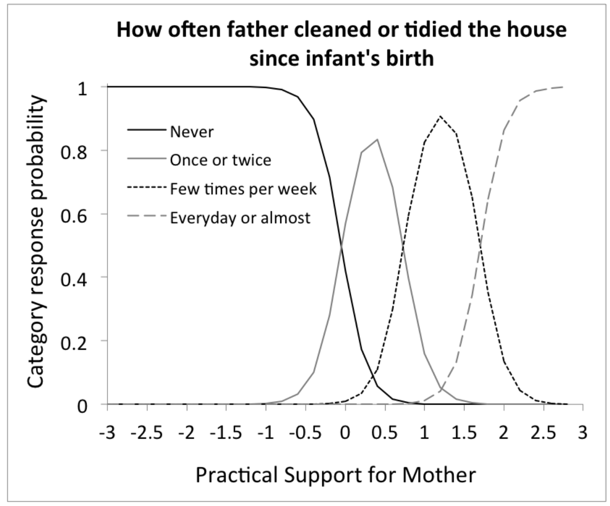
Figure B.10: Percentage distribution of whether father was the primary provider for child's material needs by item, maternal report at 2-week visit (n=178); MIHS Fathering Sub-study, 2012-13

B.7.5 Additional findings: Practical Support for Mother trait

Figures B.11 to B.14 depict the Category Characteristic Curves and Category Response Curves for the *Tidying*, *Cooking*, *Laundry*, and *Repairs* items included in the model for the Practical Support for Mother trait.



(a)

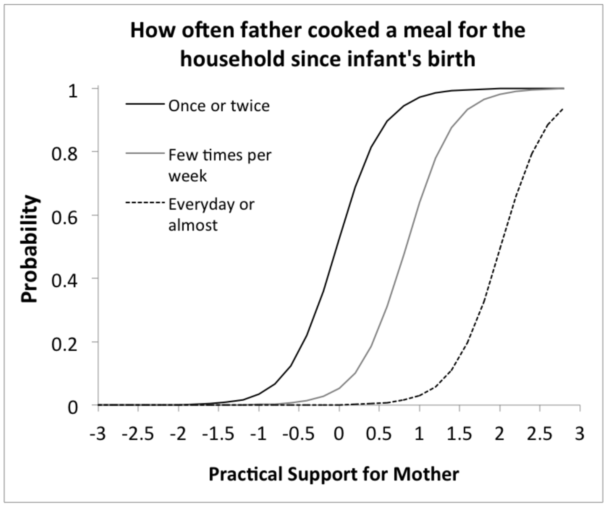


(b)

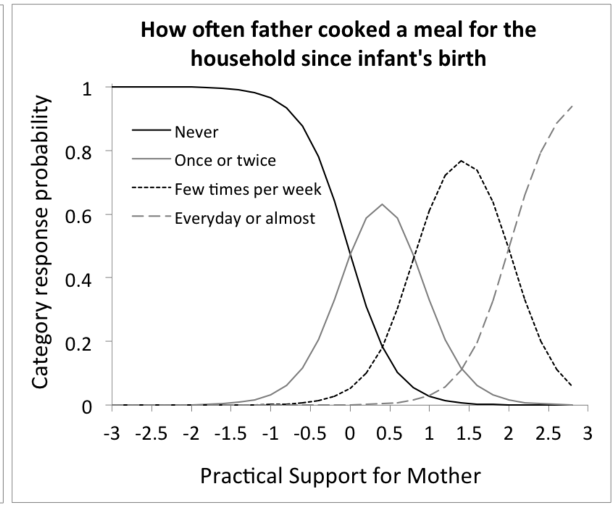
Figure B.11: Category characteristic curves (a) and Category Response Curves (b) for *Tidying* item in the IRT model for the Practical Support for Mother trait.

B.8 Results of sensitivity analysis comparing fathering practices of co-resident and non-co-resident fathers after excluding fathers who were no longer seeing the mother

Figures B.15 to B.20 show frequency distributions for the fathering items stratified by whether the father was living with the infant at 2 weeks among a sub-sample of the MIHS fathering sub-study cohort that excludes (n=16) fathers who were no longer seeing the mother.

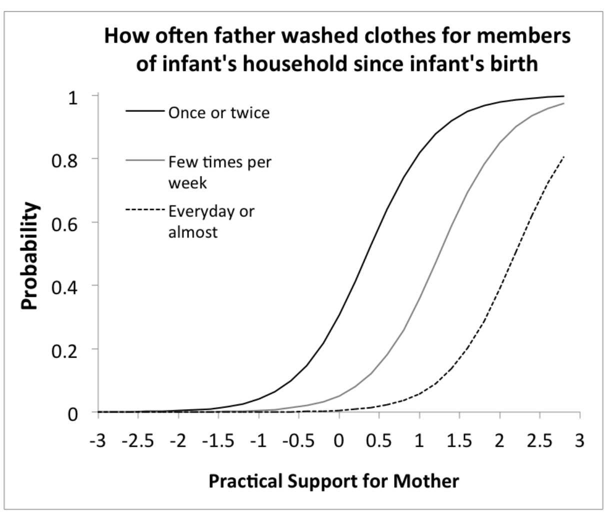


(a)

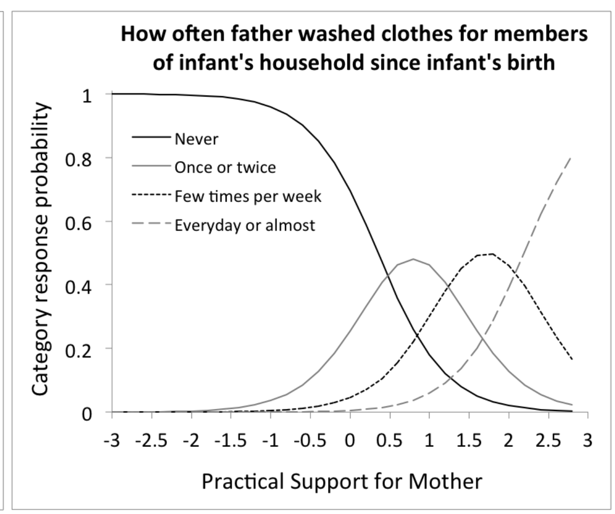


(b)

Figure B.12: Category characteristic curves (a) and Category Response Curves (b) for *Cooking* item in the IRT model for the Practical Support for Mother trait.

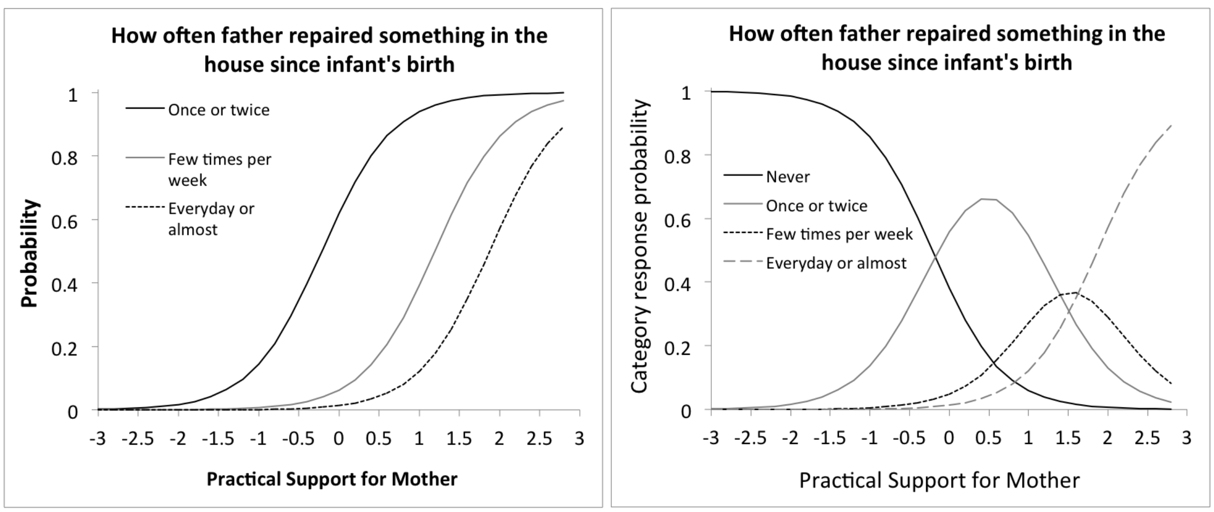


(a)



(b)

Figure B.13: Category characteristic curves (a) and Category Response Curves (b) for *Laundry* item in the IRT model for the Practical Support for Mother trait.



(a) (b)

Figure B.14: Category characteristic curves (a) and Category Response Curves (b) for *Repairs* item in the IRT model for the Practical Support for Mother trait.

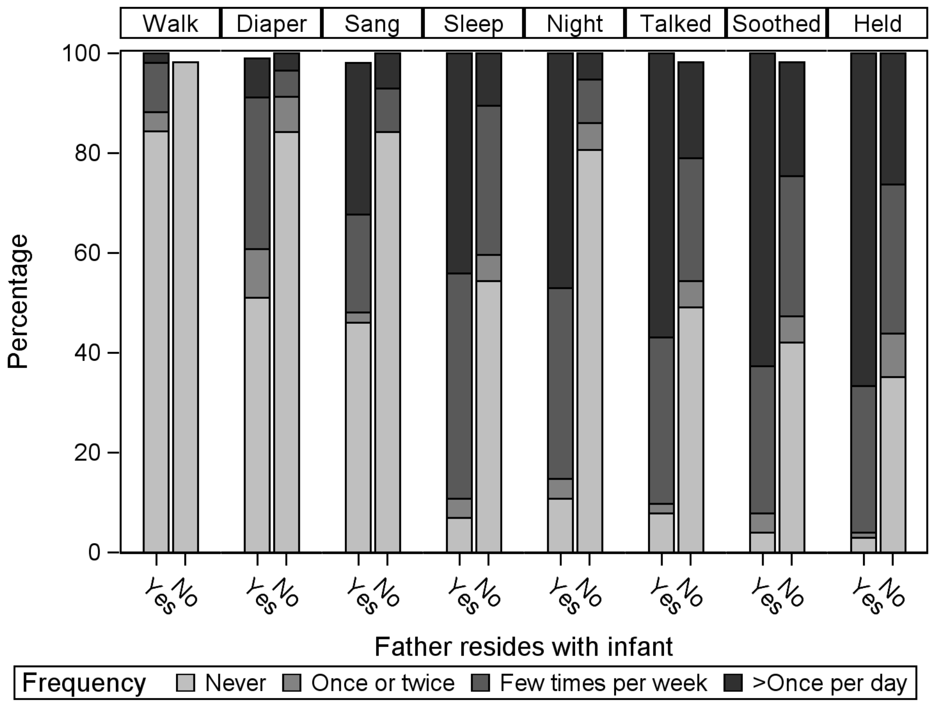
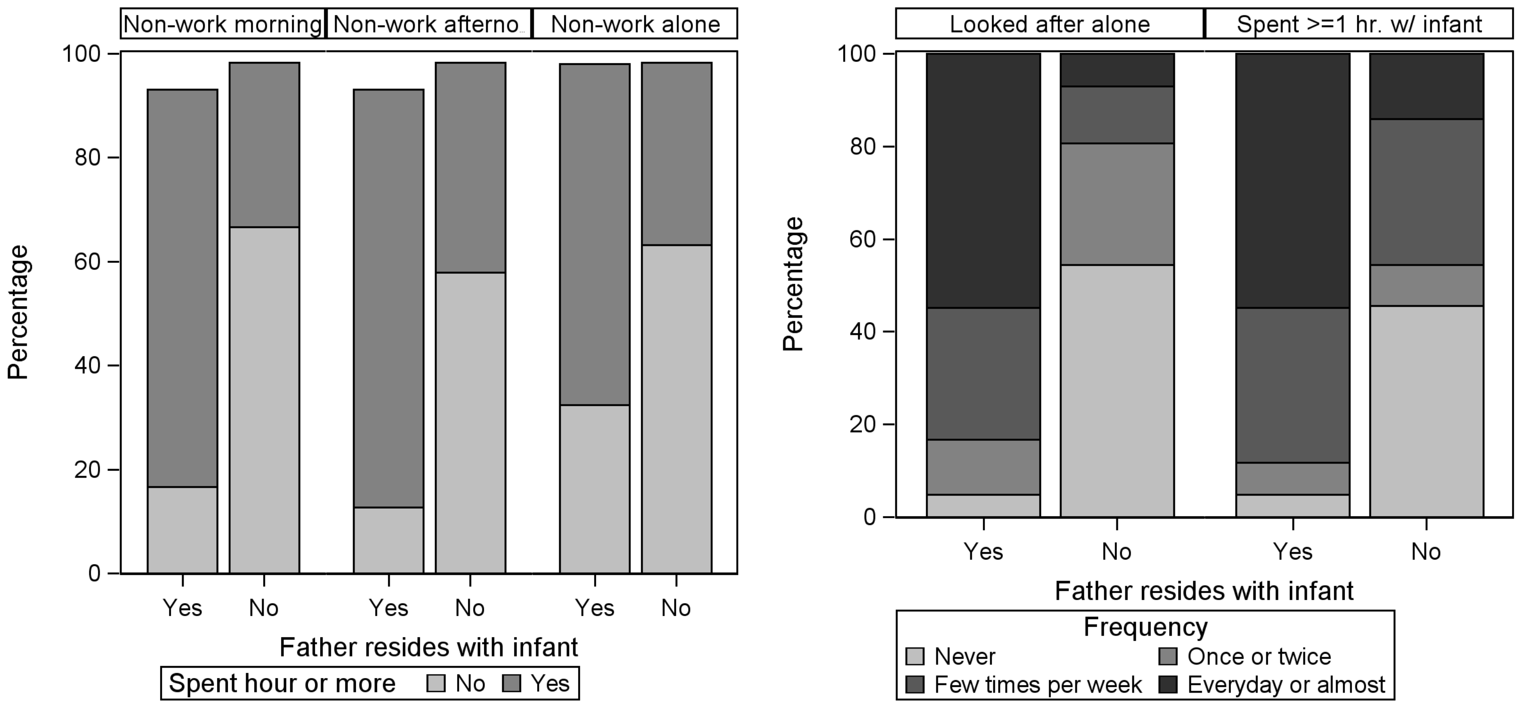


Figure B.15: Percentage distribution of father's frequency of involvement in **Direct Caregiving** by item and whether he was living with his infant, excluding fathers who were no longer seeing the mother (n=16), maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Walk - Frequency father took infant for a walk since birth
Diaper - Frequency father changed infant's diaper since birth
Sang - Frequency father sang songs or nursery rhymes to infant since birth
Night - Frequency father got up with infant when she/he woke up at night since birth
Sleep - Frequency father put infant to sleep since birth
Talked - Frequency father talked to infant since birth
Soothed - Frequency father soothed infant when she/he was upset since birth
Held - Frequency father held infant since birth



(a) (b)

Figure B.16: Percentage distribution of father's **Accessibility** by item and whether he was living with his infant for binary items (a) and ordinal items (b), excluding fathers who were no longer seeing the mother (n=16), maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Non-work morning - On days when he does not work, father usually spends an hour or more with infant in the morning
Non-work afterno - On days when he does not work, father usually spends an hour or more with infant in the afternoon
Non-work alone - On days when he does not work, father usually spends a full hour or more alone with infant
Looked after alone - How often father looked after infant while mother did other things since birth
Spent >=1 hr. w/ infant - Number of days father spends an hour or more with infant in an average week

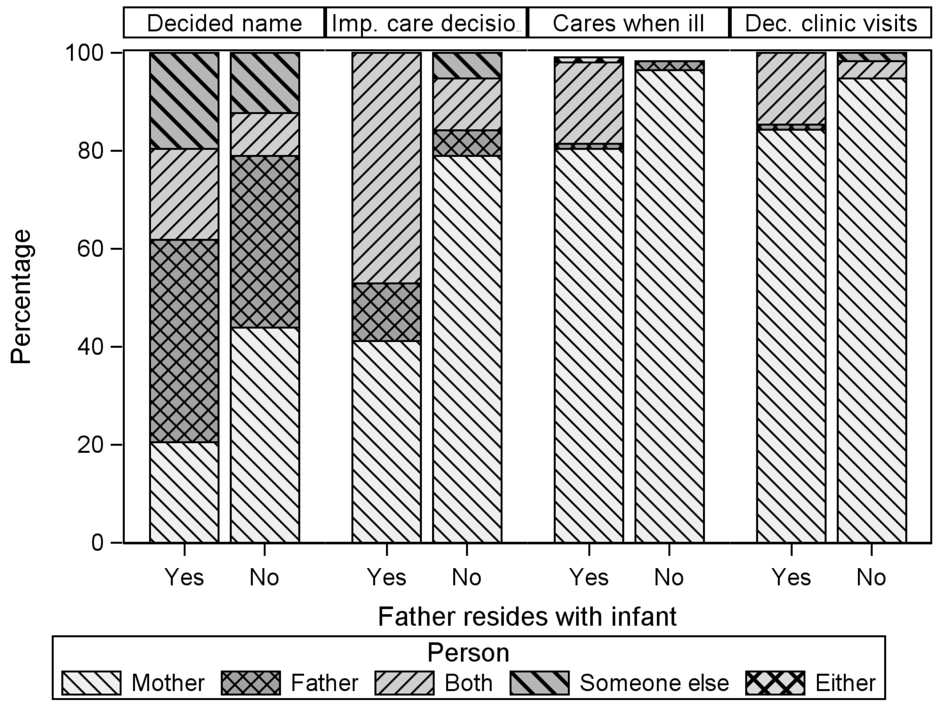


Figure B.17: Percentage distribution of person with primary **Responsibility** for infant's care by item and whether father and infant were living together, excluding fathers who were no longer seeing the mother (n=16), maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Decided name - Person who decided what infant's name would be
Imp. care decisio - Person who makes important decisions about infant's care
Cares when ill - Person who usually cares for infant when she/he is ill
Dec. clinic visits - Person who decides when infant needs to be taken to clinic or doctor

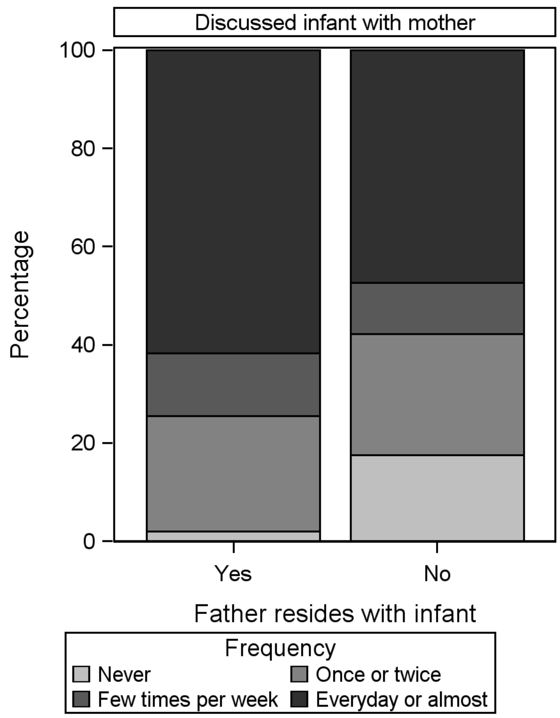


Figure B.18: Percentage distribution of frequency father talked with mother about the infant stratified by whether he was living with his infant, excluding fathers who were no longer seeing the mother (n=16), maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Discussed infant with mother - Frequency father talked with mother about infant since birth

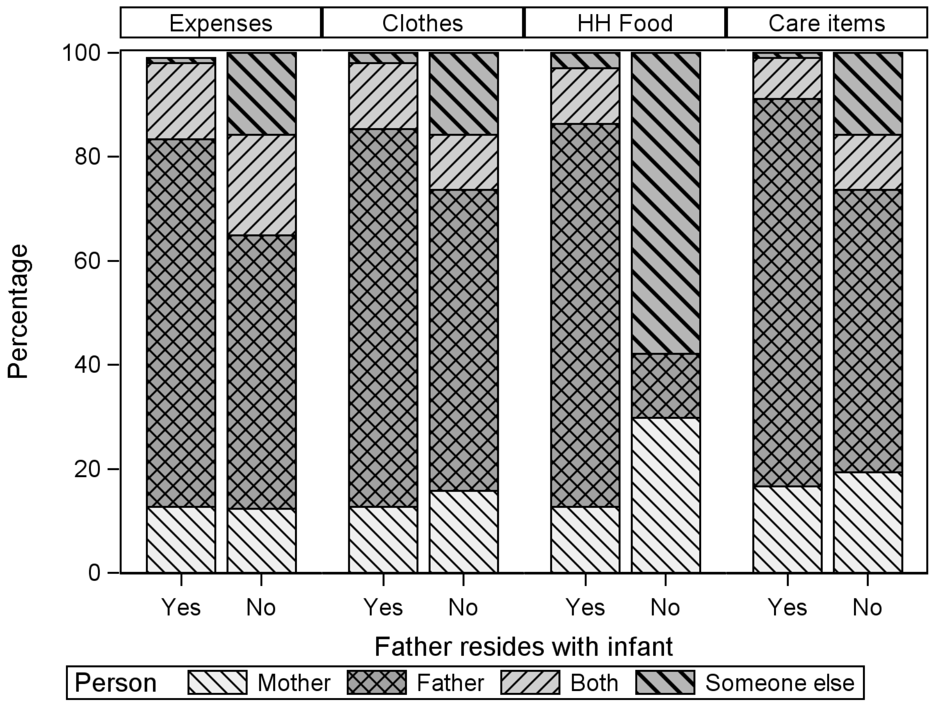


Figure B.19: Percentage distribution of person who provides for the infant's material needs (**Material Provisioning**) by item and whether father and infant were living together, excluding fathers who were no longer seeing the mother (n=16), maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

HH Food - Person who mainly paid for food for the infant's household since birth
Expenses - How expenses for infant are shared
Care items - Person who mainly paid for child care items (like diapers or wet wipes) since birth
Clothes - Person who mainly paid for infant's clothing since birth

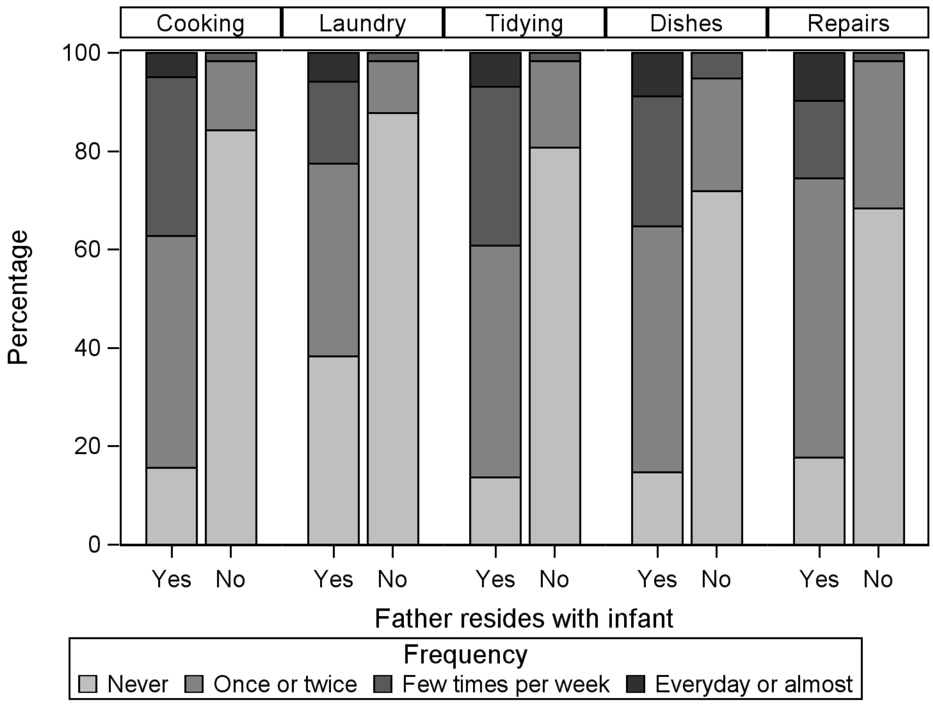


Figure B.20: Percentage distribution of father's frequency of giving **Practical Support to Mother** by item and whether he was living with his infant, excluding fathers who were no longer seeing the mother (n=16), maternal report at 2-week visit: MIHS Fathering Sub-study, 2012-13.

Laundry - How often father washed clothes for members of infant's household since infant's birth
Cooking - How often father cooked a meal for the members of infant's household since infant's birth
Tidying - How often father cleaned or tidied the house since infant's birth
Repairs - How often father repaired something in the house that was damaged or broken since infant's birth
Dishes - How often father washed the dishes or cooking pots since infant's birth