Essays on the economics of early childhood development: spatial inequalities, service provision, and parental investment

by
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DECLARATION

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This thesis includes three unpublished manuscripts.

Chapter 2:

Name	Nature of contribution	Contribution
Grace Leach	Collected and cleaned data, conceptualised methodology, data analysis, write-up of full paper.	95%
Dieter von Fintel and Gabrielle Wills	Reviewed and commented on drafts	5%

Chapter 3:

Name	Nature of contribution	Contribution
Grace Leach	Collected and cleaned data, data analysis, write-up of full paper.	85%
Dieter von Fintel	Assisted with framing and choice of methodology, and reviewed and commented on drafts.	15%

Chapter 4:

Name	Nature of contribution	Contribution
Grace Leach	Collected and cleaned data, data analysis, write-up of full paper.	90%
Dieter von Fintel	Assisted with framing and choice of methodology, helped with interpretation, and reviewed and commented on drafts.	10%

ABSTRACT

Healthy development in early childhood is a promising mechanism for the reduction of intergenerational poverty, but multiple inputs are necessary at the same time for this to occur, which renders healthy child development a challenge in resource constrained environments. While there is increasing consensus regarding the elements that children need for healthy development, there is a gap in the literature as to *how* these elements can successfully be provided, especially in low- and middle income countries (LMICs). The home, the neighbourhood and the local government capacity for service provision are all critical elements of the context for effective early childhood development (ECD), or they present risk factors. This thesis addresses this knowledge gap by exploring how children in LMICs can be provided with the socioeconomic and government services they need to support healthy development.

ECD refers to the healthy physical, cognitive, and socioemotional growth of young children. Economists have added their voice to those of other social scientists, documenting how ECD lays the foundations for cultivating skills that ensure socioeconomic security later in life, but also improves labour market productivity and economic growth potential. The discourse has increasingly emphasised Early Childhood Education (ECE) intervention, however, at the expense of prioritising a wider package of ECD services of which ECE is only one critical component. This thesis addresses this gap and emphasises the wider package which is needed for healthy child development. This dissertation will explore three topics in three essays related to the economics and spatial distribution of early childhood development.

Chapter two addresses the concept of nurturing care and proposes a measurement of ECD services to account for the combination of services needed. The study is conducted using South African data, and applies Multidimensional Poverty Index methodology. The result reveals that many children lack essential services for healthy growth in South Africa. A positive correlation between public infrastructure service delivery and child cognitive outcomes is also revealed, indicating that improved municipal environments complement attendance in Early Learning Programs.

Chapter three investigates barriers to providing services like water, sanitation and roads, which support ECD but require a network of infrastructure. Uneven regional provision perpetuates developmental inequalities in children. The study analyses the impact of terrain ruggedness

and local state capacity on the implementation of national policies and access to public health infrastructure. Regions with poor historical state capacity have lower access to services, but improved capacity overcomes the ruggedness effect.

Chapter four analyses internal household caregiving dynamics and studies the health implications of parental death or absence. Unsurprisingly, orphans and children with absent parents face worse health outcomes than those living with their parents. Paternal orphans show severe disadvantages in chronic health by age four; children without fathers are disadvantaged in terms of food security. The household environment plays a crucial role in counteracting the negative effects of paternal orphanhood. Household resources moderate the stunting penalty, but some effects remain unexplained, not linked to reduced socioeconomic status. The study emphasises the importance of multiple good-quality inputs for healthy child development.

OPSOMMING

Gesonde ontwikkeling in vroeë kinderjare is ‘n belowende meganisme om itergenerasionele armoede te verminder maar, verskeie insette is terselfdetyd nodig vir dit om te gebeur, wat gesonde kinderontwikkeling uitdagend maak in omgewings waar hulpbronne beperk is. Daar is toenemende konsensus oor die elemente wat kinders nodig het vir gesonde ontwikkeling maar daar is ‘n leemte in die literatuur oor hoe die elemente suksesvol verskaf kan word, veral in lae- en middelinkomstelande (LMICs). Die huis, die buurt en die plaaslike regering se kapasiteit vir diensverskaffing is kritiese elemente wat die konteks vir effektiewe vroeë kinderontwikkeling (ECD) of heidige risikofaktore skep. Hierdie tesis ondersoek dus hoe kinders in LIMCs voorsien kan word van die sosio-ekonomiese en regeringsdienste wat hulle nodig het om gesonde ontwikkeling te ondersteun.

ECD verwys na die gesonde fisiese, kognitiewe en sosioekonomiese groei van jong kinders. Ekonome het gedokumenteer hoe ECD die grondslag lê om vaardighede te kweek wat sosio-ekonomiese sekuriteit later in die lewe verseker maar, ook arbeidsmarkproduktiwiteit en ekonomiese groeipotensiaal verbeter. Die diskoers het egter toenemend klem gelê op Vroeë Kinderjare Onderrig (ECE) intervensies, ten koste van die prioritisering van ‘n wyer pakket van ECD dienste, waarvan ECE ‘n kritiese komponent is. Hierdie tesis spreek die leemte aan en lê klem op die wyer pakket wat nodig is vir gesonde kinderontwikkeling. Die proefskrif sal drie onderwerpe in drie opstelle ondersoek in verband met die ekonomie en ruimtelike verspreiding van vroeë kinderontwikkeling.

Hoofstuk twee spreek die konsep van koesterende sorg aan en stel ‘n maastaf van ECD dienste voor wat die kombinasie van dienste wat nodig is in ag neem. Die studie is gedoen met die gebruik van Suid-Afrikaanse data en pas die Multidimensionele Armoede Indeks metodologie toe. Die uitslag wys dat vele kinders ‘n tekort het aan die nodige dienste vir gesonde groei in Suid-Afrika. ‘n Positiewe korrelasie tussen publieke infrastruktuur, dienslewering en kinders se kognitiewe uitkomstes dui aan dat verbeterde munisipale omgewings deelname aan Vroë Leerprogramme komplementeer.

Hoofstuk drie ondersoek hindernisse tot diensverskaffing soos water, sanitasie en paaie wat ‘n netwerk van infrastruktuur benodig. Ongelyke streeks voorsiening vererger ontwikkelingsongelykhede onder kinders. Die studie analiseer die impak van die terreinruweid

en die plaaslike staatskapasiteit vir die toepassing van nasionale beleide en toegang tot publieke gesondheidsinfrastruktuur. Streke met swak historiese staatskapasiteit het minder toegang tot dienste, maar vebeterde kapasiteit kan hierdie hindernisse oorkom.

Hoofstuk vier draai na interne huishoudelike versorgingsdinamika en ondersoek die gesondheidsimplikasies van die dood of afwesigheid van ‘n ouer. Weeskinders en kinders wie se ouers afwesig is ondervind slegter gesondheidsuitkomstes as die wat by hul ouers woon. Vaderlike weeskinders toon drastiese nadele in kroniese gesondhied teen die ouderdom van vier en kinders sonder vaders is meer geneig om honger te ervaar. Die huishoudelike omgewing speel ‘n kritiese rol daarin om die negatiewe effekte van vaderlike weeskinders teen te staan. Huishoudelike hulpbronne kan die belemmeringstraf modereer maar sekere effekte bly steeds onverklaard en nie gekoppel aan verminderde sosio-ekonomiese status nie. Die studie lê klem op die belangrikheid van verskeie goeie kwaliteit insette vir gesonde kinderontwikkeling.

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To God be the glory.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ART – Antiretroviral treatment
CSG – Child support grant
DSA – Dams of South Africa
DSD – Department of Social Development
DWA – Department of Water Affairs
ECCE – Early childhood care and education
ECD – Early childhood development
ECE – Early childhood education
ELOM – Early Learning Outcome Measure
ELP – Early learning program
EPI – Expanded program on immunisation
FCG – Foster care grant
G2P – Government to person
GDP – Gross domestic product
GHS – General Household Survey
GIS – Geographic information system
HH – Household
HIC – High income countries
HIV/AIDS – Human immunodeficiency virus infection and acquired immune deficiency syndrome
HL – Homeland
LMIC – Low- and middle-income countries
MPI – Multidimensional poverty index
NCD – Non-communicable disease
NGO – Non-governmental organisation
NIDS – National Income Dynamics Study
NIECDP – National Integrated Early Childhood Development Policy
NQF – National Qualifications Framework
OAG – Old age grant
OLS – Ordinary least squares
OVC – Orphaned and vulnerable children
OVCSA – Orphaned and vulnerable children in SA
PHC – Primary Health Care
RDP – Reconstruction and Development Plan
SA – South Africa
SAR – Spatial autocorrelation regression
SDM – Spatial Durban model
SES – Socioeconomics status
UN – United Nations
UNDP – United Nations Development Programme
UNICEF – United Nations Children's Emergency Fund
US – United States
WASH – Water, sanitation and hygiene
WHO – World Health Organisation
ZIP – Zero-inflated Poisson

CHAPTER ONE

1. INTRODUCTION

Healthy development in early childhood is a promising mechanism for the reduction of intergenerational poverty (Heckman and Karapakula, 2019); it is also widely understood that multiple and simultaneous economic, medical, societal, public and private inputs are necessary for children to grow into healthy adults (UNICEF, 2017; Richter, Lye and Proulx, 2018; WHO and UNICEF, 2023). While there is increasing consensus regarding the elements that children need, there is a gap in the literature as to *how* these elements can successfully be provided, especially in low- and middle-income countries (LMICs). In 2022, more than 140 million children in LMICs have not been able to develop to their full potential (UNICEF, WHO and World Bank Group, 2023), and there is growing evidence that this is caused by the increased environmental risk factors that these children face (Walker *et al.*, 2007). The home, the neighbourhood and the local government capacity for service provision are all critical elements which create the context for effective early childhood development (ECD), and failings in any one of these present risk factors. This thesis addresses this knowledge gap by exploring how children in LMICs can be provided with the socioeconomic, public and government services they need to support healthy development. It also considers the barriers to successful ECD provision in LMICs and how these can be overcome.

ECD refers to the healthy physical, cognitive, and socioemotional growth of young children. Given the importance of ECD both for individual children and for the health of a population in general, there is a strong policy emphasis on childhood interventions by relevant role-players. The UN, in many of the Sustainable Development Goals (SDGs), for instance, refers specifically to ECD provision (Richter *et al.*, 2017; WHO and UNICEF, 2023). As such, there is a large literature which has developed regarding ECD and its effective realisation for all children. Economists have added their voice to those of other social scientists, documenting how ECD lays the foundations for cultivating skills that ensure socioeconomic security later in life (Heckman, 2008; Heckman and Karapakula, 2019). The present thesis notes that the discourse has increasingly emphasised Early Childhood Education (ECE) intervention, which has come at the expense of prioritising a wider package of ECD services of which ECE is only one critical component. This thesis seeks to address this gap, emphasising the wider package

that is needed for healthy child development; that package includes economic factors which must be considered for the realisation of healthy early childhood development.

This chapter discusses the motivation behind the thesis, and then introduces the concept of nurturing care for early development and the importance of ECD in setting the trajectory of children's lives – both in terms of their future health and their ability to take part in economic life as adults. Second, the challenges which present barriers to effective child development in LMIC contexts are discussed. Third, this chapter discusses the necessity of applying economic rationale to the question of how ECD in LMICs can be improved. Fourth, a focus is placed on child stunting as a primary outcome variable which indicates if a child has received poor ECD inputs. Subsequently, this chapter provides the context for this study, which focuses on South Africa as a case study for ECD provision in LMIC contexts. The chapter then discusses the motivations for the research questions and provides an overview of the research findings. Finally, this chapter concludes by highlighting the contributions that this thesis makes to the fields of ECD research and development economics.

1.1. Poverty, inequality, and generational income mobility

This thesis begins by considering a prominent question at the heart of development economics: the relationship between economic growth and poverty reduction. Healthy ECD is beneficial to individual children, but it generates positive externalities which also benefit society, such that ECD is increasingly understood as an important part of the strategies for economic development and poverty reduction (Jenkins, 2014). LMICs are, by definition, countries with low initial mean income, and therefore have a higher incidence of poverty. Classical macroeconomic growth models predict, that when inputs are right, these countries should experience a higher rate of economic growth than high-income countries (HICs) and a proportional decline in poverty (Cuaresma, Klasen and Wacker, 2022). In these models, poverty is defined as per capita income below a defined poverty line[1]. In essence, these models predict that faster economic growth leads to faster poverty reduction, a theory which is exemplified by the experience of the Chinese economy since the 1980s (Montalvo and Ravallion, 2010). This theory posits that a convergence in poverty rates should be experienced

[1] Different models use different poverty lines, and different metrics to define poverty, such as a headcount poverty ratio. Elsewhere, poverty is defined as a lack of capability to take advantage of opportunities presented, or the lack of access to services which enable dignity and health.

between LMICs and HICs (Ravallion, 2009; Cuaresma, Klasen and Wacker, 2022), meaning that LMICs are theorised to have higher predicted growth rates than HICs.

Poverty convergence, however, has not been realised in many regions, and has been particularly slow in Sub-Saharan Africa (Thorbecke and Ouyang, 2022). Scholars of the poverty-inequality-growth nexus posit that income inequality is a significant determinant of the growth elasticity of poverty (Cuaresma, Klasen and Wacker, 2022), which is the ratio of the percentage change in poverty to the percentage change in GDP per capita (Lenagala and Ram, 2010). That is, higher income inequality leads to reduced growth elasticity of poverty (Ravallion, 2014). As such, the reduction of income inequality is the aim both in theory and for pro-growth poverty-reduction strategies (Thorbecke, 2013). The relationship between economic growth, income inequality and poverty, therefore, has become critical in explaining the dynamics between poverty reduction and growth (Bourguignon, 2003; Ferreira, Leite and Ravallion, 2010).

Economists who study the links between poverty, productivity and income mobility identify several channels, or poverty traps, by which poverty hinders productivity and upward income mobility. A lack of economic mobility across generations can be conceptualised as a function of *inherited characteristics* which cannot be controlled by an individual (such as race, gender or socioeconomic status), and *individual effort* which are within an individual's power to change (Piraino, 2015). According to an opportunity egalitarian view, in a fair society, inherited characteristics would not influence economic mobility or the equality of opportunity available to each individual (Roemer and Trannoy, 2015). That is, poverty traps should not produce the intergenerational transmission of poverty which is evident in many societies. Poverty traps include (i) limited access to capital and financial markets, (ii) poor health which decreases productivity, (iii) low schooling outcomes which constrain human capital accumulation, and (iv) under-investment in their own family's human capital (Perry *et al.*, 2006; Currie, 2009; Ravallion, 2009; Thorbecke and Ouyang, 2022).

This thesis argues that the second and third poverty traps listed above can be addressed by healthy early childhood growth and development. There is compelling evidence that healthy development in early childhood not only improves an individual's ability to achieve economic stability later in life, but it generates positive externalities which accrue to society, such that ECD is recognised as an important element which enables economic development (Jenkins, 2014). The private benefits of ECD include better health, higher earning potential, better

cognitive development and human capital accumulation, and lower engagement in criminality (Gertler *et al.*, 2014; García *et al.*, 2020). These private benefits naturally produce public benefits in the form of lower public health care spending over the long-run, higher productivity, lower crime rates, and more resilient human capital (Dewey and Begum, 2011; Karoly, 2012). Access to high-quality ECD support for disadvantaged children not only enables greater parental labour market participation, but also reduces the gap between rich and poor children, reducing inequality of opportunity (J. Heckman, 2008; Magnuson and Duncan, 2016). Therefore, by reducing inequality, healthy cognitive and physical child development in LMICs also stands to benefit the macro economies of these countries and improve the growth elasticity of poverty. As such, ECD services should be viewed as a public good which falls into the category of services which need coordination for equitable provision. This will be discussed further in section 1.4.

The fourth poverty trap listed above – under-investment in children – can also be conceptualised in terms of the quality-quantity trade-off as proposed by Becker and Tomes (1976). Therefore, this research is applicable to countries that have above-replacement level fertility rates. In these countries, which are mostly LMICs, families value the quantity of children over investing resources to improve the quality of raising (fewer) children (where child quality is defined as in Becker and Tomes, (1976)). From a socio-demographic perspective, HICs generally choose a corner solution with a more exclusive focus on quality, whereas LMICs generally still choose higher quantities of children and there is still potential to take advantage of the quantity-quantity trade-off to benefit the developmental outcomes of children, especially in poorer regions.

Healthy ECD is a process which requires nurturing care, the provision of which is impacted by poverty (Britto *et al.*, 2017). Providing nurturing care to all children is of interest to the development economist because of the potential for healthy childhood development to overcome the constraints of generational poverty (Currie, 2009). It is therefore understood that poverty and ECD have a bi-directional relationship: poverty limits the effectiveness of ECD, while low ECD intensifies future poverty. However, understanding the physical, cognitive, and emotional development of children, determining how this can be achieved, and considering how this can be provided is a topic which necessitates multi-disciplinary study. This thesis, therefore, draws on literature in the fields of medicine, public health, biology, sociology and urban planning as well as economics.

1.2. What is nurturing care for ECD, and why is it important?

The inputs which are necessary for healthy ECD include age-appropriate and adequate nutrition, water, sanitation and hygiene (WASH) facilities, health care, a safe living environment, age-appropriate cognitive stimulation, and responsive caregiving (including early bonding, sensitive communication, development of trust, and secure attachment). These are all elements which form nurturing care for children (UNICEF, 2017; WHO and UNICEF, 2023). The home, the neighbourhood and the local government capacity for service provision create the social and socioeconomic context for nurturing care, and work together towards enabling healthy cognitive, physical, and socioemotional development in early life (Britto *et al.*, 2017), and contribute to improved socioeconomic outcomes in later life (Heckman *et al.*, 2009; Ruhm and Waldfogel, 2012). Furthermore, each element of nurturing care reinforces the others. For example, adequate nutrition for children can be undermined if they experience chronic diarrhoea due to poor sanitation, which hinders the gut from absorbing nutrients (Budge *et al.*, 2019).

Nurturing care is required from conception and remains important throughout the early years. The first 1000 days of life (from conception until 2 years of age) has been identified as a critical window for development (Cusick and Georgieff, 2016; Schwarzenberg and Georgieff, 2018). This window is described as a "golden window" which is a uniquely critical period of laying down the foundations of optimum health, growth, and development for individuals. Children are also uniquely vulnerable in this period, and nurturing care has a significant influence on a child's ability to grow, learn, and thrive (Indrio *et al.*, 2022). Nurturing care is of the utmost importance for younger children and becomes less essential as children age (Black and Merseth, 2018). This understanding of child development implies that intervention earlier in life will have larger effects, but that sustained support for children is necessary for them to grow to their full potential (Mwale, Smith and von Fintel, 2022). This hypothesis is confirmed in multiple studies that reveal large positive impacts of ECD and ECE interventions on young children, impacts which are not limited to the first 1000-day period (Currie, 2001; Cunha and Heckman, 2007a; J. Heckman, 2008; Currie and Almond, 2011). These long-run positive impacts include higher school completion rates, better high-school exam grades, higher adult wages, and better non-cognitive skills such as perseverance (Datta Gupta and Simonsen, 2007; Ruhm and Waldfogel, 2012).

Therefore, while the first 1000 days is certainly a critical window for child development requiring special attention, children require support beyond their second birthday to form strong foundations for future development. This thesis therefore studies child development from conception until the age of five. This larger age window is analysed for three reasons. First, while support for children in the first 1000 days lay critical foundations, further support is required for children to retain initial foundational development (Mwale, Smith and von Fintel, 2022). Second, a broader age range broadens the policy relevance of the study without diminishing the positive impacts on the children still within the first 1000-day window. For example, improved sanitation will disproportionately benefit these younger children, while also benefiting those who are age 3 to 5 (Bridgman and von Fintel, 2022). Third, other economic studies of child development and data availability were considered (Crookston *et al.*, 2011; Currie and Almond, 2011). In the following section, the critical nature of the skills developed in this period are discussed, with emphasis on the dynamic complementarity between early skill formation and later cognitive and non-cognitive skill formation.

During early childhood, the foundations are laid for development later in life including increased capacity to learn (Britto *et al.*, 2017); lower risk of non-communicable diseases and heart disease (García *et al.*, 2020); a higher capacity for children to unlock their full potential even in the face of adversity (Daelmans, Manji and Raina, 2021); and the capacity for higher life-time earnings (Gertler *et al.*, 2014). García et al., (2020) estimate that the internal rate of return[2] to individuals from disadvantaged backgrounds is between 8% and 18% for *high-quality*[3] early childhood interventions, and that the benefit-to-cost ratio to society of these high-quality interventions is 7.3. These types of high-quality interventions have been found to increase lifetime earnings by up to 25% for individuals who receive the intervention (Gertler *et al.*, 2014). Further estimates of the benefit-to-cost ratio to society of ECD interventions range from 1.1 to 10.6 depending on the targeted sample (Karoly, 2012). Furthermore, lower incidence of non-communicable and heart diseases reduces the cost of treatment which is incurred by public healthcare systems later in life, adding further benefit to interventions which lower the incidents of these conditions. While there are many examples of high-quality interventions, common features include starting the intervention within the first 6 months of a

[2] This internal rate of return includes the personal benefit of better health, lower likelihood of criminality, and higher parental labour market income that result from the intervention.
[3] This statistic does not give unqualified permission to provide ECD interventions. The intervention must be guided by a thorough understanding of what constitutes a high-quality intervention.

child's life and continuing until the child begins school, providing holistic support for cognitive, physical and emotional development, medical check-ups, parental education and nutritional supplementation (Heckman *et al.*, 2009; Heckman and Karapakula, 2019; García *et al.*, 2020; Van Der Berg, 2021).

ECD interventions in high-income countries (HICs) have been repeatedly found to narrow achievement gaps between disadvantaged children and their more advantaged peers within those societies (Ruhm and Waldfogel, 2012; Yang, 2021). This is true especially for children from immigrant families relative to non-immigrant families and for children in households with low maternal education relative to households where the mother is more educated (Datta Gupta and Simonsen, 2007; Black *et al.*, 2010; Fredriksson *et al.*, 2010). However, a study in Canada finds that increased attendance at low-quality childcare and educational facilities has a negative impact on child development and behavioural regulation, indicating that the effect of ECD is highly dependent on the quality of the programming (Baker *et al.*, 2005).

Evidence of the effect of education-focused interventions in LMICs is less well documented. Evidence from Argentina suggests that pre-primary education has a beneficial effect on learning outcomes for children and narrows the performance gap between poorer and richer children (Berlinski, Galiani and Gertler, 2009). Evidence from South Africa reveals that a pre-school year is beneficial only for those attending wealthier schools (van der Berg *et al.*, 2013). The authors attribute this finding to low quality programming, large class sizes in poorer schools, and the limited understanding among ECE practitioners of their role in child development. A subsequent study of ECE interventions in South Africa finds that *high-quality* ECE programs can benefit the poorest children (Van Der Berg, 2021). This indicates further that the quality of programming is critical to the success of ECE interventions, especially in LMIC contexts. The reason that the quality of programming is critical is due to the complementarity of ECD inputs, which is discussed in the following section.

1.3. What is dynamic complementarity and how does it relate to nurturing care?

Elements of nurturing care complement one another; furthermore, better child outcomes are realised when all elements are provided together; elements of nurturing care should therefore not be thought of as substitutes for each other (Aizer and Cunha, 2012; Johnson and Jackson,

2018). The complementarity of nurturing care inputs implies that healthy ECD is a function of multiple inputs that must be provided together to achieve a desired outcome, but the *dynamic* complementarity of inputs further implies that investment in children is needed over time[4], and that earlier investments raise the productivity of later investments.

The dynamic nature of human capital accumulation is due to the fact that education and skill acquisition happen in a hierarchical nature, where basic skills form the foundation of more advanced skills and so on (Cunha and Heckman, 2007a; Attanasio, Cattan and Meghir, 2022). This implies that investment earlier on in a child's life will be more cost effective in the short run and will also raise the efficacy of investment later in life (Currie, 2001). However, while early intervention is beneficial, the quality of intervention is critical to the eventual outcomes both in the short and medium term (Ruhm and Waldfogel, 2012). Nurturing care is related to the quality of an intervention in a child's life aiming to support healthy ECD. This outcome – healthy ECD – occurs as a function of the elements necessary to support cognitive, physical and emotional development, which therefore must be included in the assessment of the quality of the intervention.

Given that all the elements of nurturing care are important for healthy ECD, it is no surprise that interventions which are most effective and long-lasting supplement the home environment as well as improve the educational inputs in ECE facilities (J. Heckman, 2008; Heckman *et al.*, 2009). Research points to the proposition that supplementing home environments is likely to be more important in LMIC contexts and is seen as a critical element of "high-quality" interventions (Giese *et al.*, 2022). A natural experiment in Gambia confirms that a relatively high socioeconomic status threshold exists before significant gains in child development are realised (Husseini *et al.*, 2018), further confirming that ECD interventions require holistic programming that encompasses multiple domains and supplements home environments. These findings further support the hypothesis that a wider package in support of ECD, including (but not limited to) ECE, is essential in LMICs for improvements in ECD outcomes to be achieved.

Conditions outside the home are likely to have a greater negative impact in LMICs relative to HICs, because there are greater environmental risks in these contexts, and as such, nurturing care may be more challenging to provide in LMIC contexts (Grantham-Mcgregor *et al.*, 2007;

[4] For instance, a child who has no foundational investments who has not previously received a "full package" of investments and cannot be expected to benefit as much as a child who has prior investments.

Richter, Lye and Proulx, 2018). For example, children may come into contact with pathogens and human waste due to poor WASH facilities while playing or walking outside (Dillingham and Guerrant, 2004). This is a known cause of chronic illness in children (Budge *et al.*, 2019). Another, often unacknowledged, contribution to risk factors for children is poor local government capacity to provide services that children require, such as health services and public infrastructure. Since it is all three – the home, the neighbourhood and the local government capacity for service provision – that are needed to provide children with nurturing care, the barriers to nurturing care in LMIC environments are discussed in the following section.

1.4. What are the barriers to providing nurturing care?

Children's access to nurturing care for healthy ECD relies heavily on the network of local, regional, and national institutions which provide infrastructure, services, and support (Young, 2013). Formal institutions[5] – or "the rules of the game" (North, 1990) – which impact ECD include, government health care policy and spending, immunisation requirements, schooling laws and so forth. Formal institutions can also be considered among those which constrain or incentivise private actors (North, 1986). Examples of this definition relevant to health economics include taxes on sugary foods or zero-tax on nutritious foods (Levaggi, Marchiori and Panteghini, 2022). Perhaps of greater concern to supporting ECD are informal institutions, which consist of cultural and behavioural norms, which can either complement formal institutions or work against them (Casson, Della Giusta and Kambhampati, 2010). For example, cultural preferences for boy children can have significant negative impact on the healthy development of girl children in some cultures because they are less favoured (Tang and Zhao, 2023).

The services which these institutions, formal and informal, provide are conceptualised as "enabling environments" which either allow communities and caregivers to provide responsive care to children (UNICEF, 2017), or constrain that care. The UNICEF report on nurturing care progress for 2018-2023 emphasises that the nurturing care framework must be understood as a "whole-of-government" and "whole-of-society" effort (WHO and UNICEF, 2023). As such,

[5] Aside from the importance of formal institutions in promoting health, they are also critical for the development of an economy (For example, see Engermann and Sokoloff, 2003; Acemoglu, 2005; Robinson and Acemoglu, 2012).

where institutions are less well-resourced, poor provision of public services acts as a barrier for caregivers to provide children with nurturing care (Daelmans *et al.*, 2017).

Poverty creates an additional (private) barrier in providing nurturing care. For example, children are likely to have worse health outcomes where caregivers are unable to afford enough healthy food for children (van der Berg, Patel and Bridgman, 2022). But poor community service provision which interacts with household poverty creates an extra layer of complexity in providing nurturing care. For example, where caregivers cook food on an open fire due to costly or unreliable access to electricity, children are exposed to fire hazard as well as additional air pollution in the home. Furthermore, where caregivers cannot refrigerate food, even where caregivers want to feed children well, food systems and supply networks may create barriers to feeding children enough fresh foods such as fruits and vegetables (UN-HLPE, 2023). These examples clarify the importance of service provision in enabling caregivers to provide care for children, especially in resource constrained environments.

While dramatic improvements have been seen[6] in terms of ECD policy in LMICs, there remains work to be done in providing services that children need. Provision of health care services is lower in LMICs (Rathod *et al.*, 2017; Woldie *et al.*, 2018), for instance, contributing to higher infant and neonatal mortality (Oestergaard *et al.*, 2011; Liu *et al.*, 2016). LMICs also have lower levels of public service provision in many other sectors, including access to potable water, sanitation networks, electricity, schooling and food security (van der Berg, 2008; Crush, Frayne and Pendleton, 2012; Spaull, 2015; Khogali *et al.*, 2022; Wolf *et al.*, 2022). Since the incidence of household poverty is higher in LMICs, policy to improve public service provision in those contexts (which are also more likely be less well-resourced) is more essential in these contexts to support nurturing care holistically.

Therefore, poor networks of infrastructure, a lack of policy coordination, and poverty are each barriers to the provision of nurturing care, but also interact to form additional hurdles which must be overcome. While the provision of nurturing care at the individual level is a health concern, the lack of systems which enable the provision of nurturing care for all children is a problem best solved with an understanding of development economics.

[6] The number of governments who have initiated a multi-sectoral policy for ECD has increased by almost 50% since 2018 (WHO and UNICEF, 2023).

1.5. Why is economic rationale essential to this field?

The intergenerational transfer of poor health due to poor ECD is a poverty trap which hinders individual productivity, but it also affects macroeconomic productivity (Agénor, 2015). An environment which fosters healthy ECD is a plausible way to overcome this poverty trap (Jenkins, 2014), and is subject to a lower efficiency-equity trade-off relative to other health care spending (Cunha and Heckman, 2007a). The provision of an environment which supports healthy ECD requires an understanding of institutional health care and education dynamics, as well as the contextual decision-making of private actors (Frank, 2004).

Understanding institutional healthcare dynamics includes the study of access to primary health care (PHC) facilities (Hollard and Sene, 2016), and the importance of health facility management in reducing deaths among children and in effectively leveraging economies of scale in health care. PHC management includes coordination between the PHC and higher levels of health care, a knowledge of likely health concerns in the community, and knowing when a patient should be referred to more specialised care (Ding *et al.*, 2021). Furthermore, since healthcare spending on children reduces NCDs later in life, poor investment in early childhood health contributes to higher overall public healthcare costs used to treat NCDs later in life. The average cost of treating NCDs in South Africa has been estimated to be ZAR3 182 per adult and ZAR1 146 per child (Botha and Vermund, 2022). These estimates suggest the cost of treating NCDs in South Africa is between ZAR 19 million per year (about ZAR11 million for treating adults, and ZAR8 million for treating children). Therefore, the cost of investing in early childhood development must be considered against the cost of inaction, which is in the range of ZAR19 million per year related to treatment of NCDs alone, with other benefits of ECD, such as higher human capital, not quantified here.

Contextual decision-making of private actors also affects health. As discussed earlier, institutions, referring to the constraints and incentives which act on individuals in a society (North, 1986), can significantly reduce illness that is precipitated by a person's lifestyle. The study of the prevention of non-communicable diseases (NCDs), such as type II diabetes or hypertension, has long confirmed that targeting individual-level risk factors alone does little to improve individual outcomes (Stecher, Mukasa and Linnemayr, 2021). Rather, social determinants of health and lifestyle must also be considered, including housing, availability and accessibility of healthcare and nutritious food, socioeconomic status, and education (Jack,

2005). Targeting these social determinants of health as well as individual risk factors proves more effective in improving individual level health outcomes (Jack, 2005). It is here proposed that the same is true for improving the access to nurturing care for individual children.

Another line of economic rationale useful in the study of development has its genesis in spatial analysis. An emerging literature introduces spatial health economics as a methodological tool that searches for solutions to many issues which arise in studying the determinants of health (for examples, see Elliot et al., 2000; Costa-Font and Pons-Novell, 2007; Moscone, Knapp and Tosetti, 2007). Both micro and macro health economics investigate outcomes that are characterised by a strong spatial dimension. For example, one local hospital may provide better care relative to another region's local hospital, or health risks may be regionally concentrated (Baltagi, Moscone and Santos, 2018). Individuals may seek advice from neighbours regarding treatment; there may be regionally differentiated availability of treatments; and diets may vary by sub-climate within a country (Moscone and Tosetti, 2014). Spatial health economics uses spatial econometric modelling to measure such spatial effects, taking these spatial spill-overs into account (Baltagi, Moscone and Santos, 2018).

While the primary aim of this thesis concerns ECD, a secondary objective is to contribute towards the literature on spatial health economics. Spatial econometrics is used in all three proceeding chapters, as it is well suited to tackle problems in the field of health economics (Moscone and Tosetti, 2014), and accounts for local interdependence, which is often present in cross sectional data (Anselin, 1999, 2010). Chapter two uses spatial variation in service delivery, while chapter three exploits spatial variation in ruggedness and access to water and sanitation services. Chapter four investigates regional differences in orphanhood and parental absence. All three chapters analyse spatial variation in child outcomes, namely stunting, hunger and cognitive development.

Behavioural economic theory proposes that individual actors who have bounded rationality and imperfect information would require that social barriers, as well as information asymmetries, be addressed for lifestyle interventions to have lasting effects. Edwards, Charles and Lloyd-Williams, (2013), summarise the benefit of applying the economic toolkit to public health concerns, saying:

> *If Public Health is the science and art of how society collectively aims to improve health, and reduce inequalities in health, then Public Health*

> *Economics is the science and art of supporting decision making as to how society can use its available resources to best meet these objectives and minimise opportunity cost.* (Edwards, Charles and Lloyd-Williams, 2013)

The medical and physiological understanding of healthy child development does not automatically translate into healthy children in all contexts or translate into policies which help caregivers in all contexts. The practical application of scientific knowledge requires that the *implementation* of medical knowledge be studied to recommend actionable, context-specific insights (Lendrum and Humphrey, 2012; Dorner *et al.*, 2014). The implementation of public goods in resource-constrained environments is likely to be presented with coordination problems, the resolution of which is aided by the economic toolkit (Sákovics and Steiner, 2012). Two primary coordination problems present themselves; (i), policy coordination within government between departments that have conflicting interests and that share a limited fiscus; and (ii) a principal-agent problem.

The first problem is addressed in chapters two and three of this thesis. Chapter two specifically investigates the coordination of service delivery required for healthy development in children, and chapter three considers the barriers to providing public services which require a network of infrastructure. Both are important from an economic perspective because policy coordination for effective ECD produces positive externalities which accrue to society, such as lower health care costs and fewer school year repetitions (Berlinski, Galiani and Gertler, 2009; Gertler *et al.*, 2014), making policy coordination beneficial for policymakers in the long run. While inter-departmental policy coordination is emphasised in the UNICEF program guidance for ECD as an area critical to effective provision of ECD (UNICEF, 2017), the benefits of positive externalities must first be quantified and communicated to policymakers for this framework to be embraced. This quantification is aided by an economic toolkit. Economic rationale further benefits policy guidance where government departments are organised at different levels of geography, and these organisational structures overlap with the critical timeframes to intervene. For example, provincial government departments responsible for education services should target their focus toward ELP-going and school-going age children, while municipalities are responsible for waste removal that targets the health of children at all ages.

Second, a principal-agent problem often arises when the government or another agent takes actions to improve the home environment or service delivery on behalf of disadvantaged

communities – many of whom may not be able to pay for the service (Leonard and Leonard, 2004). External actors may not fully appreciate the way in which the service will be used and therefore provide the service sub-optimally; for example, providing fortified porridge for children may not be effective if purified water is not also provided (UN-HLPE, 2023). Insofar as paying for services can act as a signal for demand, there is little that people who do not pay for a service can use to signal that the service does not suit them. While medical knowledge is required to determine *what* service should be provided, economic knowledge is required to determine *how* the service should be provided in a manner that decreases opportunity costs and increases the probability of effective take-up (Edwards, Charles and Lloyd-Williams, 2013). This thesis therefore studies how nurturing care can be better implemented in LMICs, with the purpose of recommending actionable and context-specific insights.

1.6. A brief overview of stunting and child development

The quantitative study of ECD requires the identification of outcome variables that can act as a reliable measure of healthy development. The most common measure of healthy development is a child's height-for-age – a measure which is used extensively by researchers to measure child outcomes. It is correlated strongly with many other child development indicators (Crookston *et al.*, 2011; Alam *et al.*, 2020).

Stunting is defined as having a height-for-age Z-score which is 2 standard deviations below the mean of the World Health Organisation (WHO) 2006 reference population (de Onis *et al.*, 2006). Stunting results from a combination of poor developmental inputs which overlap with features of nurturing care, including inadequate nutrition, chronic infection and inadequate stimulation (Headey, Hirvonen and Hoddinott, 2018; Leroy and Frongillo, 2019; Burger *et al.*, 2022). While stunting is primarily a metric for monitoring child growth, this measure is a more general marker for living environments that do not encourage optimal childhood development, and in which children experience chronic insults to their development. Stunting should therefore be viewed as an indicator of child ill-health over a longer period. Stunting and cognitive underdevelopment are often correlated, which can lead to poorer schooling outcomes and lower lifetime earning potential (Dillingham and Guerrant, 2004; Prendergast and Humphrey, 2014; Beal *et al.*, 2018; Leroy and Frongillo, 2019). High stunting prevalence in a region therefore indicates where children are at risk of not reaching their full developmental potential.

Current reviews of stunting prevalence globally reveal that, despite the fact that global stunting rates have halved since 1990, there remains a higher stunting prevalence in LMICs relative to HICs, and especially in regions with fragile governance or conflict (da Silva *et al.*, 2018). The stunting rate decline has been slower in low-income relative to middle-income countries, with both absolute and relative numbers of stunted children increasing in low-income counties over this same period (da Silva *et al.*, 2018). Factors that contribute to stunting in LMICs include nonexclusive breastfeeding in the first six months, poor food security and nutrition, poor access to WASH services, chronic illness over a long period of time, air pollution, vitamin and mineral deficiency and low household income (Dillingham and Guerrant, 2004; Darteh, Acquah and Kumi-Kyereme, 2014; Prendergast and Humphrey, 2014; Beal *et al.*, 2018; Burger *et al.*, 2022).

A meta-analysis of interventions which aim to address stunting in LMICs finds that those which integrate nutrition, health (or hygiene) and social safety nets are most effective (Hossain *et al.*, 2017). These findings are consistent with the hypothesis that healthy child development – physically, cognitively and socioemotionally – requires a combination of inputs, including economic interventions. Higher rates of stunting in an area therefore acts as a marker that children in that area are exposed to risk factors which do not foster ideal long-term childhood development. As such, stunting is used in this thesis to quantitatively measure child development, acknowledging that it is a marker for children not developing fully in other developmental domains.

1.7. Context for South African case studies

The analyses which form the second, third and fourth chapters of this thesis use South Africa as a case study to add evidence to the literature regarding barriers to providing for ECD in LMIC contexts. South Africa has made some headway on improving in ECD indicators, as benchmarked against SDG goals and targets, and the performance of other LMICs. SDG Goal 2 is to achieve Zero Hunger globally. Target 2.2 is to end all forms of malnutrition which includes achieving the internationally agreed upon targets for stunting and wasting in children under five by 2025. While progress towards this target has been achieved in South Africa between 2005 and 2015, the longer-term trend in child stunting in South-Africa has remained stubbornly persistent at a relatively high level over the past 40 years (Said-Mohamed *et al.*, 2015). Between 2000 and 2022, the stunting prevalence of children under 5 has declined from

26,6% in to 22,8% in 2022. In Namibia, the stunting prevalence has changed from 29,7% in 2000 to 16,8% in 2022; a more meaningful improvement relative to that of South Africa. Indonesia and India have seen even larger declines in child stunting over these years, albeit from a much higher initial prevalence of 40 and 50% respectively (Sustainable Development Solutions Network, 2023).

SDG goal 4 is to achieve "Quality Education" for all. SDG Target 4.2 is to "ensure that all boys and girls have access to quality early childhood development, care and primary education" (Sustainable Development Solutions Network, 2023). South Africa compares similarly to other LMICs countries in regard to pre-primary education enrolment (Nonoyama-Tarumi, Loaiza and Engle, 2009), but according to the 2023 Sustainable Development Goals (SDG) Report, South Africa has not made significant progress since 2013, and significant challenges remain before the country will be able to achieve the SDG target for pre-primary education participation. In comparison, Brazil, has made significant progress in pre-primary education enrolment rates (Sustainable Development Solutions Network, 2023).

Although South Africa is formally classified as an upper-middle income country, it is one of the most unequal societies in the world (Sulla, Zikhali and Cuevas, 2022), and the socioeconomic inequality that marks the South African economy is also evident in child outcomes. Children from affluent homes in South Africa fare relatively well by international standards for cognitive and physical development, while children from disadvantaged homes are found to be developmentally off track (Oliphant, Templeman and Baranov, 2006; Shepherd, 2006; Van der Berg, Zuze and Bridgman, 2020). The children from disadvantaged homes fare similarly to those from other LMICs (Janeli Kotzé and van der Berg, 2017). Additionally, the national South African stunting prevalence of 26% in 2016[7] is comparable to the mean stunting prevalence in LMICs (Osgood-Zimmerman et al., 2018; National Department of Health, Statistics South Africa, South African Medical Research Council and ICF, 2019). By examining the barriers to providing nurturing care in the face of high levels of poverty, this thesis adds to the evidence bank of how nurturing care can be improved in LMICs.

[7] This is the official national estimate in the Demographic Health Survey of 2016. This is the most recent nationally representative measure of stunting prevalence for South Africa. This statistic is recorded as 22,4% in 2026 according to the UNICEF SDG Report of 2023.

South African inequality is due in large part to the legacy of decades of discriminatory legislation, which prioritised the development of some regions and people groups at the expense of others, contributing to persistently high levels of spatial inequality. Most notable among these policies during the apartheid era in South Africa was the creation of homelands, or "Bantustans", which were remote from the urban centres of the day. Black South Africans were forcibly removed from 'white areas' to live in these homelands. The homelands were designed as "independent states" in which the leaders were installed by the apartheid government (Lissoni and Ally, 2018).These homelands leaders were required to develop their own state apparatus, even as their authority was undermined by the South African apartheid government, for example by an inadequate resource base (Hendricks and Ntsebeza, 1999), limiting the development of these regions. The former homelands remain some of the least developed regions in the country, in terms of industry and infrastructure (Noble and Wright, 2013). David et al., (2018) conduct a municipal level analysis of poverty and inequality in South Africa and find that areas which fell into the former homelands continue to exhibit the highest levels of poverty in the country. Children who live in regions which fall into the former homelands also continue to experience poorer health outcomes relative to children who live elsewhere (Bridgman and von Fintel, 2022).

Poor health and low educational outcomes are cited among the most serious poverty traps in South Africa. Inherited circumstances play a dominant role in the lack of intergenerational income mobility in South Africa, which is largely explained by the socioeconomic gradient in educational attainment in the country (Piraino, 2015). Lambert, Ravallion and van de Walle, (2014) in a study of Senegal – which is similarly unequal – further confirm that educational attainment is more important to intergenerational income mobility than property inheritance. This finding has particular reference for South Africa, where education is an important mechanism to improve intergenerational income mobility (Piraino, 2015). In general, parents with poor health and education are less likely to access better health and educational outcomes for their children (Adato, Carter and May, 2006; Van Der Berg *et al.*, 2011; Spaull, 2015).

Another factor which must be considered is the number of children in each family, where poorer families tend to have more children relative to wealthier families (Bridgman and von Fintel, 2022; van der Berg, Patel and Bridgman, 2022). This reduces the amount of time and

resources that these families can invest in each child[8], which endangers the healthy development of children. Therefore, investment in these children who come from large, poor families by external sources, such as public services and private investment from NGOS. As such, high-quality ECD is recognised as a critical part of improving the health and wellbeing of South Africans from an early age, and as a tool to break cycles of intergenerational poverty (Daelmans *et al.*, 2017). Overcoming these spatial inequalities in development, and especially access to services, is central to the post-apartheid policy agenda in South Africa (Republic of South Africa, 1994; National Planning Commission, 2010). Indeed, overcoming poverty traps in LMICs in general has the potential to unlock virtuous cycles to promote better human development.

Multiple government departments are involved in redressing this historical inequality. Municipalities are identified in the Constitution of the Republic of South Africa as the level of government responsible for the provision of services (Republic of South Africa, 1996). However, multiple government departments are involved in providing these services which are organised at the provincial level. For example, the provincial Department of Basic Education is responsible for schools in a province, and the provincial Department of Health is responsible for primary healthcare centres and public hospitals in the province, which implies that schools, clinics and hospitals are administered provincially (DBE, 2019; Department of Health, 2023). However, differences in the level of implementation of policies is observed within policy-responsibility-level. This is likely due to location-specific preconditions such as the spatial differences within municipalities that arose as a result of the Group Areas Act and the creation of homelands, which explicitly benefited some areas within cities, leaving them with higher levels of infrastructure. Therefore, while the administration of many policies is done at the provincial level, local administrative capacity in municipalities is identified as a critical barrier to the successful provision of services (Oosthuizen and Thornhill, 2017).While administration of these services is therefore often more centralised than the municipality, this level of geography is nevertheless chosen for this analysis to reflect the differences in pre-conditions within provinces. Ideally, data availability would allow for the identification of sub-municipal differences that relate to suburb-specific historical legacies.

[8] Furthermore, wealthier mothers tend to have children later in life, and are more able to invest in each child. The tendencies are researched in a large literature which studies the quantity-quality tradeoff in terms of the children in a home (Vargha and Donehower, 2019; Doepke *et al.*, 2022).

This has relevance where municipalities are responsible for the provision of public services such as water and sanitation services, as well as waste removal and safety services such as policing. Urban municipalities are responsible for raising funding themselves, while many rural municipalities that cannot generate their own financing receive grants from the national government (Oosthuizen and Thornhill, 2017). This creates the possibility of differences in policy implementation due to historical preconditions, which is discussed in the remainder of this thesis.

However, the government is not the only actor effecting change to overcome historical inequality. Private, non-profit, and non-government organisations (NGOs) are also key actors in South Africa, especially in the provision of ECD services and support. For example, NGOs such as GrowECD and SmartStart provide important financial and practical support for newly started ELPs (GW Foundation, 2023; SmartStart, 2023). The importance of a "whole-of-society" approach is therefore emphasised in this thesis, and is discussed further in Section 5.2.3.

The final factor which is considered for the context of this study is orphanhood and parental absence in South Africa, which each have bearing on child health outcomes. Orphanhood and parental absence are both common in South Africa. According to the 2021 General Household Survey, just 1 in 4 children under the age of 5 lives with both of their parents and more than half of children under the age of 5 do not live with their fathers, either because of death or absence (StatsSA, 2021). Of children under the age of 18, 2,9% and 9% are maternal or paternal orphans, respectively, and 3,2% are double orphans.

Orphanhood in South Africa increased dramatically between the mid-1990s and 2010, largely due to the HIV pandemic in South Africa at that time. The halt in the increase in orphanhood is attributed to the successful rollout of Antiretroviral treatment (ART) in 2004 (De Paoli, Mills and Grønningsæter, 2012).[9] Since 2010, orphanhood has remained relatively stable. Paternal absence is particularly high for black African children relative to other race groups in South Africa (Makusha and Richter, 2015). The evidence suggests that there are relatively few child-headed households in South Africa, but the number of these types of households has increased since 1990 (Hill, Hosegood and Newell, 2008a; Richter and Desmond, 2008; Meintjes *et al.*,

[9] A comparison of the rate of orphanhood as children age between 2001 and 2011 can be seen in Appendix 4-D.

2010; Skinner *et al.*, 2013). The increase in child-headed households is attributed to the HIV pandemic, and significantly negatively influences child development outcomes (Mturi, 2012). Due to the severe disadvantage that orphanhood and parental absence carries (Kearney, 2023), the impact of orphanhood and parental absence is studied in Chapter 4.

1.8. Chapter summaries

This dissertation will explore three topics in three essays related to the causes and spatial distribution of early childhood development outcomes. Chapter two investigates *where* children receive the services required to provide a context which enables healthy childhood development and proceeds to validate this measure. Chapter three builds on the findings of chapter two and investigates the barriers to public service provision in the form of water, sanitation, and hygiene (WASH) infrastructure. Chapter four turns toward internal household caregiving dynamics and studies the health implications of parental death or absence. Figure 1.1 shows the provincial and municipal administrative boundaries of South Africa which are used in Chapters 2, 3 and 4.

Figure 1.1: Map of South African provinces and municipalites

Figure 1.1: South African administrative boundaries.
Source: By Adrian Frith - Drawn by Adrian Frith based on MDB Local Municipal Boundary 2018 dataset, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=107035041

1.8.1. Chapter two

The second chapter is motivated by the growing understanding of nurturing care. There is a gap in the current literature on how the provision of these services is measured, and as such, the second chapter focuses on measuring ECD service provision, and validating the measure. This paper is a response to the call to broaden data- and evidence-gathering systems, and foster multisectoral programming for ECD (UNICEF, 2017).

The chapter proposes that Multidimensional Poverty Index (MPI) methodology can be used to create a sub-national index of multidimensional service delivery for children in LMIC contexts (Alkire and Foster, 2011; Alkire *et al.*, 2015). This sub-national index is able to uncover where the home, the neighbourhood and the local government capacity for service provision provide the critical elements which create the context for effective ECD, and where they do not. This exercise is successfully completed using South African data and shows that there is no municipality in South Africa where all children receive the full complement of the services they need to grow healthily.

A first validation of this measure is provided by assessing whether the ECD services index correlates with individual child outcomes, including stunting and a measure of cognitive development. The analysis reveals that public infrastructure service delivery, including sanitation, tap water, refuse removal, electricity and safe outdoor environments is positively related to child cognitive outcomes in children who attend an early learning program (ELP) in South Africa. There is no significant association with stunting, however. This null outcome is explained by the fact that the sample of children who attend an ELP is representative of the most advantaged children in South Africa, which causes the stunting prevalence in the sample to be lower than national estimates (Henry and Giese, 2022). These results imply that improved municipal environments are complementary inputs with ELP attendance.

This chapter reveals that public infrastructure services such as water and sanitation services, waste removal, roads, and municipal electricity provision are most effective when concurrent and complementary inputs to ELP attendance; however, these are not adequate in many regions of South Africa. These services also require a network of infrastructure. This type of infrastructure includes transport, sanitation, and communications networks, all of which are unique because they rely on previously constructed infrastructure stock (Di Giacinto, Micucci and Montanaro, 2012). For example, typical sanitation infrastructure relies on a network of

sewage pipes between houses, as well as pumps and a waste treatment plant to function optimally. These types of infrastructure are also subject to network effects, where the marginal productivity of investment in the infrastructure is greater than other types of investment, but only when a minimum stock is already present. Initial investments in this infrastructure (to build the minimum stock) has similar marginal returns to other types of government spending (Candelon, Colletaz and Hurlin, 2013).

1.8.2. Chapter three

The third chapter follows this reasoning, analysing the major barriers to the provision of services which require a network of infrastructure, which, in turn, enables improved home and neighbourhood environments. This paper is motivated by the need to improve delivery of essential services through system strengthening, which is an essential requirement for improved nurturing care (UNICEF, 2017). More specifically, this paper addresses the following question in the UNICEF's program guidance for ECD:

> *What are the major bottlenecks and barriers perpetuating inequalities in the realisation of developmental potential of young children, at immediate, underlying and structural levels?* (UNICEF, 2017:32)

The third chapter draws on two original datasets. These datasets are used to estimate the differential impacts of two factors – terrain ruggedness, and spatial variation in local state capacity – on the implementation of national development policy, and specifically on access to public health infrastructure. State capacity comprises of all the elements that are important for the proper functioning of the state, including human capacity, physical infrastructure, and the ability to provide an environment which is conducive to economic growth (Acemoglu, 2005; Besley, 2011). These features are critical in determining the speed at which improvements in development and effective policy implementation can take place. To account for differing levels of local state capacity, the analysis used former homeland boundaries. Former South African homelands, or "Bantustans", were subject to decades of discriminatory policies during the apartheid era, which designated areas in which black South Africans could live. In many of these homelands the legacies of those policies have endured to the present, preventing these areas from developing a strong state apparatus – at least to the extent that they are likely to have developed in the absence of this disadvantage (von Fintel, 2018).

The research finds that national policy is less well implemented in rugged places, and in places with poor historical local state capacity. Furthermore, the study proposes that regional inequalities in access to public health infrastructure are in fact largely explained by historical local state capacity. The analysis finds that local state capacity is still a considerable constraint for former homeland areas and is a factor which hinders the effectiveness of policy intervention. Terrain ruggedness reduced the effective implementation of policy changes, but the effects of historical institutional capacity reduced implementation more than did the effects of the ruggedness of the area. The analysis shows that access to infrastructure in rugged homelands improved between 1996 and 2011. This suggests that once local institutional capacity is strengthened, it can be used to leverage technology, recover costs, and uphold policy such that ruggedness does not present an insurmountable barrier to the provision of services which require a network of infrastructure. Therefore, while ruggedness may have had an impact on the initial local state capacity formation of an area, exogenous forces which influence local informal and formal institutions can overcome this barrier. These findings have implications for national and international development policies which aim to improve investments in and access to public health infrastructure.

1.8.3. Chapter four

Following on from this, the thesis turns toward the internal household dynamics which impact children's care, analysing the effect of parental death or absence on child health. Parents play a pivotal role in providing care to their children and in mobilising household socio-economic resources to the benefit of their children's development. Orphans tend to have worse human capital outcomes in developing regions, but little is known about the health outcomes of children with absent or deceased parents in LMIC contexts (Evans and Miguel, 2007; Ardington and Leibbrandt, 2010; Salifu Yendork, 2020). Making the distinction between parental absence and death offers insights into the role of parental investment relative to public and private transfers in promoting child development, but this distinction has not been studied extensively. This study works towards reducing this knowledge gap.

First, this chapter maps the demography of single orphanhood and parental absence in South Africa, which is a helpful descriptive exercise to see where orphanhood is most prevalent in South Africa. To the author's knowledge, these descriptive maps have not been produced elsewhere. Second, this paper finds that paternal orphans are significantly more vulnerable to

stunting relative to all other children, and children with absent fathers are more vulnerable to poorer health outcomes and food insecurity (which may lead to stunting) relative to all other children. Private household resources moderate the association between paternal orphanhood and stunting but do not fully moderate the hunger penalty. This indicates that the household environment is an important influence which counteracts the paternal orphan stunting penalty.

This finding is consistent with the hypothesis that lower household asset ownership could be an important mechanism which contributes towards poor child health. Even so, household income and public cash transfer income do not mitigate the hunger penalty for paternal orphans; and neither household income, grant income nor remittance income moderate the hunger penalty associated with father absenteeism. This reveals that there remains an unexplained penalty associated with paternal orphanhood and absence which is not caused by reduced socioeconomic status. These findings suggest that an improved household environment is a crucial element which improves child health, and that this effect could work through remittance income from family members, labour market income, or grant income, among other factors. Together with the first essay, the thesis emphasises that both household and regional contexts matter for child health.

1.9. Contributions

There has long been a growing consensus as to *what* children need for healthy development (Evans, 1997; Britto *et al.*, 2017; UNICEF, 2017; Daelmans, Manji and Raina, 2021). This thesis contributes toward a deeper understanding of *where* children receive nurturing care, and *how* it can be provided to children who do not receive it. The thesis considers risk factors which emanate from structural factors such as access to sanitation infrastructure and policy coordination, as well as those which emanate from private factors such as orphanhood. By focusing on the broader package of ECD, which is not limited to ECE, this thesis adds balance to the literature on early childhood interventions. Furthermore, this thesis provides evidence to the effect that the external environment which children encounter exerts on their development is at least as important as the home environment.

The second contribution of this thesis is methodological. While the primary aim of this thesis concerns ECD, a secondary objective is to contribute towards the literature on spatial health economics. This literature addresses the spatial correlation which is present in health economics studies (Baltagi, Moscone and Santos, 2018), such as regionally concentrated health

risks. Many social determinants of health exhibit spatial clustering, including regional diets and climate, regional access to treatment, the quality of hospital care and availability of specialised care, air pollution, access to clean water and neighbourly opinions, to name a few (Elliot *et al.*, 2000; Moscone and Tosetti, 2014; Baltagi, Moscone and Santos, 2018; Burger *et al.*, 2022). This thesis successfully applies spatial econometric modelling to reveal that inputs to child health, as well as child development outcomes, are spatially correlated in South Africa. Furthermore, sub-national maps which demonstrate the spatial distribution of child health, access to WASH services, orphanhood and parental absence have been produced. By examining the spatial demography of orphanhood new insights into where these children live has been explored. Finally, the spatial demonstration of issues concerning ECD give new insight allowing targeted government policy toward those areas that are falling behind.

The individual chapters of the thesis contribute towards the evidence base of how ECD can better be provided in LMICs, by (i) measuring multi-sectoral service provisioning for children in LMICs; (ii) analysing the importance of local government capacity for providing services, as well as how local capacity for providing services relates to child development; and (iii) analysing the impact of orphanhood and parental absence in a LMIC context. These chapters add to the literature on how children can experience better access to nurturing care in South Africa and other LMIC contexts (for examples, see Black et al., 2021; Weber and Darmstadt, 2023).

First, in the second chapter, the thesis identifies where children receive the services which support ECD. Worryingly, most children in South Africa do not receive the full complement of the services they need for healthy development. Second, it reveals that barriers to development policy implementation can be overcome by a concerted strategic effort to enhance the quality of local service. Local government capacity comprises elements that are important for the proper functioning of the state – including human capacity, physical infrastructure, and the ability to provide an environment which is conducive to economic growth (Acemoglu, 2005; Besley, 2011). Therefore, the literature suggests that a strategic effort to strengthen local capacity will include augmentation of administrative capacity and human capital (Fernandez and Rainey, 2013), as well stronger management to lead the implementation of policy (Coovadia *et al.*, 2009). It will also include investment in network-based infrastructure, which has higher marginal returns than other government investments (Candelon, Colletaz and Hurlin, 2013), but the exact manner of investment which would be appropriate in South Africa

is beyond the capability of the data to determine. The determination of such would be a fruitful avenue of future research.

The third chapter goes on to show that this strategic effort to enhance the quality of local service, noted above, has been effective in some former homelands where access to WASH infrastructure has been improved, lending hope that poor historical state capacity can be overcome in other areas. Finally, in the fourth chapter, this thesis presents a first mapping of the demography of orphanhood and parental absence in South Africa, and contributes towards the literature regarding how orphans and children with absent parents fare relative to other children in the country.

The evidence presented in the following chapters is subject to limitations[10] which will be discussed in chapter five. But even so, the work presented in the remainder of this thesis can be seen as an important contribution towards the literature of how all children in LMICs can receive nurturing care towards improved early childhood development, for their benefit as well as the benefit of their country's economy as a whole.

[10] In particular, the evidence is relevant for the South African context more specifically, and generalizability is not assumed. These factors are discussed in Chapter 5.

CHAPTER TWO

2. PROMOTING EARLY CHILDHOOD DEVELOPMENT THROUGH MULTI-DIMENSIONAL SERVICE DELIVERY IN SOUTH AFRICA: A MUNICIPAL VIEW

2.1. Introduction

There is a growing call to reduce environmental risk factors for children in LMICs, and to provide children and parents in these places with the services they need to promote healthy child development (Walker *et al.*, 2007). The inputs which are necessary for healthy early childhood development (ECD) include adequate nutrition, clean water, sanitation and hygiene facilities, as well as access to health care, cognitive stimulation and responsive caregiving (UNICEF, 2017). These are all elements which form nurturing care for children (Richter, Lye and Proulx, 2018). The home, the neighbourhood and the local government capacity for service provision are all elements which create the context for nurturing care. Therefore, it is well understood that any attempt to improve child development outcomes must be multisectoral in nature, and focus on the environment inside and outside the home. Providing all the elements of nurturing care at the same time presents a challenge in resource constrained environments in LMICs.

Each of the factors which make up nurturing care for children also reinforce each other. For example, adequate nutrition and access to water, sanitation and hygiene (WASH) facilities are both critical in preventing stunted growth in children (Soliman *et al.*, 2021). Furthermore, while access to WASH facilities in the home is important, living in an area with a network of WASH facilities also contributes towards better child health[11]. Since children play outside of their home – in different streets, parks and in neighbours' homes – a network of sanitation is especially important in creating a pathogen-free environment (Bridgman and von Fintel, 2022).

[11] Additionally, the tap inside the home is likely to provide better access to clean water if it is part of a bigger network. In other words, being part of a network of WASH services network is a proxy for economies of scale and improved service provision in and out of the home.

The tendency for multiple inputs to reinforce each other will be termed "concurrent complementarity", building on the notion of "dynamic complementarity".

There is dynamic complementarity[12] between the investments made in children in each period of their development, but research has indicated that early intervention has the largest effect, especially for disadvantaged children (Heckman, 2008). Furthermore, interventions that supplement childcare education in the home, in nutrition or in parenting are more effective than those that focus only on Early Childhood Education (ECE) (Heckman *et al.*, 2009). The majority of research in this field has been conducted in High Income Countries (HIC), but the need for multi-dimensional intervention may be more critical in Low and Middle Income Countries (LMIC) due to resource constraints in the home and community environments (Engle *et al.*, 2007; Richter *et al.*, 2017). Therefore, this chapter focuses on why the provision of these concurrently necessary inputs must be improved in LMICs to strengthen early childhood development.

This paper uses Multidimensional Poverty Index (MPI) methodology to create an index of multidimensional service delivery for children in a LMIC context. This approach is motivated by the consensus that ECD is multidimensional in nature, and that children need multiple inputs *at the same time* for healthy development (UNICEF, 2017; Richter, Lye and Proulx, 2018). The MPI approach to service delivery measurement allows the observer to see in which regions children are not receiving the full complement of services they require to develop to their full potential according to the international literature (Engle *et al.*, 2007; Grantham-Mcgregor *et al.*, 2007; Walker *et al.*, 2007; Richter *et al.*, 2017). The analysis uses data which has been collated from a number of administrative and survey datasets which are representative at the municipal level. The approach uses the most recently available regionally representative data to create new insights into ECD service delivery, and how this can be improved in a broader sense rather than improving access to one service only. This paper responds to calls such as those in Grantham-Mcgregor et al., (2007) and Richter et al., (2017) to use a data-driven approach in researching how to scale up ECD in LMICs.

As an example of how MPI methodology can be applied to service delivery for children, South African data is used. South Africa presents a useful case study for several reasons: 1) many

[12] This term is coined by James Heckman and refers specifically to the complementarity between investments made over different periods of childhood, the impact of which, over time, is greater than the sum of the inputs.

children in the country are found not to be developing to their full potential[13]; 2) there is a strong imperative in South African policy to provide all inputs necessary for ECD; and 3) there is data which is available for analysis which is representative at the municipal level. More than 1 in 5 of South African children under the age of five in 2021 were stunted (Sustainable Development Solutions Network, 2023), and less than half of four- to five-year-olds attend an Early Learning Program (ELP) (StatsSA, 2018). Of those who attend an ELP, less than half of children are on track to start with formal schooling by the age of 6 (Tredoux *et al.*, 2023). These statistics indicate that many children face challenges that prevent them from developing to their full potential, and that improving child development is imperative.

In this study, data on 13 indicators of service delivery reaching children is identified from available large scale household surveys and administrative records for each municipality in South Africa. There has been a recent effort to measure the relationship between multidimensional child poverty and child health (von Fintel, 2021), and other efforts to map poverty across geographic space (Barnes *et al.*, 2009). There is a recent study which details the how the provision of WASH factors are related to child growth in young children in Soweto – a large township in Gauteng province, which shows that the provision of safely managed sanitation access is critical for child growth (Momberg *et al.*, 2020). However, there are no studies which show how service provision in different regions relates to early childhood development and early child health in those regions across South Africa. This study therefore shifts the focus to local contextual factors that relate to child health. The focus of service provision in municipalities is motivated by the fact that municipalities are a strong functional unit of governance in the area of service provision in South Africa (SA National Planning Commission, 2012). Furthermore, municipalities play a significant role in the provisioning of various public infrastructural services and are specifically identified as a key stakeholder in the provision of early childhood development services (Republic of South Africa, 2015).

Following on from this, this paper provides a first validation of this measure by assessing whether the ECD index correlates with individual child outcomes. While recent nationally

[13] Researched papers in The Lancet describe loss of development potential in over 200 million children in LMICs due to stunting (Engle *et al.*, 2007; Grantham-Mcgregor *et al.*, 2007; Walker *et al.*, 2007; Daelmans *et al.*, 2017). These papers argue that when children are stunted, they have lost development potential. The same line of argument is followed here (that because 26% of South African children are stunted, they have lost development potential).

representative data on child cognitive outcomes in South Africa is scarce, it is possible to analyse cognitive and physical development outcomes for 4 and 5 year old children who attend early learning programs[14] (ELPs) in South Africa to test the validity of the MPI measure. The analysis of individual child outcomes reveals that public infrastructure service delivery, including sanitation, clean tap water, refuse removal, electricity and safe environments is positively associated with cognitive outcomes in children who attend an ELP in South Africa, even once socioeconomic status is accounted for. Since the sample of children who attend ELPs in South Africa is representative of the more advantaged children in the country (Henry and Giese, 2022). Sample selection on the outcome variable in relation to municipally representative explanatory variables therefore places a downward bias on the results, and the coefficients should be viewed as lower-bound estimates. These results imply that improved municipal and home environments are complementary inputs to early childhood care and education for those who attend an ELP. The findings do not shed light whether improved municipal and home environments have the same associations with outcomes of children who did not attend ELPs.

The findings in this paper suggest that ECE benefits children who attend an ELP and have higher socioeconomic status and better-resourced home environments (StatsSA, 2021). International evidence suggests that ECE investment benefits poor children, closing the achievement gap between the educational outcomes of rich and poor children in HICs (Ruhm and Waldfogel, 2012). Therefore, this paper implies that expanding ELP attendance, together with improvements in home and municipal environments, would be a cost effective intervention for the reduction of child poverty. This implication is consistent with the hypothesis that interventions which include supplementing child nutrition and improving the home environment have a larger positive impact than those which focus only on cognitive stimulation (Engle *et al.*, 2007; J. Heckman, 2008; Heckman *et al.*, 2009; Ruhm and Waldfogel, 2012). An important qualifier to this argument is that positive impacts of ECE investment on those who come from poor home environments are further contingent on program quality (Van Der Berg, 2021). Reducing developmental risk factors in regional and home environments is important in promoting ECD, but particularly so in LMIC contexts with low ELP attendance (Saloojee *et al.*, 2007; Walker *et al.*, 2007; Britto *et al.*, 2017). The MPI methodology allows

[14] ELPs are non-school based provisioning of ECCE for children under the age of 5, which is the age at which children become eligible for a school-based pre-Grade 1 year called Grade R. ELPs can be registered with the Department of Social Development to receive a subsidy, but many ELPs are unregistered and informal.

governments and policy makers to assess where regional services for children are lacking, and exactly how this can be addressed. Only when their home environments are improved will children be able to fully benefit from ELP attendance.

There is a strong and growing policy emphasis on childhood interventions in the international literature in both HICs and LMICs. As cited above, a large portion of this literature focuses on early childhood education, which is seen as one important part of holistic ECD. There is a growing interest in ECE policy prioritisation due to its promotion by large international development organisations over time (Wotipka *et al.*, 2017). However, while the discourse on ECD has increasingly emphasised ECE more narrowly, this can come at the expense of prioritising a wider package of ECD services. This paper therefore re-emphasises a policy focus on this wider package which is needed for healthy child development.

This paper starts by reviewing the literature on complementary investments in early childhood development and the multidimensional nature which is required in ECD service provision. The next section also reviews the literature on ECD in South Africa to give context to the case study which is applied. Section 3 develops a multidimensional measure of service delivery for children, which is guided by the understanding of the necessary inputs for nurturing care. Section 4 discusses the data which is used in this paper, and section 5 presents the methodology which is applied in the analysis. Section 6 goes on to present the results of the analysis, while section 7 discusses the implications and policy relevance of this case study and concludes.

2.2. Literature Review

2.2.1. Dynamic complementarity: the case for investing in early childhood development

Multisectoral interventions aiming to improve child development can be expensive and administratively cumbersome. As such, there is a large body of literature which details the best time to invest in a child's development for maximum impact. Studies on interventions focused on improving the cognitive and non-cognitive skills of children find that early investment is critical. Heckman (2008) shows that the returns to investing in children at a younger age are greater than the returns for the same investment in older children. Furthermore, the skills, competencies and capabilities acquired at a young age become the foundation for further skills, competencies and capabilities, creating dynamic complementarity between current and future

capabilities. While interventions throughout the person's life-cycle are influential in the expression of inherited genetics, behavioural regulation and cognitive development, early interventions and social experiences are found to be particularly impactful for these three aspects of human development (Champagne and Curley, 2005).

In macroeconomic models, childhood is typically conceptualised as one stage in a person's life-cycle (J. Heckman, 2008). A more nuanced understanding of child development recognises that there are more and less critical stages within childhood, and that investment has a larger impact in those critical stages (Cusick and Georgieff, 2016; Schwarzenberg and Georgieff, 2018). These critical stages are during the first 4 to 5 years of childhood, and during the onset of puberty into early adolescence (Grantham-Mcgregor *et al.*, 2007; Dahl and Suleiman, 2017). While investing in children during each stage of childhood has positive impacts, later investment in children should be seen as complementary to early investment rather than as a substitute (Heckman, 2008b). Furthermore, different windows of child development are critical for different areas of growth, where the age from 0 to 2 years is critically important for linear growth (Momberg *et al.*, 2020), and puberty is critically important for phycological and behavioural development (Berenbaum, Beltz and Corley, 2015). Interventions aimed at different developmental windows should leverage these areas of growth.

Interventions in early childhood development often take the form of an early learning program (ELP) or an educational and care facility. Two critical examples studied thus far are the Perry Preschool and the Head Start programs in the United States (Heckman *et al.*, 2009; Gibbs, Ludwig and Miller, 2011). These high quality educational interventions had large impacts on both the cognitive and non-cognitive outcomes of the children who participated. As such, these examples have paved the way for many other education-based interventions.

2.2.2. The return on investment for ECD interventions

The Perry Preschool Program and the Head Start Program in the United States were both found to be most beneficial for children from poorer homes relative to children from wealthier homes (Heckman *et al.*, 2009). Investments in children are most effective at young ages, and have been repeatedly found to narrow achievement gaps between disadvantaged children and their more advantaged peers (Ruhm and Waldfogel, 2012; Yang, 2021). The nature of the investment is most commonly an educational program which children attend which may include healthcare, cognitive stimulation and nutritional inputs. ECD intervention studies in

other HICs such as Sweden, Norway, Germany, France and Denmark have also found that disadvantaged children benefit more from high-quality educational interventions than their wealthier peers. This is true especially for children from immigrant families relative to non-immigrant families, and for children in households with low maternal education relative to households where the mother is more educated (Datta Gupta and Simonsen, 2007; Black *et al.*, 2010; Fredriksson *et al.*, 2010). However, a similar study in Canada finds that increased attendance at low-quality childcare and educational facilities has a negative impact on child development and behavioural regulation, indicating that the effect of ECD is highly dependent on the quality of the programming (Baker *et al.*, 2005). High program quality is dependent on enough contact-time with children each week, the training of practitioners, nutritional supplementation, and home visits or education for parents (Ruhm and Waldfogel, 2012).

Evidence of the effect of education-focused intervention in LMIC contexts is less well documented. Evidence from Argentina suggests that pre-primary education has a beneficial effect on learning outcomes for children and narrows the performance gap between poorer and richer children (Berlinski, Galiani and Gertler, 2009). Evidence from South Africa shows that a pre-school year is beneficial only for those attending better resourced schools. The national rollout of a pre-school year, referred to as Grade R in South Africa, allowed for the analysis of the effect of Grade R attendance on later schooling outcomes. Grade R was found to be ineffective in all but the top 40% of schools, and only the wealthiest 20% of schools saw a substantial benefit (van der Berg, Girdwood, Shepherd, van Wky, Kruger, Viljoen, Ezeobi and Ntaka, 2013). The authors of the paper attribute their finding to low quality programming and large class sizes in poorer schools, and to the likelihood that some practitioners in these schools have a limited understanding of their role in child development. A subsequent study of ECE interventions in South Africa finds that high-quality ECE programs can benefit the poorest children; high-quality programs have the potential to significantly increase the number of children[15] who are on-track to start with Grade 1 (Van Der Berg, 2021). This indicates further that the quality of programming is critical to the success of ECE interventions, and is especially critical where home environments are resource constrained.

There is thus a contradiction between HIC and LMIC contexts. The studies in a HIC context (the US) mentioned above show that ECE investment benefits poorer children and closes the

[15] The percentage of children increased from 28% to 48% after treatment.

achievement gap between the educational outcomes of rich and poor children in HICs, even in the long-run (Ruhm and Waldfogel, 2012). This effect is attributed to increased educational stimulation for the poorest children in these countries, stimulation which they would not receive at home in absence of ECE attendance, as well as to the increased potential for both parents to work and earn an income to improve the household environment (Baranyai, 2023). However, evidence from a LMIC context in South Africa suggests that the quality of the intervention is critical. Therefore, while return on investment in ECD is large for younger children in LMIC contexts relative to older children, positive impacts on those who come from poor home environments is contingent on program quality (Van Der Berg, 2021).

The larger return on investment for early-life interventions reduces the efficiency-equity trade-off. Heckman argues that there is less of an efficiency-equity trade-off the earlier the investment is made, and that the interventions which are most effective and long-lasting supplement the home environment as well as improving the educational inputs in facilities (Heckman, 2008; Heckman et al., 2009). Heckman makes this point regarding successful ECD interventions in HIC contexts. Elsewhere, it has been shown that supplementing home environments is likely to be more important in LMIC contexts relative to HIC contexts due to the increased likelihood of low socioeconomic status in home backgrounds in LMICs which limit caregiver's ability to provide nurturing care (Walker *et al.*, 2007; Britto *et al.*, 2017; Giese *et al.*, 2022). With that in mind, discussion turns to the multisectoral approach to promoting ECD.

2.2.3. The importance of socio-environmental factors for child development

The environment which a child experiences on a daily basis is a large determining factor in shaping developmental outcomes (Thomson, Petticrew and Morrison, 2001; Sharpe *et al.*, 2018). In addition to the home environment, the child's inherited genetics and the parenting they receive are important for shaping both cognitive and non-cognitive abilities (such as motivation, perseverance and integrity), which, in turn, influence a child's future educational and labour market outcomes. Educational attainment and non-cognitive skills further impact rates of school drop-out, teenage pregnancy, participation in crime and drug use (Cunha and Heckman, 2007).

The built environment in which a child lives is critical to their healthy development. Features of the built environment include access to nutrition, water, sanitation and hygiene, safe places

for a child to play and to sleep, access to routine health care such as vaccinations, and access to emergency health care for illness (Coutsoudis *et al.*, 2000; Fink and Rockers, 2014; Ronfani *et al.*, 2015). Variations in home environment are caused by both systemic and structural features. Local preconditions present systemic barriers to improved built environments, such as low access to water and sanitation. Local administrational capacity present systemic barriers. While local preconditions are impossible to change, they can be overcome by removing structural barriers.

The environment in which young children live also needs responsive caregiving, monitoring for their safety, and cognitively stimulating interaction with a parent or guardian in order to be secure and to develop social and non-cognitive skills. Each of these elements is enhanced by higher parental education, especially maternal education (Nepal, 2018). These critical features of the built environment are often lacking in LMIC contexts, and maternal education also tends to be lower in LMICs (Grantham-Mcgregor *et al.*, 2007; Bornstein *et al.*, 2012). This implies that effective ECD interventions in LMICs relative to HICs require an additional focus on improving elements of the built environment.

There are multiple factors which aid child development, but there are three which have been determined as critical in the literature on ECD; namely nutrition, lack of chronic infection, and responsive caregiving (Burger *et al.*, 2022). First, access to nutrition is fundamental to healthy physical and mental development, but feeding a child enough food is not necessarily the only concern. Children also require important micro-nutrients such as iron, iodine, zinc and vitamin-A for healthy brain, bone and organ development. Lack of access to healthy nutrition can cause "hidden hunger", which is when a child receives enough calories to grow, but inadequate micronutrients to develop healthy physical and cognitive abilities (Muthayya *et al.*, 2013). Second, adequate hygiene, including access to WASH and to hygiene education is critical for avoiding chronic infection. Poor WASH facilities and poor hygiene practices contribute towards child illness, and especially diarrhoea in young children (Headey and Palloni, 2019). Poor WASH and frequent diarrhoeal episodes can prevent children from absorbing nutrition, and thereby cause children not to develop to their full potential (Fink, Günther and Hill, 2011; Budge *et al.*, 2019). Third, children require responsive caregiving and cognitive and social stimulation with a parent or guardian. This includes monitoring for the child's safety to reduce harm and stress (Richter, Lye and Proulx, 2018). Verbal interaction promotes language understanding, and positive interaction with a parent or guardian fosters behavioural regulation

(Page Melissa *et al.*, 2010; Bray *et al.*, 2020). Reading to a child regularly improves cognitive development and language acquisition (Kuo *et al.*, 2004; Kalb and Van Ours, 2013). The external environment, as well as the internal home environment, are therefore both factors which heavily influence child development.

ECD is, therefore, a broader construct than ECE. Despite this, interventions in early childhood development tend to focus more on the ECE element[16]. While ECE interventions may have beneficial effects in many contexts, an additional focus on the home environment and elements of the built environment – both critical to child development – is needed in LMIC contexts in order to see improved child outcomes.

Each of the three factors highlighted above – nutrition, hygiene and responsive caregiving – also reinforce each other. For example, adequate nutrition and access to WASH facilities are both critical in preventing short stature and stunting in children, a finding which suggests that nutrition and WASH reinforce each other in creating a healthy environment enabling child development (Soliman *et al.*, 2021). Furthermore, while access to WASH facilities in the home are important, living in an area with a network of WASH facilities also contributes towards better child health[17]. Since children play outside of their home, and interact with other children closely, a network of sanitation provision is important in creating a pathogen-free environment (Bridgman and von Fintel, 2022). Therefore, it is well understood that any attempt to improve child development outcomes must be multisectoral in nature, and it must focus on the environment inside and outside the home.

The concurrent complementarity in inputs to child development reinforces the need to view ECD service provision at a multisectoral level; as such, coordination across departments and units becomes increasingly necessary. For this purpose, the multidimensional nature of ECD and its measurement is discussed below.

[16] A notable exception to this is the work done on changing parental behaviour (see Attanasio, Fernández, Fitzsimons, Grantham-McGregor, Meghir and Rubio-Codina, (2014) for an example).

[17] Additionally, the tap inside the home is likely to provide better access to clean water if it is part of a bigger network. In other words, being part of a network of WASH services network is a proxy for economies of scale and improved service provision in and out of the home.

2.2.4. Multidimensional poverty index measurement

There is a well-developed literature on the multisectoral approach required for successful ECD interventions (See Del Carmen Casanovas et al, 2013; Black et al., 2017; Richter et al., 2017). Effective ECD interventions are not confined to education interventions only; they encompass health, socioemotional and parenting interventions as well. The need for concurrent inputs and inter-departmental coordination is documented in international guidelines for child health, such as the UNICEF guidelines for ECD programs (UNICEF, 2017). The UNICEF report emphasises social protection, child protection, education, health, nutrition, WASH, gender equality and communication with parents as key components of all successful ECD interventions. Similarly, South African policy documents such as the National Integrated Early Childhood Development Policy (NIECDP) also emphasise the importance of ECD for South African society, and the multisectoral approach through which it must be provided (Republic of South Africa, 2015).

Given the multidimensional nature of child development, monitoring the success or failure of ECD service provision requires an instrument that accounts for the multi-sectoral and multi-dimensional nature of the required services. For this purpose, this paper borrows from and modifies the methodology used to create multidimensional poverty indices (MPI). The MPI methodology was operationalised, for example, in the Human Development Index which provides a multidimensional poverty measure for 190 countries and territories. This composite measure of a national population's longevity, education and income is arguably a more complete picture of a country's level of poverty than a metric of income poverty alone (UNDP, 2023). MPI methodology has also been applied in analyses of healthcare provision, successfully showing that better health outcomes require more than just attendance at health facilities. Home medication and follow-up medical attention is also needed (Becker, Boustani, Gellatly and Chorpita, 2018; Lakind, Bradley, Patel, Chorpita and Becker, 2022).

In this paper, the MPI methodology is applied to provide a framework for conceptualising the multidimensional requirements of ECD services in particular regions. Instead of measuring one element of service provision for children, such as vaccinations or ELP attendance, this MPI measure concurrently takes each of the three critical dimensions of ECD into account. This paper, in applying the MPI methodology to service delivery for early childhood development in South Africa, provides a case study of how this methodology can be applied elsewhere.

The MPI developed in this analysis focuses on three Domains of services for children: (i) access to healthcare, including nutrition, (ii) the provision of safe and clean environments, and (iii) access to education services. A direct measure of parental care is not included in this version of the index because of a lack of available data on this. This omission is highlighted as a future avenue for extending this analysis. The construction of this composite index which measures ECD service provision is discussed in section 3, after a brief review of the South African ECD and ECE context.

2.2.5. Early childhood development in South Africa

The socioeconomic inequality that marks the South African economy is also evident in child outcomes. Children from affluent homes in South Africa fare relatively well by international standards for cognitive and physical development such as stunting, while children from disadvantaged homes are found to be developmentally off-track (Oliphant, Templeman and Baranov, 2006; Shepherd, 2006; Van der Berg, Zuze and Bridgman, 2020). Children living in former South African homelands fare particularly poorly (Barnes *et al.*, 2009). These geographical areas were demarcated as separate "Bantustans" where black South Africans were forcibly moved under the apartheid government. In these areas, infrastructure was not provided for, and they were purposefully neglected in their development (Fourie and Herranz-Loncan, 2015; von Fintel and Fourie, 2019).

This legacy lasts to the present day. These areas are poorly serviced in terms of infrastructure, especially in WASH, and are areas where poverty is more concentrated relative to other areas of the country (Bridgman and von Fintel, 2022). While there have been notable improvements since 1994[18], children in the former homeland areas still have poorer access to health and educational facilities, and they are more likely to live in homes without WASH services and electricity (Barnes *et al.*, 2009). Poor health and poorer educational outcomes are cited among the most serious poverty traps in South Africa. Parents with poor health and education are less likely to access better health and educational outcomes for their children (Adato, Carter and May, 2006; Van Der Berg *et al.*, 2011; Spaull, 2015). ECD is recognised as a critical part of

[18] Access to WASH services has increased (see chapter 2).

improving the health and wellbeing of South Africans from an early age, and as a tool to break cycles of intergenerational poverty.

There is a steep socioeconomic gradient in early childhood development outcomes in South Africa. Children who live in the wealthiest 20% of South African homes are 65% more likely to reach appropriate cognitive developmental milestones by age five relative to five-year-olds from poorer homes (Giese *et al.*, 2022). This gradient becomes even steeper as children progress into the schooling system. Kotzé and van der Berg, (2017) calculate a measure of socioeconomic status (SES) which is comparable across countries and use it to measure SES gradients in educational outcomes in multiple countries. The SES gradient is found to be very steep in South Africa and South African children across the socioeconomic distribution perform poorly in comparison to countries with far lower GDP per capita than South Africa. The particularly steep socioeconomic gradient and concomitant low scores in child outcomes in South Africa may contribute to the need for ECD interventions to supplement home environments in order to be successful. This is consistent with the hypothesis that there is a fairly high SES threshold which exists before child health measures improve substantially (Husseini *et al.*, 2018). Therefore, in analysing service delivery and child outcomes in this chapter, service delivery is expected to be negatively related to child outcomes. Covariates which may influence this relationship include income and living in a metropolitan area.

Given the importance of ECD, there is a strong policy emphasis on childhood interventions in the country. This paper seeks to broaden the focus of ECD service provision by providing a data-driven approach to measuring where South African children receive the critical elements required concurrently to enable them to thrive, and where they do not.

2.3. Developing a multidimensional index of access to ECD

Applying MPI methodology to South African data, this section translates the multiple inputs required for ECD into a single measure of service delivery for ECD. This allows the analyst to uncover where children are receiving the full package of the concurrent services that they need to thrive, as envisioned in the National Integrated Early Childhood Development Policy. This measure of public servicing by municipality should be seen as denoting the strength or failure of location-specific service provision *for children*, and in support of early childhood development in those places. This analytical tool could be applied to any region or country, but here it will be applied in South Africa as an example.

In order to apply this methodology, information on the level of service delivery to which children have access for each critical input for ECD must be collected. Observations should be at the level of functional local government in order to aid the policy relevance of the exercise, but it is acknowledged that the level of government most appropriate to analyse will differ by country. In South Africa, the municipality will be the level of local government under analysis. Municipalities play a significant role in local provisioning of public infrastructural services and are specifically identified as a key stakeholder in the provision of early childhood development services (Republic of South Africa, 2015: 75). While municipalities are responsible for service delivery and infrastructure maintenance, national funding is allocated to poorer, rural municipalities to fund these activities. However, some municipalities have weaker administrative capacity to fulfil these roles (Oosthuizen and Thornhill, 2017). Therefore, it is acknowledged that while local preconditions may be weaker in some municipalities, local administrative capacity is a critical component which hinders services provision. This is discussed further in Chapter 3.

The South African NIECDP, as the main policy statement in this area, stipulates the services that the South Africa government is responsible to undertake to provide to all children. Section 5 of the document sets out specific service focus areas that are important for ECD in the country, including (1) health care and nutrition, (2) social protection, (3) parent support programmes, (4) opportunities for learning, (5) national public early childhood development communications, (6) housing, water, sanitation, refuse removal and energy sources, (7) food security, and (8) play facilities, sport and culture (Republic of South Africa, 2015:56-61). Provincial and local government departments are given the responsibility of measuring and reaching universal service delivery in these areas (Republic of South Africa, 2015:75). For the purpose of this paper, these 8 service delivery focus areas in the NIECDP are combined into three primary Domains of service provision. These are (i) health care provision, (ii) public service provision, and (iii) access to education services. Data has been collected which measures each of these Domains and is described in the data section[19]. Figure 2.1 shows how

[19] Service Domains (2) social security, and (5) national public early childhood development communications are not included. The exclusion of social security is discussed in the section below. This is due to data constraints in finding indicators to measure these variables appropriately.

these specific focus areas in the NIECDP fit together with the Domains and Sub-Domains of service delivery for children.

For the purposes of this study, the first Domain of service provision is the Health Services Domain. There are 5 Sub-Domains which assess the level of health care provision in a municipality. These are (i) whether all children have their regulation "road to health" booklet, (ii) the proportion of children who have received their full complement of immunisations (14 vaccines administered by 2 years of age), (iii) the number of children who have received their minimum immunisation (9 doses by 9 months of age), (iv) access to health care facilities, and (v) food security. These 5 Sub-Domains correspond to service delivery focus areas 1, 3 and 7.

The "road to health" booklet is a small booklet that is given to mothers with information on immunisation schedules, growth charts, nutritional advice and space for health care practitioners to record the medical history of children. This provides a measure of whether a child has accessed a healthcare facility at least once, usually at birth, in South Africa (Smith, Leach and Rossouw, 2024).

The second Domain of service provision is the Public Infrastructure Service Domain. There are also 5 Sub-Domains to assess the level of public infrastructure service provision in a municipality. These are (i) access to improved sanitation, (ii) access to tap water, (iii) waste removal, (iv) electricity, and (v) safety. These Sub-Domains correspond to service delivery focus areas 6 and 8 in the NIECDP. For brevity, this Domain of services will be called "Public Services".

There is no Sub-Domain which measures social security. This sub-domain was excluded for 2 reasons; first, receipt of government cash transfers is highly correlated with poverty. It would be most appropriate to measure the percentage of eligible households who receive cash transfers, but this data does not exist at the regional level. Such a variable is also likely to be highly correlated with food security (van der Berg, Patel and Bridgman, 2022). Second, while the social grant system is a critical poverty-reduction mechanism in South Africa, they do not exclude the need for other services, such as wate removal, health care and sanitation services. Given that the purpose of this analysis is to measure the level of services that children receive which enable them to grow to their full potential, whether or not their family receives a social grant, measurement of social security (in the form of government grants) is not necessary for

this index. There is precedent for excusing this measure when analysing multidimensional poverty in South Africa (see von Fintel, 2021).

Figure 2.1: NIECD Policy and domains of service delivery for children

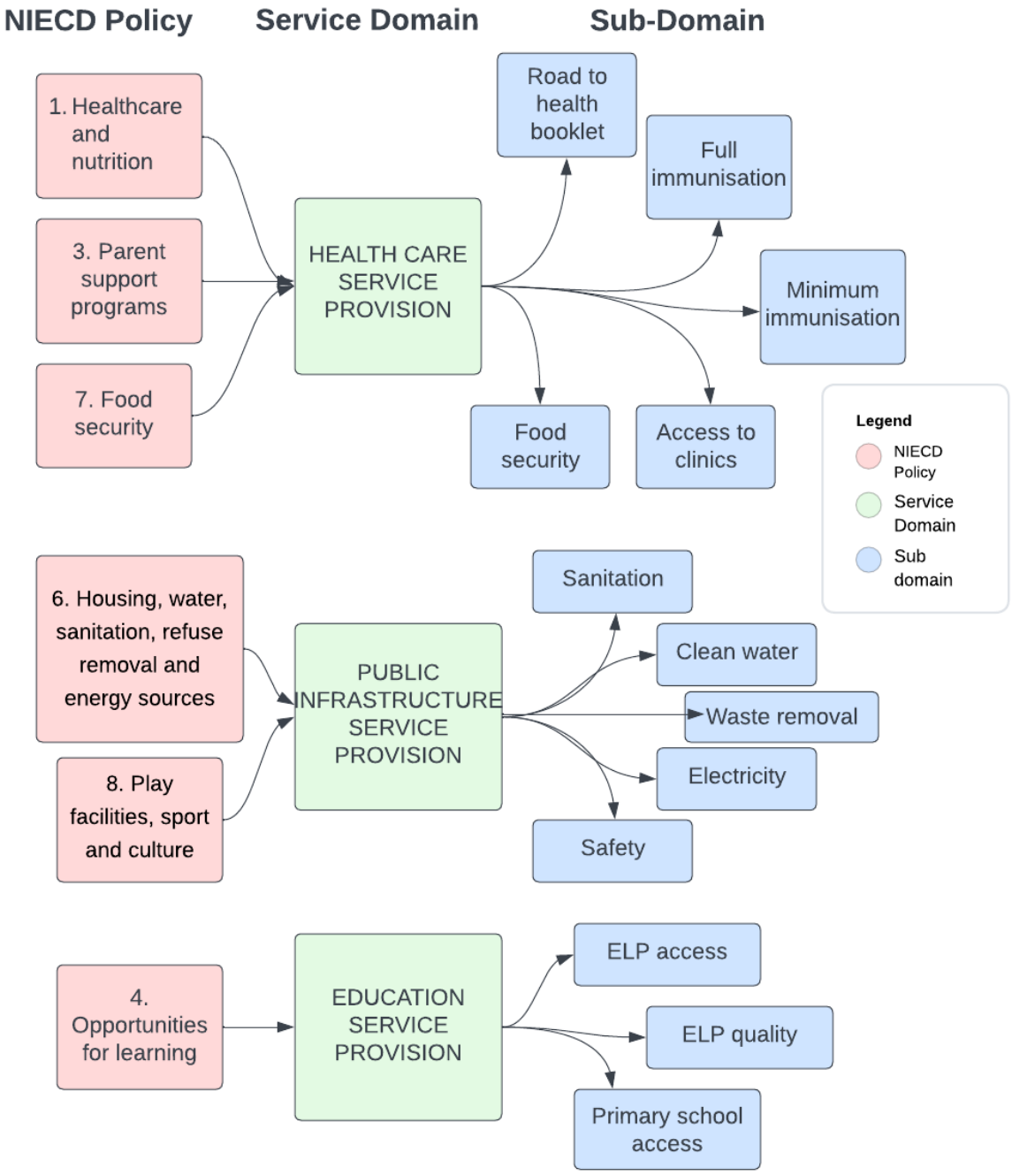

Figure 2.1: Construction of MPI domains.

Source: author (based on Republic of South Africa, 2015; UNICEF, 2017).

The third Domain is access to Education Services. There are 3 Sub-Domains which measure the level of access to quality education. These are (i) access to ELP facilities, (ii) the assessed quality of ELP facilities in the municipality, and (iii) the educator-to-learner ratio in primary schools in the municipality. These Sub-Domains correspond with service delivery area 4. It is important that there is access to both early learning opportunities, such as ELP facilities, and also the assurance of access to resourced primary schools in a municipality. For this reason, measuring access to quality "learning opportunities" in this analysis includes a measure of primary schools where the educator-to-learner ratio is less than 1:40.[20] This is the national minimum ratio for teacher resourcing allowed in public primary schools in South Africa (Education Labour Relations Council, 2003).

While service delivery is measured within municipalities, it is acknowledged that national and provincial government mandates influence municipal service provision. Specifically, provincial departments of Basic Education and Health are responsible for service provision in the Education and Health Domains. For the remainder of this chapter, service delivery by municipality is discussed, where failure to provide services is attributed to government structures and administrative systems which govern service delivery, which may include municipal administrative constraints.

2.4. Data

The analysis consists of 2 sub-analyses. This first sub-analysis uses municipal level data to create a composite indicator of ECD service delivery. The second sub-analysis uses the Thrive by Five Index and ECD Baseline Audit 2021 (DataDrive and Department of Basic Education., 2021) to analyse how these municipal level services relate to child level outcomes. Each of these datasets is described below.

2.4.1. Municipal level data

At a municipal level, the status of ECD related service delivery in the 3 Domains noted above is constructed, using a composite measure of service delivery in 13 Sub-Domains at the

[20] Using gross enrolment in primary school as a metric of school access is of little use given almost universal access to primary schooling. There is no large scale nationally representative measure of performance in primary school that could be disaggregated at municipal level.

municipal level. To identify measures in 13 Sub-Domains, data has been compiled from multiple publicly available sources. A key criterion for selecting the datasets for this analysis was whether they are representative at a municipal level.

Table 2.1 shows the data source, the year of observation for each variable which is used in analysis, as well as the level of government responsible to provide each Sub-Domain. Because multiple data sources are used, variables are measured in different years (2016 – 2021). While this is not ideal, it is unavoidable as all the information has not been collected in the same year or in a single study as of yet. The different time years from which each of the data points are taken is not an issue of great concern, as these indicators are often slow-moving.

The unit of analysis for the first analysis is the municipality. In each of the 13 Sub-Domains a measure is constructed for each municipality or district municipality in South Africa (N=52). However, children are a key focus of this analysis. For this reason, access to services is expressed as the proportion of households *with children*[21] in a municipality with access to the service. Access to healthcare facilities is converted to the number of clinics per 500 children, and access to ELPs in the municipality is converted to the number of ELP facilities per 10 children under 5 years of age. The child population estimates used for the calculations of access to clinics and ELP facilities are the 2016 Community Survey person weighted population estimates. The population of children under the age of 18 in 2020 and the population of children under the age of 5 in 2020 are both extrapolated using the projected child population growth rate, which was calculated per province by the Children's Institute at the University of Cape Town (Hall, 2022).

Finally, 3 variables are constructed at the municipal level which count the number of Sub-Domains in which adequate services for children are not provided. Here it must be emphasised that while the municipal level of service delivery is measured, failure to provide services is the responsibility of higher levels of government. However, poor national, provincial, and municipal administrative capacity may all contribute to municipal differences in outcomes. For both the Health and Public Services Domains, this variable ranges from 0 to 5, where a value of 5 indicates that the municipality has poor service provision in all 5 Sub-Domains of health

[21] Households with children are defined as households with one or more child under the age of 18, as per the official StatsSA definition.

or public infrastructure servicing for children. For the Education Domain, this variable ranges from 0 to 3.

Table 2.1: MPI data sources and years.

Domain	Sub-Domain	Data Source	Responsible to Provide	Year
Health	Road to health card	Expanded programme on immunisation (EPI) national coverage survey report (Makamba-Mutevedzi, Madhi and Burnett, 2020)	Provincial[22]	2019
	Full immunisation (all 14 doses)	Expanded programme on immunisation (EPI) national coverage survey report (Makamba-Mutevedzi, Madhi and Burnett, 2020).	Provincial	2019
	Minimum immunisation	Expanded programme on immunisation (EPI) national coverage survey report (Makamba-Mutevedzi, Madhi and Burnett, 2020)	Provincial	2019
	Healthcare facility access	Official list of healthcare facilities (Department of Health, online).	Provincial	2019
	Nutrition	National Community Survey (StatsSA, 2016)	Provincial[23]	2016
Public Services	Sanitation	National Community Survey (StatsSA, 2016)	Municipal[24]	2016
	Access to water	National Community Survey (StatsSA, 2016)	Municipal	2016
	Waste removal	National Community Survey (StatsSA, 2016)	Municipal[25]	2016
	Electricity supply	National Community Survey (StatsSA, 2016)	Municipal	2016
	Safety	National Community Survey (StatsSA, 2016)	Municipal[26]	2016
Education	Access to ELP	ECD Census (Department of Basic Education)	Municipal[27]	2021
	Quality of ELPs	2021 ECD Census (Department of Basic Education, 2022)	Municipal	2021
	Access to Primary School	National Database of South African Schools (Department of Basic Education).	Provincial[28]	2021

Table 2.1: Data sources and years of observation for MPI construction.

Each Sub-Domain in the Education Domain carries more weight because there are 3 Sub-Domains instead of 5. These three Sub-Domains were chosen to represent the "opportunities for learning" which are emphasised in the NIECD Policy Document. 5 Sub-Domains were not necessary for measurement of service delivery in this domain, and therefore only three Sub-

[22] Provincial departments of health in South Africa are responsible to provide local health care services (Department of Health, 2023).
[23] Provincial government is responsible to implement the national Infant and Young Child Feeding Programme (Department of Health, 2007).
[24] Municipal governments are given the responsibility to provide sanitation and water services (Department of Water and Sanitation, 2016).
[25] Municipal government is given the responsibility of coordinating and implementing waste removal (National Treasury, 2011).
[26] Local government is responsible to provide policing and safety services (National Planning Commission, 2010).
[27] Municipalities are given the responsibility to provide access to ECD services and ELPs in the NIECDP (Republic of South Africa, 2015)
[28] It is the responsibility of each provincial department to finance and manage its schools

Domains are used. Furthermore, each Sub-Domain receives an equal weight in the final estimation of overall service delivery.

2.4.2. Facility level data

The second dataset analysed is a facility level dataset called the Thrive by Five Index and ECD Baseline Audit of 2021 (DataDrive and Department of Basic Education, 2021). The Thrive by Five baseline survey produced data at the facility level for over 2400 ELPs. This rich dataset has facility level information on WASH, meals served, user fees, the educational materials in the facility, use of a curriculum as well as other indicators of ELP programming.

Furthermore, this data includes child outcome measures for over 5000 children under the age of 5 who attend the facilities. The child outcome measures include child height-for-age and stunting, as well as a measure of cognitive development. This measure, called the Early Learning Outcomes Measure (ELOM), provides a reliable and fair assessment of the cognitive ability of children aged 50 to 69 months. Test-retest validity of the ELOM score has also been established (Snelling *et al.*, 2019; Anderson *et al.*, 2021). The sample of 5225 children is nationally representative of children who attend ELPs in South Africa. The ELOM variable measures development in five domains: Gross Motor, and Fine Motor Development, Numeracy and Mathematics, Cognition and Executive Functioning, and Literacy and Language skills. The assessment tool has 23 items clustered in these five domains. During the 45-minute assessment, highly trained fieldworkers assess the child's performance on each item and award a raw score, which is then transformed into a scaled score for each domain. A domain total score is awarded to each child out of 20. The five domain scores are then summed to derive the ELOM total score out of 100. Scores for each domain and for the total fall within one of three performance bands: On Track, Falling Behind and Falling Far Behind. The cut-off points for On Track, Falling Behind and Falling Far Behind for children aged 50-59 months were set empirically and in consultation with key stakeholders (Giese *et al.*, 2022) This assessment tool has been formulated by multidisciplinary team, including experts in ECD, child psychology, economics and child assessment, and aims to assess whether or not a child is "On Track" to start formal schooling by the age of 6. For a description of the study methodology and sampling technique, see DataDrive and Department of Basic Education, (2021).

The data includes a variable that indicates the child's age in months and their gender. Also included in the data is an indication of whether or not the ELP facility charges fees, and whether

or not they receive the Department of Social Development (DSD) subsidy. Receipt of the DSD subsidy is an important measure which identifies the poorest programs, and ones that have to provide meals, as 50% of the subsidy must be spent on food. The fees charged and the subsidy indicator variables control for the socioeconomic status of the facility. Table 2.2 shows descriptive statistics for the ELOM dataset.

In this data, 6% of children are stunted or severely stunted[29], which is lower than national estimates. The most recent national estimate for stunting prevalence for children under the age of 5 in the Demographic and Health Survey of 2016 is 27% (National Department of Health *et al.*, 2019). It is important to note, however, that the Thrive by Five sample of children are all between 4 and 5 years old; the comparable stunting prevalence for children 4 to 5 years old in the DHS was 16% in 2016. In 2017, the stunting prevalence for 4 to 5 year olds, as measured in the nationally representative sample in the National Income Dynamics Study (NIDS), was 12% (Southern Africa Labour and Development Research Unit, 2018). There is no more recent study where child stunting is measured in South Africa. However, regardless of the comparison study, the stunting rate is at least half that of other comparable estimates.

Table 2.2: Descriptive statistics

Variable	N	Mean	Min	Max
Age in Months	5 222	54,7	50	59
Female	5 222	51%		
Fees charged	5 222	93%	0	R3 883
Stunted	270	5,2%		
Severely stunted	31	0,6%		
Metro	938	17,90%		
ELOM Cut-offs	Number of children		Percentage meeting cut-off	
Falling far behind	1 525		29,2%	
Falling behind	1 359		26%	
On track	2 338		44,7%	

Table 2.2: Descriptive statistics for the ELOM dataset.

The stunting prevalence in this data, at 6%, is therefore considerably lower than the national estimates for children of 4 to 5 years. Since the sample of the Thrive by Five data comprises

[29] Children who are three standard deviations below the mean of the 2006 WHO reference population are considered to be severely stunted.

only children who attend ELP facilities, this lower stunting prevalence is likely due to sample selection in this data (Henry and Giese, 2022). More advantaged children are those able to attend an ELP; the average monthly income for children who attend an ELP in 2021 is almost three times the average monthly income of families with no eligible children attending an ELP (StatsSA, 2021). A lower stunting rate is therefore expected for children who attend ELPs than would be expected of a nationally representative sample. Further research into the stunting prevalence among non-ELP attenders would be of value in elucidating the value of multi-dimensional service provision for children. The sample selection evident in the Thrive by Five data has implications for how the results of the analysis must be interpreted.

2.5. Methodology

The first part of this section details the methodology that is used to investigate multidimensional service provision for ECD at the municipal level. The focus of service provision in municipalities is motivated by the fact that municipalities are a strong functional unit of governance in the area of service provision in South Africa (National Planning Commission, 2012). The second part of the discussion on methodology details ways in which the study sought to assess how child outcomes are related to the level of municipal service delivery.

The first aim of this analysis, therefore, is to create a measure of concurrent service delivery for ECD. The second aim is to relate this measure to child-level outcomes in a LMIC context; the goal is to evaluate whether concurrent complementarity in ECD inputs is a critical feature which supports successful ECD interventions.

2.5.1. Municipal level service provision for children

A multidimensional poverty measure is created to assess the level of municipal service delivery in the three service Domains deemed necessary for multisectoral ECD service provision; namely the Health Services Domain, the Public Services Domain and the Education Services Domain as in Figure 2.1. The methodology for this part of the analysis is derived from the Counting Approach. In Alkire and Foster, (2011) and Alkire et al., (2015), the Counting Approach uses a double cut-off method. This analysis uses a single cut-off. To identify the municipalities in which children are underserviced in terms of ECD service provision, a cut-off for each Sub-Domain is identified. For example, for the “Full immunisation” Sub-Domain,

a municipality is considered to have poor provision if fewer than 90% of children have been fully immunised. There is a cut-off specific to each Sub-Domain which is obtained from the literature or from policy prescriptions (see Table 2.3). The joint distribution of multiple indicators of ECD service provision across different Domains is then used to identify municipalities which have poor provision across multiple indicators of ECD service provision.

In the second step of the Counting Approach which is proposed by Alkire et al., (2015), a cross-dimensional cut-off would be used to indicate how **wide** the lack of service provision must be in order for the municipality to be identified as providing multidimensionally poor ECD service provision. This proposed step combines the multiple Sub-Domains into one composite number which is comparable across observations (municipalities). This step is not completed in this analysis due to the arbitrariness of the weights which must be applied to the Sub-Domains in order to create a composite number (Ravallion, 2011). Instead, the Sub-Domains are combined in an additive index which ranges from 0 to 13, in which each Sub-Domain has an equal weight.

This final (additive) composite number is helpful to see **where** service delivery is multidimensionally poor, but it cannot inform the observer as to **how** service delivery in that municipality can be improved (Ravallion, 2011). In order to observe how a municipality can improve service delivery for children, service delivery in each Domain of service provision is reported, as well as the cumulative number of services in which a municipality is failing to deliver adequate services for children[30]. This aids the policy relevance of the paper, because it allows for individual municipalities to see the precise level of services they provide in each Domain.

Table 2.3 describes service Domains and Sub-Domains in section 3, along with the cut-off criteria. In creating any poverty measure, the choice of the cut-off value, or poverty line, is necessarily chosen by the analyst. To reduce arbitrariness in this process, the cut-off values are guided by standards and norms as set out in South African policy[31] or by standards set out in international guideline documents where available[32] (Ravallion, 2011).

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[30] Households with children are defined as households with one or more child under the age of 18, as per the official StatsSA definition.

31 The South African Constitution, The Department of Health guidelines, as well as the National Development Plan are consulted for this purpose (Republic of South Africa, 1996; National Planning Commission, 2010)

32 UNICEF ECD guidelines (UNICEF, 2017), and independent literature is consulted here (Kika-Mistry and Wills, 2022; van Ravens *et al.*, 2023) .

Table 2.3: Indicators of service delivery and cut-off criteria for each Sub-Domain

Domain	Sub-Domain	Cut-off	Policy Guideline
Health	Road to health card	Less than 95% of all children have received a Road To Health booklet from the Department of Health.	(Department of Health, 2018)
	Full immunisation (all 14 doses)	Less than 90% of children at 35 months are fully vaccinated with 14 doses at 35 months.	UNICEF
	Minimum immunisation	Less than 90% of children at 35 months have received all doses of minimum required doses at 9 months.	UNICEF
	Healthcare facility access	Less than 1 clinic per 500 children under the age of 5.	Subjective
	Food insecurity	More than 20% of households with children ran out of money for food at least once in the past 30 days.	South African Constitution.
Public Services	Sanitation	Less than 80% of households with children have access to a flush toilet (connected to a municipal sewage system or a septic tank)	(National Planning Commission, 2010)
	Access to water	Less than 90% of households with children have access to water which is less than 200m from their house (WHO minimum standard).	(National Planning Commission, 2010)
	Waste removal	Less than 80% of households with children have their waste removed weekly by the municipality.	(National Planning Commission, 2010)
	Electricity supply	Less than 85% of households with children have access to electricity.	(National Planning Commission, 2010)
	Safety	Less than 80% of children live in areas where they are safe outside during the day.	Subjective
Education	Access to ELP	Less than 1 ELP per 10 children under the age of 5.	(van Ravens *et al.*, 2023)
	Quality of ELPs	75% of ELPs meet 75% of government regulations.	(Kika-Mistry and Wills, 2022)
	Access to teacher-resourced primary schools	All primary schools have an educator: learner ratio of 1:40 or less.	(Education Labour Relations Council, 2003)

Table 2.3: indicators of service delivery and cut-off criteria in the MPI.

Only where no research exists as to the acceptable levels of service provision, or no policy document sets a standard level of provision, are subjective cut-offs assigned for a service

indicator and tested for robustness. When assigning cut-offs, for the purposes of this study, the municipality is defined as poor if they *do not* meet the desired level of provision. For a detailed description of the cut-off criteria for each Sub-Domain, see Appendix 2-A. The cut-off for acceptable service delivery as set out in national South African policy and in international best-practice is maintained throughout this analysis, and is not relaxed even where it is stringent. This decision is taken in order for this analysis to illuminate how South African service delivery compares to the standards set out in South African policy.

The Sub-Domain "Quality of ELPs" relies heavily on the methodology employed by Kika-Mistry and Wills, (2022). To create an indicator of ELP quality by municipality, the 2021 ECD Audit is used. Compliance with norms and standards set out in the Children's Act (2010) is the basis of measure. The proportion of ELPs in the municipality which comply with 75% of these regulations is then computed. This level of compliance (i.e. 75%) arguably identifies ELPs that have some level of acceptable-quality programming, so that attendance at the ELP is beneficial for children (Kika-Mistry and Wills, 2022; Moses and van der Berg, 2023). A full description of how this indicator of ELP quality was constructed can also be found in Appendix 2-A.

2.5.2. Facility level environment

Following the municipal analysis, this paper goes on to relate the municipal level services to child outcomes. In order to do so, facility level services must be controlled for. The Thrive by Five Index and ECD Baseline Audit data of 2021 is used, and the level of service provision in each facility is identified. The service provision within each facility is guided by the norms and standards for ELP facilities as set out in South Africa's Children's Act (2010).

Table 2.4 shows the proportion of facilities in the dataset which provide services in each of the items listed. The data has information on 5222 children in 1251 facilities. Of these 1251 facilities, 522 ELP facilities were randomly selected to answer more detailed questions regarding compliance with the regulations for ELP facilities in South Africa. The number of facilities meeting this regulation are shown in the second column, and the number of ELP facilities with missing information is shown in the final column. The proportion of facilities meeting the regulation is calculated from the total number of facilities surveyed. The results in the table are shown in descending order, with the most provided service at the top. That is, a

fence around the facility is most common, and a practitioner-to-child ratio of 1:20 or less is least common, among the ELP facilities listed.

Once the level of services within each facility has been identified, the following regression models are estimated:

Equation 2.1:

$$outcome_{imf} = \beta_0 + \boldsymbol{\beta_1 Municipal\ Services_m} + \beta_2 \boldsymbol{Facility\ Services_f} + \beta_3 \boldsymbol{x_i} + u_{imf}$$

Key child outcomes estimated include child cognitive outcomes reflected in ELOM Scores and child stunting measures. These outcomes are measured at the individual child level but are expressed as a function of municipal level (*m*), facility level (*f*) services, and individual child characteristics (*i*). Municipal services are municipal level measures of Sub-Domain or Domain-level service provision. Facility level indicator variables measure whether or not the facility provides adequate services in each of the regulations above. The term $\boldsymbol{x_i}$ is a vector of child-level controls, including child age, child gender, the fees charged by the ELP facility and an indicator for being in a metro. Standard errors are clustered at the facility level for models which have facility level characteristics, and at the municipal level for models with municipal level characteristics, which accounts for municipal level services which are the same for children within a municipality. This model is run separately for each of the separate Domains for municipal and facility level services for children described in section 3, and finally includes all Domains in the final model. All variables used in the analysis are standardised to allow for the comparison of the coefficients β_1 and β_2 to evaluate which level of service provision for ECD is more strongly associated with child outcomes.

Table 2.4: Norms and standards in the Thrive by Five baseline survey

Regulation	Proportion of facilities Meeting Regulation	N	Missing
ECD programme has outside fence 1.8m high	94,02%	519	23
ECD programme has enough educational materials	93,84%	518	0
Staff have an ECD specialisation (certificate, diploma or degree).	92,57%	511	26
ECD programme has outside gate	90,04%	497	23
ECD programme provides meals or snacks.	88,59%	489	0
Evidence of feedback from parent/ teacher meetings	86,78%	479	23
ECD programme has enough art materials.	86,05%	475	0
ECD programme operates in a formally built structure	84,42%	466	
Food is prepared separately and away from children	82,79%	457	0
ECD programme has enough furniture	82,43%	455	23
Report cards issued to parents/ caregivers	80,07%	442	0
Immunisation records are up-to-date.	79,71%	440	0
Centre does not have dangerous obstacles that prevent children from playing.	76,63%	423	28
Evidence of a structured learning programme	76,63%	423	0
Refrigeration facilities for perishable food	73,73%	407	60
ECD programme has enough puzzles	70,47%	389	23
ECD programme has tap water on-site	69,38%	383	0
ECD programme has first aid kit with adequate supplies	63,95%	353	0
ECD programme has enough construction materials	61,78%	341	0
ECD programme has enough fantasy materials	59,78%	330	0
ECD programme has a flush toilet.	59,6%	329	
ECD programme has enough outdoor materials	59,24%	327	23
At least 1 fire extinguisher on site.	50,91%	281	0
Displayed list of contact details of emergency services	48,91%	270	0
Nearest clinic from ECD programme is less than 2km away.	44,93%	248	0
ECD programme has an accident/ injury file.	40,94%	226	0
Practitioners received first aid training.	37,86%	209	329
Centre has an evacuation plan.	30,8%	170	0
ECD programme has enough music materials	23,55%	130	23
The staff to child ratio is 1:20 or less	12,5%	69	0
Number of regulations met	21	457	95

Source: own calculations. Data: 2021 ECD Census. List of regulations taken from Kika-Mistry and Wills (2022).
* The missing values indicate how many facilities did not answer the question. The proportion of facilities meeting the regulation is calculated out of all 522 facilities (and therefore accounts for the missing values)

Table 2.4: Norms and standards in the Thrive by Five baseline survey

2.6. Results

2.6.1. Municipal service delivery for children

There are 9 South African provinces, with 8 metropolitan and 44 district municipalities. Within these metropolitan and district municipalities there are 205 local municipalities. Using the district municipality level data for each indicator, the cut-off values for acceptable service are applied. This allows the analyst to see if service provision for children falls below the minimum acceptable standard of in each Sub-Domain in an municipality. Table 2.5 shows the percentage of municipalities in which there is poor service delivery for children for each Sub-Domain. Tables 2-B1 and 2-B2 in Appendix 2-B list the municipalities with the best and worst service delivery for each Domain. These tables should be seen as critical information for the formation of policy to improve service delivery for children, and improve government structure which govern these services.

Municipal provision of full immunisation for children and access to teacher resourced primary schools is relatively low in comparison to the other indicators, with 94% and 92% of municipalities having poor service in those Sub-Domains, respectively. Only 23% of municipalities provide poor electricity supply to households with children, although the effects of the current energy crisis in South Africa on child health remain to be seen; while households may have electricity installed, the rolling black-outs, referred to as load-shedding[33], are likely to reduce the positive effects of electricity access.

With regard to food security, in almost 4 out of 5 municipalities (79%), more than 20% of households with children have run out of money for food in the last 30 days. Food insecurity is likely to have been exacerbated since 2016 when this data was collected due to COVID-19 and the lockdowns which ensued, and especially for households with children (Van der Berg, Zuze and Bridgman, 2020; van der Berg, Patel and Bridgman, 2022). In 16 out of 52 municipalities, more than 20% of children live in neighbourhoods where it is not perceived as safe enough to go outside of their homes during the day. This prevents children from having a

[33] South Africa has experienced rolling blackouts at varying degrees of severity since 2008. These blackouts have become increasingly long and frequent in 2022 and 2023 at the time of writing this paper.

safe place to play in these municipalities. The minimum and maximum proportion for each of these indicators of service delivery were 0 and 100% respectively.

The final column in Table 2.5 shows the estimated percentage of children who have access to an adequate level of service delivery, as defined by the cut-off criteria described above[34]. In some cases, national service delivery is near to the criterion for good service delivery. For example, 85% of children have minimum vaccination (target 90%), and 90% of households with children have access to electricity (target 90%). However, in many more service Sub-Domains, the national level of service delivery is below the target for service delivery set out in national policy. This illustrates the usefulness of a regionally specific measure of service delivery rather than a national measure. The regional measures of service delivery show where the provision of services which support nurturing care is lacking in South Africa, enabling for services which support ECD to be expanded where they are needed most.

Table 2.5: Municipal level results of service provision

Domain	Sub-Domain	Percentage of Municipalities that have poor service provision (do not meet cut-off)	Standard deviation	Estimated percentage of children with adequate service delivery
Health	Road to health card	52%	0,505	93%
	Full immunisation (all 14 doses)	94%	0,235	76%
	Minimum immunisation	87%	0,345	84%
	Healthcare facility access	15%	0,364	1,32[a]
	Food security	79%	0,323	73%
Public Infrastructure Services[35]	Sanitation	63%	0,480	53%
	Access to water	46%	0,505	80%
	Waste removal	71%	0,457	47%
	Electricity supply	23%	0,425	90%
	Safety	31%	0,466	81%
Education	Access to ELPs	27%	0,448	1,22[a]
	Quality of ELPs	69%	0,466	63%
	Access to Primary School	92%	0,269	2%

[a] This value is a ratio rather than a percentage, representing the number of clinics per 500 children, and the number of ELPs per 10 children.

Table 2.5: Municipal level multidimensional service delivery.

[34] This is calculated using the average of municipal service delivery, weighted by the estimated population of children in that municipality in 2020.
[35] These are public infrastructure services.

Figure 2.2 shows the overall measure of multidimensional service delivery for children per municipality in South Africa. The legend ranges from 0 to 13, where a value of 0 indicates that a municipality has poor service in zero Sub-Domains. The colour is darker where the municipality has poor service delivery in more Sub-Domains. This map is helpful to indicate where service delivery for children is poor in multiple services simultaneously, but this map is not helpful in illuminating how a municipality can improve service delivery. As such, this map should not be used as policy guidance.

The black dots represent urban centres, and the outlines of former South African homelands are included. These features are included in the map to demonstrate that service delivery in South Africa is known to be better in urban centres and worse in former homelands (David *et al.*, 2018; Schotte, Zizzamia and Leibbrandt, 2018; The World Bank, 2018). Almost 50% (24 out of 52) of municipalities have poor service delivery for children in 9 or more service delivery Sub-Domains. Five municipalities provide poor service for children in 11 of 13 Sub-Domains of service delivery.

To provide more useful information relevant to policy, Figure 2.3 goes on to show maps of service delivery in each Domain for children by municipality. A map for each Sub-Domain can be found in Appendix 2-B. These maps illustrate that service delivery for children is inadequate in many municipalities, and they provide a policy relevant view of Domain specific aspects which require improvements in the provision of multisectoral ECD service provision. Each map is useful for different government departments. For example, the Health Services Domain map is most useful for the Department of Health in South Africa.

While access to health services is highly varied, there are bottlenecks in municipalities in the North West, Mpumalanga and Gauteng provinces. Access to public services is particularly poor in many municipalities in the Eastern Cape and Kwa-Zulu Natal and is relatively good in many municipalities in the Western and Northern Cape provinces. Access to education services is relatively good in many municipalities in the Western and Northern Cape and Gauteng, but is poor or very poor in most other regions. The reasons *why* service provision varies across municipalities is outside the scope of this chapter to discuss and is explored in chapter 3 of this thesis. This chapter focuses on examining where children receive the full complement of the services they require to thrive, as set out in South African policy.

Figure 2.2: Multidimensional service delivery for children (Number of Sub-Domains (max 13) in which municipalities are not meeting cut-offs for adequate service delivery)

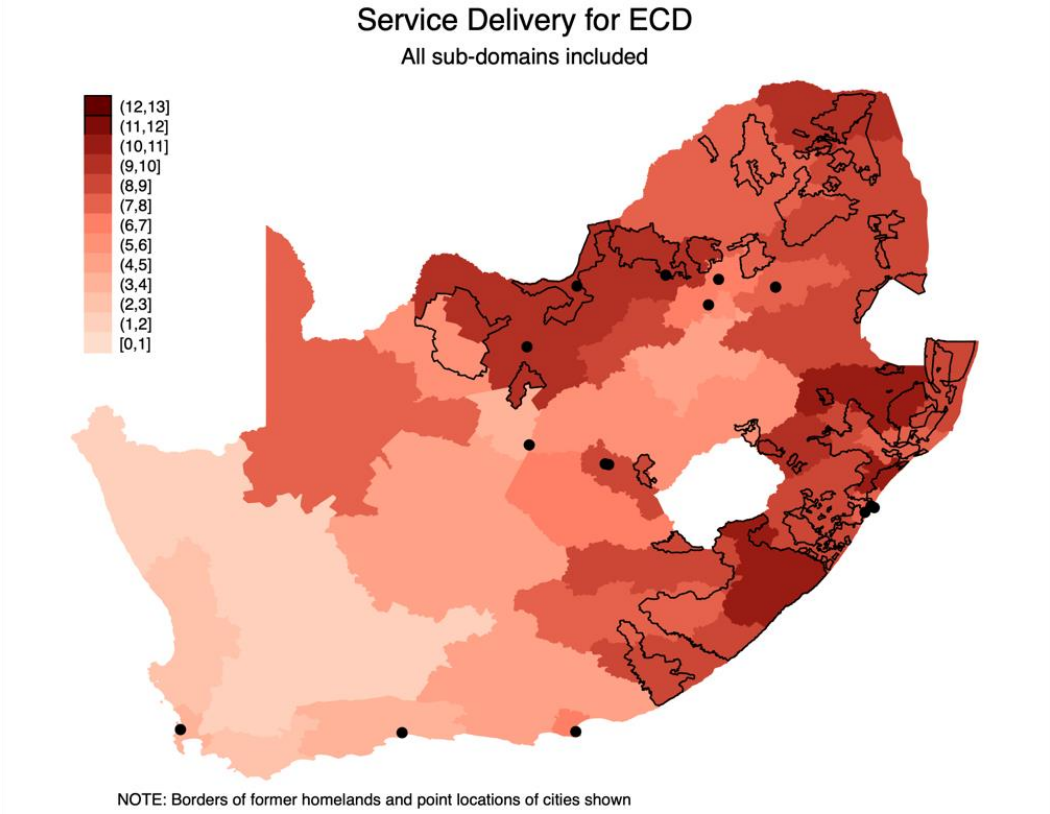

Figure 2.2: Map of municipal multidimensional service delivery for children.

Figure 2.3: Municipal level service delivery for children by Domain[36]

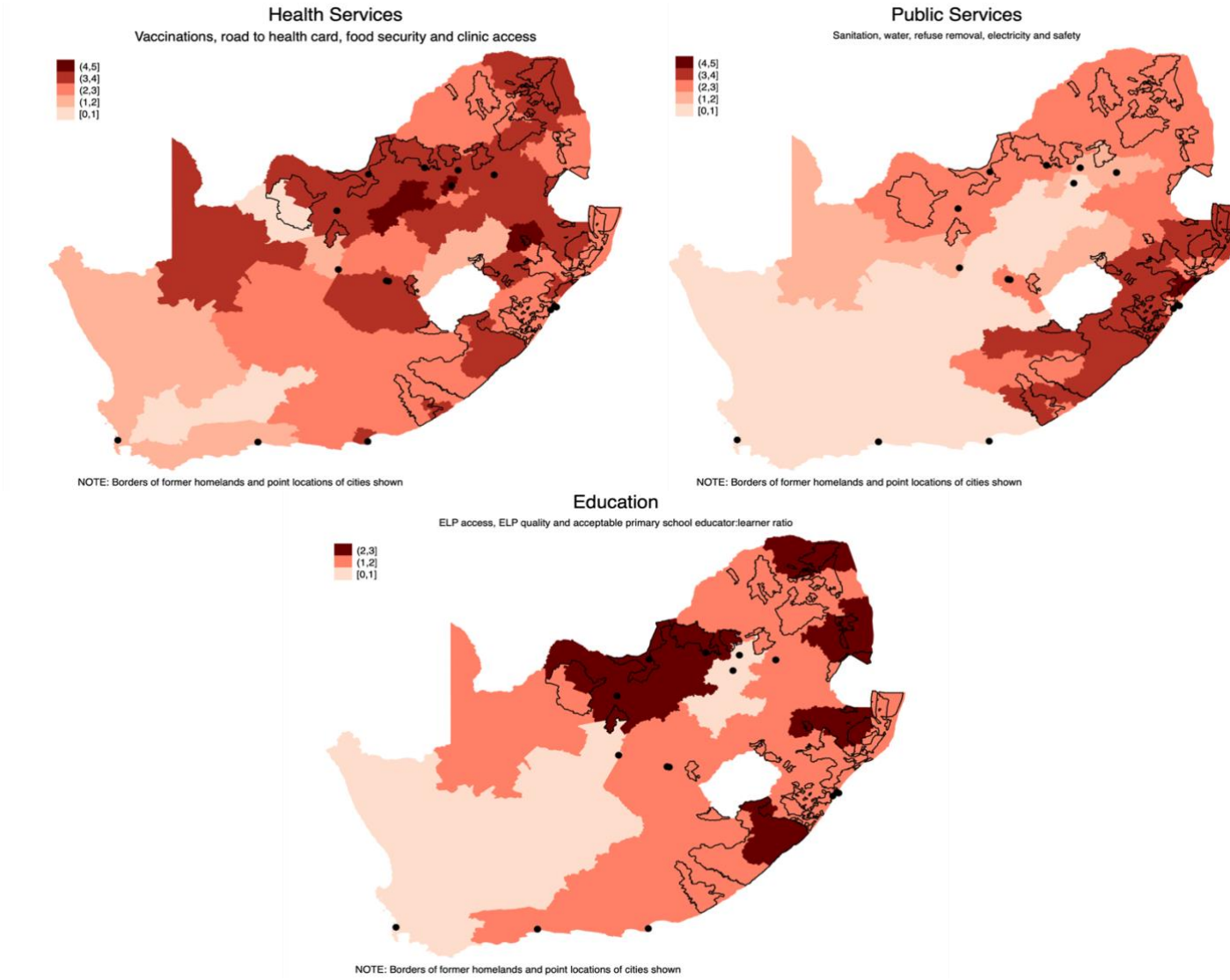

Figure 2.3: Map of service delivery in each Sub-Domain of service for children.

2.6.2. Do facility level or municipal level services matter more for children?

It is now possible to use this municipal level data together with the Thrive by Five baseline survey with child outcomes for 5225 children who attend an ELP. This enables an analysis of whether municipal level service delivery for children has more impact on child outcomes

[36] The number of Sub-Domains in the Health and Public Services Domains ranges from 1 to 5, and 1 to 3 in the Education Services Domain. Where the colour is darker, the municipality has poor service delivery in more Sub-Domains.

relative to facility level services for children who attend ELP facilities[37]. Tables 2.5 to 2.7 present the results of OLS models which use Equation 2.1, focusing on health services, public infrastructure services and Education Services, respectively. Linear ordinary least squares models were run using STATA17. The data used here is publicly available online.

Table 2.6 presents the results estimating conditional associations between health servicing and child cognitive outcomes, measured by ELOM scores. The fees charged by the facility, the child's age and gender, and whether or not the facility is in a metro area are controlled in each model. Each of these controls is significant, except for being in a metro. There is a positive and significant association between fees charged and ELOM score. This finding is consistent with high SES caregivers selecting high SES facilities which charge fees, so that the variable controls for socioeconomic home background. Alternatively, the estimate quantifies the benefit of fees used by ELPs to improve quality of care and therefore has a positive impact on cognitive development[38]. Whether this association is due to the caregiver's ability to pay fees or the fees themselves is not determined here. Children who are one month older score 0.9 ELOM points higher, which is due to the natural development of cognitive abilities as children age, as expected in the literature (Giese *et al.*, 2022; Moses and van der Berg, 2023). Girls score significantly better than boys, which is also expected in the literature (Spaull and Makaluza, 2019). The receipt of the DSD subsidy is significantly negatively associated with ELOM scores. The subsidy is targeted towards the most poorly resourced ELP facilities, so that this indicator controls partially for the negative association between facility-level SES and child outcomes.

Column 2 in Table 2.6 adds controls for facility level services. ELOM scores are significantly higher where the facility keeps records of immunisations. Keeping a record of child immunisation may be a proxy for better administrative capacity in the facility, or higher levels of attention paid to each child. It is hypothesised that rather than the immunisation records having a direct impact on child outcomes, it is likely that administrative capacity represented by record-keeping and the closer attention to children is associated with the higher ELOM

[37] It is natural to inquire how municipal level services relate to facility level services. This question is explored in Appendix 2-C.
[38] These models are not able to disentangle this reverse causality, however, this is not problematic because this is a control variable not a treatment variable. The positive association is not a causal effect.

score. This hypothesis is outside the scope of the current discussion to confirm, but is suggested for future research.

Table 2.6: Regressions of health services on ELOM score

	ELOM Score					
	Models using Health Services Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	0.8882***	0.5677*	0.6497**	0.2360	0.7032**	0.3853
	(0.3010)	(0.3410)	(0.3096)	(0.3763)	(0.2769)	(0.2863)
Child age	2.4797***	2.4660***	2.7262***	2.7358***	2.6797***	2.6783***
	(0.4197)	(0.4173)	(0.3750)	(0.3586)	(0.3807)	(0.3834)
Female	1.0213**	1.0344**	1.3547***	1.3924***	1.3633***	1.3541***
	(0.4051)	(0.4059)	(0.2611)	(0.2464)	(0.2669)	(0.2608)
Metro	0.4440	0.3994	0.3754	0.2742	1.1185	0.9933
	(0.6549)	(0.6310)	(0.7780)	(0.8221)	(0.7759)	(0.9724)
Subsidy received	-2.2922***	-2.2828***	-2.1221***	-2.2255***	-2.3086***	-2.2205***
	(0.6194)	(0.6532)	(0.5180)	(0.4933)	(0.5515)	(0.5246)
Immunisation records kept		0.9345*		1.1040**		
		(0.5291)		(0.5221)		
Clinic close to ELP		0.4900		0.2035		
		(0.6290)		(0.4762)		
Facility serves meal		-0.2585		0.1901		
		(0.7262)		(0.5974)		
Municipality food insecure			-1.8021**	-2.4521*		
			(0.7845)	(1.2592)		
Access to clinics poor			-0.6737	-1.2260		
			(0.7059)	(0.9599)		
Full vaccination poor			0.0347	-0.2110		
			(0.6201)	(0.7657)		
Minimum vaccination poor			0.0372	-0.4811		
			(1.0507)	(1.2357)		
Health services poor				1.0843	-0.6397	-0.5391
				(1.5803)	(0.8250)	(0.8744)
Public services poor						-0.9467
						(0.6232)
Education Services poor						0.5506
						(1.1949)
Constant	44.8641***	44.8240***	44.7347***	41.0938***	46.8493***	47.6386***
	(0.5886)	(0.5874)	(0.7360)	(5.1903)	(2.9392)	(3.1877)
R-squared	0.0730	0.0777	0.0952	0.1014	0.0856	0.0895
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the facility and at the municipal level for the remaining columns.

Table 2.6: Regression results for health services on ELOM score.

Municipal level services are included in column 3. The coefficient on municipal food insecurity is large, negative and significant. This finding is consistent with the hypothesis that wider municipal food insecurity – rather than facility-specific constraints – is a driver of lower ELOM

scores in disadvantaged facilities. Column 4 includes all covariates. Receipt of a subsidy and child level characteristics remain the most significant predictors of ELOM score relative to municipal level health services.

Column 5 includes the overall level of service provision in the Health Services Domain constructed using MPI methodology. The coefficient is insignificant, suggesting that municipal level health servicing that reaches households with children is not associated with higher cognitive outcomes in children attending an ELP facility in South Africa. Finally, column 6 includes variables which indicate the overall level of service provision in each Domain. Municipal service provision in the Health Services and Education Service Domains is insignificant, but municipal service provision in the Public Infrastructure Service Domain is significantly associated with ELOM score.

Table 2.7 shows the results from similar regressions, but now includes individual sub-domains of the Public Service Domain instead of the Health Services Domain. Column 4 includes controls for municipal level and facility level access to services. The coefficients on poor municipal level access to electricity and child safety has a negative and significant association with child ELOM scores. Interestingly, neither indicators of poor municipal level WASH service delivery nor facility level WASH related services are significantly associated with child ELOM scores. WASH facilities may have more impact on stunting prevalence relative to cognitive scores, which will be discussed further below (Buttenheim, 2008). Column 6 shows that the significant correlation between public infrastructure and ELOM scores is largely attributable to child safety and municipal waste removal.

Table 2.8 shows the results from similar regressions, but now includes individual sub-domains of the Education Service Domain. There are no robust and significant results here, which could be due to the nature of the data used. That is to say, the null result could be driven by the lack of variation in the Education Service Domain (most municipalities have poor service in 2 or 3 out of 3 Sub-Domains). Additionally, the cut-off criterion for poor service in the primary school teacher-to-learner ratio Sub-Domain is stringent – if only one school has more than 40 learners per teacher, the whole municipality is considered to have poor service in that Sub-Domain. This stringency is acknowledged, but retained because this is the threshold for primary school teacher-to-learner ratios as set out in South Africa's national education policy (Education Labour Relations Council, 2003).

Table 2.7: Regressions of public services on ELOM score

	ELOM Score					
	Models using Public Service Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	0.8882***	0.3984	0.1013	0.1143	0.3932	0.0766
	(0.3010)	(0.3229)	(0.2842)	(0.2792)	(0.2833)	(0.2780)
Child age	2.4797***	2.4590***	2.6419***	2.6428***	2.6951***	2.6337***
	(0.4197)	(0.4204)	(0.3539)	(0.3530)	(0.3876)	(0.3519)
Female	1.0213**	1.0179**	1.3885***	1.3886***	1.3547***	1.3903***
	(0.4051)	(0.4058)	(0.2403)	(0.2410)	(0.2632)	(0.2404)
Metro	0.4440	-0.1286	-1.2643	-1.2611	0.7809	-1.3751
	(0.6549)	(0.6635)	(0.9423)	(0.9436)	(0.8843)	(0.9267)
Subsidy received	-2.2922***	-2.3616***	-1.7771***	-1.7751***	-2.2447***	-1.7940***
	(0.6194)	(0.5941)	(0.4710)	(0.4724)	(0.5329)	(0.4790)
ELP has flush toilet		1.2106*		-0.1458		-0.1161
		(0.6375)		(0.4856)		(0.4687)
ELP has tap water		0.6801		-0.0370		-0.0188
		(0.5401)		(0.5259)		(0.5197)
Municipal sanitation poor			1.5968	1.5870		1.1536
			(1.8631)	(1.8702)		(2.3050)
Municipal tap water poor			0.3491	0.2584		-0.2722
			(1.5772)	(1.5170)		(1.5388)
Municipal electricity poor			-1.2952***	-1.3242**		-1.7842
			(0.4497)	(0.5205)		(1.0757)
Municipal waste removal poor			-2.5629*	-2.5707*		-3.0806**
			(1.2940)	(1.2966)		(1.3711)
Municipal child safety poor			-2.4392***	-2.4362***		-2.1782**
			(0.8296)	(0.8294)		(0.8410)
Public services poor					-0.8784	1.1409
					(0.7104)	(2.2964)
Constant	44.8641***	44.9214***	44.8094***	44.8056***	46.8064***	42.0978***
	(0.5886)	(0.5680)	(0.5875)	(0.5884)	(2.1640)	(5.5950)
R-squared	0.0730	0.0836	0.1201	0.1202	0.0883	0.1207
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the facility and at the municipal level for the remaining columns.

Table 2.7: Regression results for public services on ELOM score.

Table 2.8: Regressions of Education Services on ELOM scores

	ELOM Score					
	Models using Education Service Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	0.8882***	0.6115*	0.7162**	0.5484	0.6833***	0.5484
	(0.3010)	(0.3511)	(0.2982)	(0.3273)	(0.2381)	(0.3273)
Child age	2.4797***	2.4725***	2.7727***	2.7498***	2.6992***	2.7498***
	(0.4197)	(0.4171)	(0.3531)	(0.3538)	(0.3884)	(0.3538)
Female	1.0213**	1.0566***	1.3995***	1.4252***	1.3628***	1.4252***
	(0.4051)	(0.4069)	(0.2389)	(0.2398)	(0.2606)	(0.2398)
Metro	0.4440	0.2787	0.0719	0.0214	0.8505	0.0214
	(0.6549)	(0.6224)	(0.9537)	(0.9585)	(0.9923)	(0.9585)
Subsidy received	-2.2922***	-2.5209***	-2.3076***	-2.4504***	-2.3307***	-2.4504***
	(0.6194)	(0.6801)	(0.5249)	(0.4790)	(0.5559)	(0.4790)
Facility has acceptable PC ratio		-0.7683		-0.4788		-0.4788
		(0.7144)		(0.5792)		(0.5792)
Facility has educational materials		0.7139		0.5268		0.5268
		(0.4824)		(0.4016)		(0.4016)
Municipal primary school TL ratio poor			1.3986	1.3995		1.3995
			(1.0629)	(1.0506)		(1.0506)
Municipal ELP access poor			-1.1173	-1.1090		-1.1090
			(0.6960)	(0.7070)		(0.7070)
Municipal ELP quality poor			-0.9544	-0.8234		-0.8234
			(0.8558)	(0.8414)		(0.8414)
Education services poor					-0.6227	0.0000
					(1.0767)	(.)
Constant	44.8641***	44.8109***	44.7742***	44.7837***	45.9886***	44.7837***
	(0.5886)	(0.5744)	(0.7555)	(0.7613)	(2.6172)	(0.7613)
R-squared	0.0730	0.0773	0.0987	0.1011	0.0845	0.1011
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the facility and at the municipal level for the remaining columns.

Table 2.8: Regression results for education services on ELOM score.

To further investigate the null results in Table 2.8, Table 2-D1 in Appendix 2-D uses the ELOM scores for children enrolled in an ELP to investigate how compliance with regulations for ELP facilities relates to cognitive development. The child's age in months, the gender and a control for whether or not the facilities charge fees are included as controls. These controls are all

significant predictors of ELOM scores (Tredoux, Dawes and Mattes, 2022). Table 2-D1 shows that compliance with individual regulations does not significantly improve ELOM scores. The exception is that having more teaching staff who have a National Qualifications Framework (NQF) level 6 to level 9 qualification is positively and significantly associated with higher ELOM scores.

The same regressions as in tables 2.6, 2.7 and 2.8 are estimated using child stunting rates as the outcome variable. In these models, the outcome is an indicator variable that is equal to one if a child is stunted. These regressions show that full municipal vaccination is significantly negatively associated with stunting in this data. In contract to the results in table 2.7, there are significant associations between municipal level access to sanitation and stunting. Other than these findings the exercise produces insignificant results, which suggests that neither municipal level nor facility level services for children are significant in predicting stunting rates for children who attend an ELP. Importantly, the sample of children who attend ELPs in South Africa is representative of the more advantaged children in the country relative to children who do not attend an ELP. This result has important implications for the understanding of Tables 2.6 to 2.8 and will be discussed in the following section. These regression results can be seen in Appendix 2-E. Provincial aggregates of service provision, provincial fixed effects, and population density controls are explored as robustness checks in Appendix 2-E as well, and the results remain comparable.

2.7. Discussion and conclusions

Figure 2.2 and Figure 2.3 provide insight into the level of regional service delivery for children, and show that MPI methodology can successfully document the level of multidimensional service delivery for children in different regions of South Africa. This methodology can be applied in other country contexts with available data. The combination of overlapping *regional* data sources (as opposed to individual-level micro data usually required for MPI indices) and the insights from the MPI paradigm produce an index that has a low data burden but effectively maps the landscape of child-centric multiple deprivation. The potential for applying this approach in many contexts is therefore large. This data-driven approach can quantify where service delivery for children reaches an acceptable standard in multiple services at the same time, and where governments need to focus to ensure that all children receive the support they need to reach their full development potential.

In this case study, which uses South African data, these maps show that children receive adequate service provision in all Sub-Domains of service delivery in not one municipality. This implies that there are children throughout the country hindered from meeting their full potential. The reasons *why* service provision varies across municipalities is outside the scope of this chapter to discuss and is explored in chapter 3 of this thesis.

Tables 2-E1 to 2-E3 show that the level of municipal services is not significantly associated with stunting in children who attend ELPs in South Africa. Over half of 4 to 5 year olds did not attend an ELP facility in 2021, and the average monthly income for households that sent a 4 or 5 year old child to an ELP in 2021 is nearly three times more than the average monthly income for households who have 4 or 5 year old children who are not attending an ELP (StatsSA, 2021). The stunting prevalence in children who attend ELPs is half the national estimate of stunting prevalence. This implies that the households who select into ELP attendance are more advantaged; the children from these households are less likely to be stunted, and the household environment is more likely to provide support in each of the important elements that are needed for a child to reach full potential. ELPs therefore do not play a large additional role in improving long-run child nutrition outcomes, and children's stunting status would have already stabilised at their full potential by the time they enter an ELP. For this reason it appears that nutritional status is insensitive to ELP quality and local service provision, though this may not be the case in the broader population of children. More importantly, the children who are not attending ELPs are not reaping the potential benefits of cognitive stimulation in the ELP, and are likely to be more influenced by municipal services relative to children who also attend an ELP. However, the data is unable to trace these potential benefits. Improving municipal and household environments can be critical for these non-attendees.

In contrast to nutrition, Tables 2.5 to 2.7 show that municipal level public infrastructure service delivery is associated with improved *cognitive development* in children who attend ELP facilities. The sample of children analysed is representative of those who come from wealthier households in the country and are half as likely to be stunted (as mentioned above). The municipal level services – such as WASH facilities – that improve cognitive development should be seen as concurrently complementary inputs to home environments, reducing stunting

in the sample of children who attend an ELP. ELPs are able to build on the foundations laid at home to provide additional benefits which improve cognitive development[39].

Since the data on ELOM scores is representative of children who attend an ELP in South Africa, these results suggest that improved municipal environments are complimentary inputs to ELP attendance for those children who attend an ELP. This finding is consistent with the hypothesis that interventions which supplement child nutrition and the home environment have a larger positive impact than those which focus only on cognitive stimulation (Engle *et al.*, 2007; J. Heckman, 2008; Heckman *et al.*, 2009; Ruhm and Waldfogel, 2012). A meta-analysis of ECD interventions in LMICs find that the most effective interventions include health and nutrition services, are longer than one year, have three or more contact sessions with children a week, and target younger children from disadvantaged homes (Engle *et al.*, 2007; Van Der Berg, 2021). The finding is also consistent with the *dynamic* complementarity literature, which emphasises that investments in children are more effective when children have been exposed to prior investments in their well-being.

There are two major implications of the fact that the majority of South Africa children do not attend an ELP. First, the municipal level of service provision for children becomes more pertinent for these children. Children are sensitive to the environmental conditions in which they live, including both the municipal and the household environment (Aguayo and Menon, 2016; de Onis and Branca, 2016; Budge *et al.*, 2019). Children who do not attend an ELP are therefore more sensitive to adverse home environments and community conditions; because they do not attend an ELP, these children – unless they have access to improved services at home – become vulnerable to stunted cognitive and physical development. The second implication is that expanded access to high-quality ELP facilities would be beneficial for South African children. There is a substantial body of literature which discusses the necessary steps which need to be taken in South Africa in order to expand access to ELP facilities (Van Der Berg, 2021; Wills and Kika-Mistry, 2021; Kika-Mistry and Wills, 2022; Moses and van der Berg, 2023). This literature includes discussion of reducing user frees through supply-side funding, improving the quality of programs provided to disadvantaged children, providing

[39] Furthermore, ELPs which supplement the home environment as well may have an additional positive effect which is not measured here.

more ELP facilities in rural areas and improving compliance with regulations for ELP facilities to improve quality programming.

An analysis of ELP attendance in LMIC contexts found that in sub-Saharan Africa, ELP attendance for 5-6 year olds was highest in Equatorial Guinea, at 54%, and was below 10% in 15 out of 26 countries that were surveyed. In Central and Eastern Europe, attendance for 5-6 year olds ranged between 0 and 15% of children (Nonoyama-Tarumi, Loaiza and Engle, 2009). Attendance for 3-4 year olds was lower in most countries that were surveyed. More recent studies have found that ELP attendance has increased in LMICs, but is still only 21,5% in low-income countries, and 38% for lower-middle income countries (Lu *et al.*, 2020). The South African attendance rate for 4 and 5 year old children was 46% in 2018[40], which is higher than attendance in other LMIC contexts. The importance of improved municipal and home environments in countries with lower attendance rates is therefore potentially even greater relative to the South African context.

Therefore, this case study, methodology and findings are relevant for many other countries, and could be applied to assess the need for improved service delivery for children worldwide, seeking to provide all children with the environment they need to develop to their full potential. Furthermore, together with the increase of access to ELPs, greater attention should be paid to the regional services that children experience on a daily basis. Only when their home and neighbourhood environments are improved will children be able to fully benefit from ELP attendance. This methodology can also be applied to individual children where the data allows, enabling an analysis of which children are likely to receive inadequate services. This type of analysis would engender improved policy in LMIC contexts targeted for specific children who are vulnerable and more likely not to reach their full development potential relative to children who receive adequate support.

All the datasets used in this analysis were representative of the district municipality. Sampling frames ensured that different urban informal and rural environments were represented in the data. This analysis shows that there are variations of service delivery within provinces, and establishes that even within policy-responsibility-level there are differences in the implementation of policy. This implies that government structures and administration and

[40] This includes children who attend an ELP facility, but not Grade R.

institutional governance work better for some municipalities relative to others. However, there are also likely to be varying levels of policy implementation even within municipalities due to historical preconditions that affected suburbs differently. This level of higher data granularity is therefore an improvement on provincial level data, and even more granular data (at ward level, for example) may help to further research differences in policy implementation at the local level.

In conclusion, whereas the majority of research on the impact of expanding ELPs has been conducted in HICs, this paper focuses on LMICs. It is found that the need for multi-dimensional interventions to promote early childhood development is critical in LMICs due to resource constraints in the home and community environments; therefore, early childhood interventions that are not limited to educational inputs alone are more likely to be successful. The findings in this paper imply that expanding ELP attendance and concomitant improvements in home and municipal environments would be a cost effective intervention to improve childhood thriving and to support cognitive development. This in turn would contribute to improved human development, which is a critical foundation for economic development as a whole.

CHAPTER THREE

3. STRENGTHENING POLICY IMPLEMENTATION IN REGIONS WITH BARRIERS TO INFRASTRUCTURE DEVELOPMENT

3.1. Introduction

The ability of a state to uphold the rule of law, collect taxes, invest in infrastructure, and protect property rights are all elements which make up a state's capacity (Jimenez-Ayora and Ulubaşoğlu, 2015). State capacity comprises of all the elements that are important for the proper functioning of the state, including human capacity, physical infrastructure, and the ability to provide an environment which is conducive to economic growth and human development (Acemoglu, 2005; Besley, 2011). These features are critical in determining the speed at which improvements in development and effective policy implementation can take place. Geography can act as a barrier or a booster to strong state capacity formation and to economic growth (Sachs, Mellinger and Gallup, 2001; Nunn and Puga, 2012; Jimenez-Ayora and Ulubaşoğlu, 2015). These studies posit that more rugged terrain weakens the ability of the state to form a strong state capacity, and increases transaction costs, the cost of collaboration, the cost of farming and building, and the cost of providing state infrastructure.

In addition, transaction costs present a larger barrier to institutional formation, which is critical to infrastructural development, where there is rugged terrain (Jimenez-Ayora and Ulubaşoğlu, 2015). The strength of a state's capacity influences the effective functioning of both the public and the private sector since the private sector also requires strong institutional capacity to function well (Nunn and Wantchekon, 2009; N. Nunn and Puga, 2012). While "bad geography" in the form of rugged terrain is highly correlated with weaker state capacity development, technological innovation which can overcome ruggedness could enable institutions to adapt. For example, telephones no longer require landline connection, and rely on signal from towers for connectivity which is easier to supply in rugged terrain relative to landline connections (Wolff *et al.*, 2005).

Historically, there have been multiple pathways by which ruggedness has tended to hinder state capacity formation and development (Nunn and Puga, 2012; Jimenez-Ayora and Ulubaşoğlu, 2015). One such mechanism has been through increasing transaction and transport costs,

creating barriers to infrastructure development and collaboration (Collier, Kirchberger and Söderbom, 2013). Another pathway by which ruggedness may impact development is through impeded network effects; a rugged area which is surrounded by other rugged areas is likely to experience greater constraints in terms of development due to ruggedness than a rugged area bordered by flat terrain. However, there are indications that geography need no longer place the same constraints on economic development in the twenty first century, in which technology has advanced to allow the impact of ruggedness to be overcome (Wolff *et al.*, 2005; Parker, 2014; Deen-swarray, 2016).

This paper investigates regional inequalities in access to infrastructure in relation to terrain ruggedness and local state capacity. Specifically, the paper focuses on the spatial variation in access to Water, Sanitation and Hygiene (WASH) infrastructure. This focus is prompted by the importance of WASH in facilitating a healthy and pathogen-free environment in which people can live and which is also of great concern for the health of children (Dillingham and Guerrant, 2004; Fink, Günther and Hill, 2011; Headey and Palloni, 2019; Bridgman and von Fintel, 2022). The analysis of WASH infrastructure is further prompted by the technical difficulty of providing water and sanitation infrastructure, which requires a greater monetary investment and more specialised skill relative to electricity or telecommunication infrastructure (Zhou and Tol, 2005; Chee, Lansey and Chee, 2018). The concept of WASH is complex, and each component plays an important role in facilitating a health environment (Momberg *et al.*, 2021). This chapter focuses on water and sanitation, hereafter WASH infrastructure. Hygiene is the third critical feature that is not measured here due to data unavailability, and which also depends less on built infrastructure relative to water and sanitation.

WASH infrastructure serves as a useful case study for understanding the impact of state capacity for service provision more generally. In doing so, this study sheds light on some of the barriers to infrastructure development and provides new insights on how infrastructure development can be strengthened in contexts where institutional capacity is lacking. If geography presents the largest barrier, then increased investment in technology and in the building of a network of infrastructure (such as for transport, sanitation, and communications) might be more appropriate; if insufficient state capacity is the critical driving factor, then promoting the rule of law, policy coordination and institutional culture may be more important.

This paper turns to the case of South Africa to study the impact of geography, on the one hand, and the impact of local state capacity on the other hand, on the provision of WASH

infrastructure. South Africa has a few extremely mountainous regions, as well as flat plains in the interior and north of the country. This implies that ruggedness imposes a greater constraint for infrastructure development in some areas of the country relative to others. Additionally, some areas of the country were subject to decades of discriminatory policies during the Apartheid era. Most notable among these policies during the apartheid era in South Africa was the creation of homelands, or "Bantustans", which were remote from the urban centres of the day. Black South Africans were forcibly removed from "white areas" to live in these homelands. The homelands were designed as "independent states" in which the leaders were installed by the apartheid government (Lissoni and Ally, 2018).These homelands leaders were required to develop their own state apparatus, even as their authority was undermined by the South African apartheid government, for example by an inadequate resource base (Hendricks and Ntsebeza, 1999), limiting the development of these regions.

In many of these homelands, the legacies of those policies have endured to the present, preventing these areas from developing a strong state apparatus – at least to the extent that they are likely to have developed in the absence of this disadvantage (von Fintel, 2018). For this reason, homeland boundaries are used to proxy for weaker local state capacity within former homeland regions in a quasi-experimental difference-in-difference approach. This approach does not, however, account for potential changes in local state capacity that may have occurred when the former homelands were re-integrated into the South African state, and its national and provincial governments after democracy. Given that South Africa has these characteristics, it presents a useful case to examine the effect of terrain ruggedness relative to the effect of exogenously determined levels of infrastructure development and state capacity for public service provision.

This research draws upon two original datasets, developed to examine the impact of geography and that of local state capacity on (1) water supply and (2) household access to WASH infrastructure across the electoral wards of South Africa[41]. The analysis of these datasets considered the changes in (1) the network of dams constructed in South Africa from 1950 to 2015, and (2) the provision of tap water and sanitation in households from 1996 to 2011. Both

[41] Although electoral wards did not exist in the homelands during the time period under study, the spatial nature of the data allows for the electoral wards which were made in 1994 in the former homelands to be treated as "former homelands" as opposed to non-homelands, allowing the effects of the homeland policies in these wards to be illuminated.

analyses examine the impact of policy changes on the provision of WASH infrastructure, and how the treatment effect differs in areas with rugged terrain, and in areas with exogenously determined levels of infrastructure development.

First, this analysis shows that access to WASH infrastructure is lower in rugged places and is also lower in the former homelands relative to non-homeland areas. Second, the analysis shows that households in the former homelands continued to experience a substantial disadvantage regarding WASH access between 1994 and 2011 in general, regardless of ruggedness. However, certain former homelands saw a faster increase in access to WASH infrastructure relative to other former homeland regions, even though they are rugged areas. This result suggests that institutional barriers are relatively more critical than geographic barriers to improved infrastructure access. The policy implications of this finding are discussed below.

In short, both ruggedness and the legacies of homeland policies hinder the effective implementation of policy; however, where local state capacity is enhanced, the improved capacity can be used to leverage new technology to overcome both historical institutional barriers and the barrier of bad geography. Improving service delivery in this regard is especially pertinent, given the current state of "uncoordinated and fragmented" sanitation policy (Department of Water and Sanitation, 2016), and the poor to critical state of many South African sanitation systems (WISA, 2022).

To place this analysis in context, the following section provides a short review of the literature on the respective roles of geography and state capacity in economic development. Section three goes on to give an overview of the landscape regarding water and sanitation policy in South Africa from 1912 until the present. This section is key in understanding how WASH policy was targeted in South Africa, giving context to the role of state capacity in South African water provision. The paper goes on to describe two new datasets which have been constructed for this analysis in section four. Section five details the methodology. The results of the two-part analysis are provided in section six. Finally, section seven discusses these results and their implications for policy, and section eight concludes.

3.2. Context from the literature

3.2.1. Geography vs state capacity and institutions

Rugged terrain increases the cost of collaboration between neighbours because it increases transport and transaction costs, and is therefore strongly correlated with lower state capacity and weaker institutions (Jimenez-Ayora and Ulubaşoğlu, 2015). North (1990) asserts the primary importance of institutions - or "the rules of the game" – in explaining economic growth and welfare. In the presence of imperfect, costly information and bounded rationality, better institutions are those which decrease transaction costs between actors. Therefore, terrain ruggedness can hinder state capacity via the initial institutional formation, and institutions may continue to be weaker due to path-dependence. This is confirmed by Jimenez-Ayora and Ulubaşoğlu, (2015) who find that where rugged terrain has historically increased communication and transport costs, there are less well developed informal institutions, neighbourly collaboration, and trust. Additionally, state capacity to uphold the rule of law, collect taxes, invest in infrastructure, and form a strong state apparatus is lower in more rugged places. These findings imply that technology which can decrease barriers to communication and decrease transaction costs could allow institutions to adapt and increase state capacity in areas where ruggedness was previously a barrier.

Robinson and Acemoglu (2012) propose that differences in the formulation of economic and political institutions which favour economic growth, protect property rights, and enable cooperation explain the prosperity of some nations and the poverty of others. A complimentary explanation is proposed by Engermann and Sokoloff, (2003), who propose that the most important feature of good institutions is the ability for them to change as needed to become "well adapted for economic performance in their specific settings", where those adaptations are the element which enabled improvements in overall welfare over time.

This paper enters this debate to study the separate effects of local state capacity and that of terrain ruggedness on the development of a network of infrastructure. Specifically, this paper investigates which feature is more crucial in determining access to Water, Hygiene and Sanitation (WASH) infrastructure.

3.2.2. Spatial inequality in South Africa

The analysis uses the case of South Africa, which has marked spatial variation in access to WASH infrastructure, as well as differing levels of ruggedness. Additionally, decades of discriminatory legislation, which prioritised the development of some regions at the expense of others and has had a lasting legacy, contributes to the persistence of high levels of spatial inequality and local differences in state capacity. Most notable among these policies was the creation of homelands, or "Bantustans", during the apartheid era in South Africa. Black South Africans were forcibly removed from "white areas" to live in these homelands. The homelands were designed as "independent states" in which the leaders were installed by the apartheid government (Lissoni and Ally, 2018).These homelands leaders were required to develop their own state apparatus, even as their authority was undermined by the South African apartheid government, for example by an inadequate resource base (Hendricks and Ntsebeza, 1999), limiting the development of these regions.

In many of these homelands, the legacies of those policies have endured to the present, preventing these areas from developing a strong state apparatus – at least to the extent that they are likely to have developed in the absence of this disadvantage (von Fintel, 2018). These areas are still currently some of the least developed regions in terms of industry, and they have a small labour market and continue to have the highest levels of poverty in the country (Noble and Wright, 2013). David et al., (2018) conduct a municipal level analysis of poverty and inequality in South Africa and find that areas which fell into the former homelands continue to exhibit the highest levels of poverty in the country. Children who live in regions which fall into the former homelands also continue to experience poorer health outcomes (Bridgman and von Fintel, 2022). The historical fact of the homeland policies led to a lower level of infrastructure development and local state capacity in the former homelands relative to non-homeland areas. The former homeland areas have lower levels of infrastructure development to this day, and pit latrines are still a common type of toilet used. This has led to devastating child deaths if they fall into the latrine (BBC News, 2018; Aljazeera, 2023; McCain, 2023).

The discriminatory policies which have contributed towards lower levels of infrastructure and local state capacity in former homeland regions are exogenous to the geography of the areas themselves. Municipalities which fall within former homelands continue to have lower state capacity in the form of service delivery and the ability to recover service delivery costs than

other areas of the country (McDonald and Pape, 2002; Reddy, 2016). Overcoming these spatial inequalities in development, and especially access to services, is central to the post-apartheid policy agenda in South Africa (Republic of South Africa, 1994; National Planning Commission, 2010). However, while the areas which fall within the boundaries of the former homelands have certainly been influenced by institutions, these areas also have comparatively rugged terrain. Therefore, in redressing the lack of institutional development, it is necessary to consider the role of past inequalities in development and the role of terrain ruggedness, and the impact of both on present institutional capacity for the provision of services in the former homelands.

This research enters a larger debate which looks at the context-specific drivers of access to infrastructure in South Africa and sheds light on barriers to improved policymaking. If geography presents the biggest hurdle to institutional capacity, then increased investment in sanitation technology and building a network of infrastructure might be more appropriate. On the other hand, promoting the rule of law and appropriate institutional culture may be more important if institutional path-dependence exerts the largest influence. Given the importance of access to public services, as discussed in Bridgman and von Fintel (2022) and in chapter 2 above, it is important to consider the question of providing access to sanitation specifically when looking at spatial inequality in health outcomes as a measure of welfare.

3.2.3. Water and Sanitation policy and provision

A review of the history of the policies regarding water and sanitation enable a quantitative analysis to determine how different policy interventions have affected infrastructure development, uncovering how rugged terrain and local state capacity impact the implementation of these policies. In 1948 the Nationalist Party came into power, and gradually introduced discriminatory policies which became known as Apartheid, including the creation of “black homelands” in 1951. This political shift in had implications for the governance of water and sanitation in the form of the Water Act of 1956. This 1956 Act harmonized water and sanitation policy, and targeted economically important sectors including mining, agriculture, and industry (Perret, 2002). The 1956 Act focused on the provision of small-scale irrigation systems and infrastructure in areas which were designated for white-owned farms and industry, and neglected areas which were demarcated as homelands (Perret, 2002; Bodurtha Qua-Enoo et al., 2006).

In November 1994, the Reconstruction and Development Plan (RDP) changed the face of national policy. This new democratic government made commitments to address poverty and inequality on all levels, including equitable access to housing, water, and sanitation (Republic of South Africa, 1994). The Water Management Act of 1998 declared water to be a national asset which should be maintained and distributed to all citizens (Movik, 2011). The Act shifted the focus of South African water policy from the creation and development of water supply infrastructure to an expansion of the existing system, focusing on the supply of water to previously excluded households. This is partially due to the fact that much of the infrastructure and water storage that had been completed did not include the former homelands, and due to the reprioritisation of government spending. The 1998 Act aimed to generate the financing for the expansion of the network through service cost recovery from existing water users; however, it should be noted, the financial viability of the sector continues to be under strain due to funding gaps and poor cost recovery (Department of Water Affairs, 2022).

Both the 1956 and 1998 shifts in national policy can be viewed as treatment effects that impacted the financial and practical local state capacity for managing and supplying water resources. When new policy priorities are determined by the national government, the implementation of these policies necessitates increased attention to the new policy agenda, as well as the ability to finance it, at the local government level. In this way, national policy changes which impact water and sanitation can be viewed as an indirect stimulus to local state capacity to supply water and sanitation in a local municipality. A more complete discussion of the history of water and sanitation policy can be found in Appendix 3-A.

The changes in sanitation technology have also affected the cost of WASH provision, which changes the potential for its effective provision. Sanitation which does not require networks of sewage systems are more viable in rugged landscapes. For example, double seal water pit toilets have been effective in providing increased WASH access to remote and highly rugged villages in Nepal (Chand and White, 2015). Multiple other low-cost toilets which do not require water or electricity are being developed, which would be viable in rugged areas (Parker, 2014; Chand and White, 2015; Andersson, Otoo and Nolasco, 2018). There is also an important shift in the development of sanitation technologies towards waste treatment for reuse instead of waste treatment for disposal (Andersson, Otoo and Nolasco, 2018). These advances stand to provide positive externalities arising from WASH access for rural farming communities, such

as the ability to use treated urine as fertilizer (Andersson, Otoo and Nolasco, 2018; van Welie, Truffer and Yap, 2019).

3.3. Construction of datasets on water supply and demand

3.3.1. Data on the progression of dam construction

The first dataset used for this research was built to assess the progression of dam construction in South Africa between 1950 and 2015. The primary source of data is a list of dams in South Africa which have been registered with the Department of Water Affairs (DWA). This is freely available and can be downloaded from the DWA website. This data has information on the name, longitude, latitude, and various technical information about all state-built dams including the net service capacity in cubic litres and the date of construction. The registration date is recorded as well as the date of any major maintenance on the dam.

Using the latitude and longitude coordinates for each dam, the 2011 electoral ward of each dam was identified. There are registered dams in 1002 electoral wards, which represents 23% of all wards. A variable was then constructed which counts the number of dams built in each year in each ward. Following this, 5-year intervals were created, and the number of dams built in each ward in each 5-year period was captured, with pre-1950 as the base period and 2015 as the end date. A panel was then constructed. This panel is a repeated cross-section of all electoral wards, with the 5-year time periods as the temporal unit. The average terrain ruggedness of each ward was merged into this dataset, as well as a dummy variable which is equal to one for wards which fall within the boundaries of the former homelands.

The ruggedness variable is taken from the replication data for the paper by (N and Puga, 2012), which was published as a publicly available resource in 2012. Nunn and Puga (2012), provides terrain ruggedness data on a 30-arc second grid across the surface of the earth. This data is created to provide sensitive estimates of the average slope as well as the changes in slope for each 30-arc second grid square. This translates into grid squares of 800 East/West metres by 900 North/South meters in South Africa. The average terrain ruggedness for each electoral ward is then estimated by aggregating the ruggedness calculated in each 30-arc second grid square across electoral wards in South Africa. The dummy variable for homelands was created by taking the shapefile for the Apartheid homeland boundaries and overlaying the shapefile for

2011 electoral wards. Every ward which falls within the homeland boundaries is then given a value of one, and all other wards are coded as zero.

Lastly, transcribed data from the 1911 South African census was included. This data is captured at the 1911 municipal level and includes information on the total number of dams recorded in the municipality. This variable is taken as a proxy for the historical institutional capacity for supplying water. To control for 1911 data on 2011 ward boundaries, aerial weighting was used to estimate the number of 1911 dams on 2011 boundaries. This method assumes that dams in 1911 were evenly distributed over space within a 1911 district (Jega, Comber and Tate, 2017). Due to the aerial weighting, all models which use the 1911 data must cluster standard errors at the 1911 administrative boundaries. As stated above, the data taken from the Department of Water Affairs (DWA) website has information on the year in which each dam was constructed. This data has a non-trivial number of missing entries, which is analysed in Appendix 3-B; the entries are found to be missing at random.

Figure 3.1 shows the progression of dam construction in South Africa from 1950 to 2015. The background of the maps shows terrain ruggedness, where darker red wards are more rugged, and the former homelands are outlined in black. The blue dots show the location of each dam which was built within the 5-year period under observation. Table 3.1 presents the number of dams built in each 5-year interval. There was a noticeable increase in dam construction between 1960 and 1990, and the construction of new dams slowed between 1995 and 2015. Notably, few dams can be observed in the areas within the homeland boundaries. For the purpose of the analysis, the cumulative count of all dams built over time within a ward between 1950 and 2015 is used.

Figure 3.1: Dam construction in South Africa, 1950 to 2015[42]

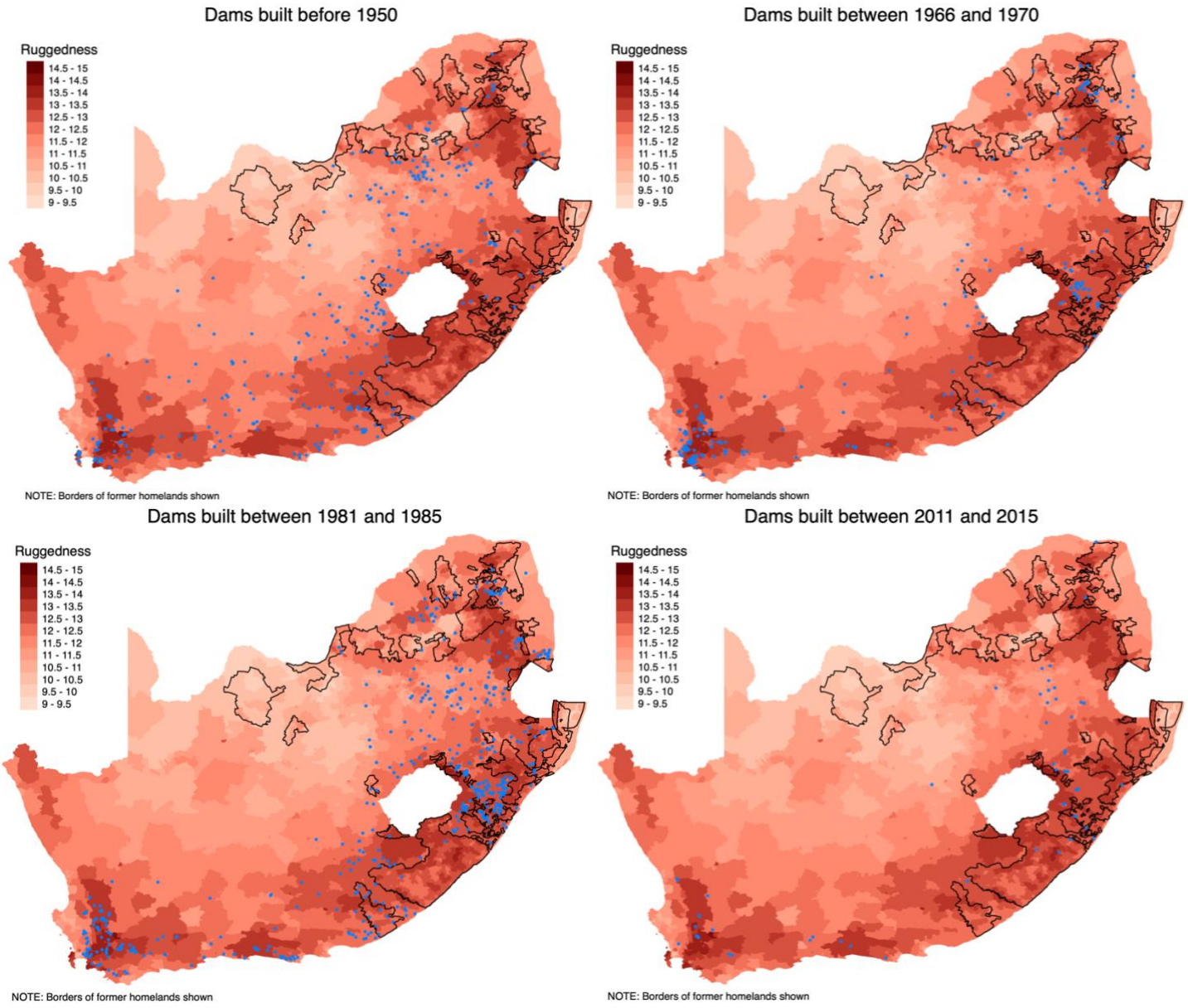

Figure 3.1 Placement of dams in South Africa.

[42] These 4 intervals were chosen to display the change in dam placement in South Africa between 1950 and 2015. Figures for each 5-year interval are available on request.

Table 3.1: Dam construction in 5-year intervals in South Africa, 1950 to 2015

5 Year Interval	*Number of Dams Built*
1950 - 1955	143
1956 - 1960	242
1961 - 1965	239
1966 - 1970	419
1971 - 1975	383
1976 - 1980	344
1981 - 1985	681
1986 - 1990	614
1991 - 1995	393
1996 - 2000	340
2001 - 2005	157
2006 - 2010	74
2011 - 2015	68

Table 3.1: Dam construction in 5-year intervals in South Africa, 1950 to 2015.

Source: own data.

There are 3 274 wards in which no dams were built between 1950 and 2015. This feature of the data is explored in Appendix 3-B, and is the reason why a Zero Inflated Poisson (ZIP) regression is estimated. This is described further in section 3.4.

3.3.2. Data on household demand for water from 1996 to 2011

The second dataset has been compiled from multiple publicly available sources to investigate household access to WASH infrastructure over time. Electoral wards are the unit of observation, where data from other sources is aggregated to create a spatial panel dataset at the level of the electoral ward. The primary sources of data are the South African censuses of 1996, 2001 and 2011, all harmonised to 2011 electoral ward boundaries. This data is available for public download on the StatsSA SuperCross website (StatsSA, 2011c). Multiple variables were drawn from this source including the proportion of formal, informal, and traditional housing in each ward; the total population of individuals; and the total number of households, as well as other municipal services such as the frequency of refuse removal.

Important outcome variables taken from this source include the level of access to sanitation and tap water in each ward. With regard to the level of access, the questionnaire for each of the South African censuses asks if the household has a flush or chemical toilet, pit latrine, bucket

toilet or no toilet access. These questions are directly comparable across the three census years. Households were also asked regarding their access to tap water with options to choose "Piped (tap) water inside" or "Piped (tap) water in the yard" as two of seven given options in 1966 and 2001, and two of five given options in 2011 (StatsSA, 1996, 2001, 2011b). The analysis which follows this section uses these questions to derive the proportion of households with access to tap water and sanitation. The proportion of household with piped tap water inside the house or in the yard were used as the proportion of households with access to tap water. Correspondingly, the proportion of households with access to flush or chemical toilets inside or on the property were coded as having access to sanitation. These variables are expressed in proportion to all the households in the electoral ward.

These primary outcome variables were analysed to verify that the harmonization of the 1996, 2001 and 2011 census data was valid. During this process, concerns were raised regarding the data on access to tap water, where the proportion of households with access to tap water inside the house declines in 2001, and then increases dramatically in 2011. Upon investigation of the different census questionnaires, it was found that the order of answer options was different in 2001, where the "Piped (tap) water inside" option was given last in 2001 but listed first in 1996 and 2011. This raises the concern that people may have answered this question differently in 2001 based on the order of answer options. For this reason, the 2001 variable for tap water access is not used in the analysis below, and comparisons are drawn for access to tap water between 1996 and 2011. The other variables which were checked for valid harmonization were the total population, the access to sanitation and the variables regarding the type of housing. These variables displayed the expected distributions and plausible changes over time.

As in the first dataset described above, a variable for the ruggedness of each ward is included, which provides sensitive estimates of the average slope as well as the changes in slope in each ward. Higher values for this variable indicate a greater level of ruggedness. A dummy variable which records which wards fall within the boundaries of the former homelands is also included. Additionally, a dummy variable for rugged wards is included. This is guided by the relationships between ruggedness and the variables shown in figures 3-C1 and 3-C2 in Appendix 3-C. Lastly, following the method of von Fintel and Fourie (2019), the final dataset on household access to WASH infrastructure drops the Northern Cape and the Western Cape provinces from the sample. This is due to the lack of former homelands in these provinces.

Table 3.2 reports the summary statistics for the harmonised census data which has been described.

Table 3.2: Summary statistics of harmonised census data

Variable	N	Mean in Non-homelands	Mean in Homelands	Std. Dev.	Min	Max
			1996			
Proportional tap inside	3 695	52,6%	14,8%	0,33	0	1
Proportion flush/chemical toilet	3 695	63,5%	13,2%	0,39	0	1
Proportion formal housing	3 695	66,1%	49,6%	0,3	0	1
Proportion traditional housing	3 695	7,4%	41,7%	0,31	0	1
Population density#	3 695	2872,4	547,1	36110,53	0	789950,5
			2001			
Proportional tap inside	3 695	37,5%	8,8%	0,027	0	1
Proportion flush/chemical toilet	3 695	68,5%	18,0%	0,37	0	1
Proportion formal housing	3 695	72,4%	57,6%	0,28	0	1
Proportion traditional housing	3 695	6,7%	34,9%	0,28	0	0,97
Population density#	3 695	31390,1	6060,2	39530,16	0,73	920310,8
			2011			
Proportional tap inside	3 695	54,6%	16,2%	0,31	0	0,99
Proportion flush/chemical toilet	3 695	79,8%	22,1%	0,39	0	1
Proportion formal housing	3 695	81,4%	69,8%	0,24	0	0,99
Proportion traditional housing	3 695	3%	24%	0,24	0	0,98
Population density#	3 695	3432,8	636,7	40390,15	0,67	1019250,2
			Time invariant			
Mean proportion formal housing	3 695	74%	59%	0,25	0,01	0,99
Log ruggedness	3 695	11,59	12,15	20,109728	-0,29	110,41

Population density measures people per square kilometre. Source: own data.

Table 3.2. Summary statistics of harmonised census data, 1996 - 2011.

This table shows that, on average, the level of access to infrastructure in former homelands was significantly lower in 1996 relative to non-homeland wards. On average, former homeland wards are more rugged than non-homeland wards, indicated by the fact that the log ruggedness was 11,59 in non-homelands and 12,15 in former homeland wards. Water infrastructure is

different to other service infrastructure, such as electricity infrastructure, largely for technical reasons. The cost of transporting water is greater than the cost of transporting electricity, especially if there is a change in elevation. A 100m vertical lift of water is comparable in cost to transporting the same amount of water 100km horizontally (Zhou and Tol, 2005). The cost of setting up water transportation is also more expensive, especially the subterranean transportation of water that is usually preferred (Chee, Lansey and Chee, 2018), and especially where there is rugged terrain which requires transporting water over undulating or steep surfaces. The greater level of ruggedness in the former homelands therefore poses a greater technical challenge relative to less rugged wards.

Data from the first census of the Union of South Africa in 1911 was also transcribed and added to the data. As with the dam data from 1950 to 2011, information from the 1911 census is drawn into this dataset to control for historical conditions[43]. This data is included in the analysis to serve as proxy for the historical administrative capacity to supply WASH infrastructure in each ward.

3.4. Methodology

This section describes the methodologies which have been used to analyse the datasets described above. There are two distinct parts to this analysis which both investigate the mitigating effect of ruggedness and state capacity on WASH infrastructure access. In both analyses, a difference-in-difference approach is used to estimate the differential treatment effect of policy changes in rugged and homeland areas.

3.4.1. Methodology 1: Analysis of historical dam construction in South Africa

The dataset on Dams of South Africa (DSA) is designed to uncover the impact of ruggedness and homeland boundaries on dam construction over the period when the backbone of water supply infrastructure was developed in South Africa. This analysis does so by evaluating the effect of the coordinated WASH policy in the Water Act of 1956 – which targeted dam

[43] The 1911 census records the number of dams, as well as the number and yield of wells for each magisterial district in 1911, which covers the full territory of modern-day South Africa. Once this data for each magisterial district was transcribed, aerial weighting was used to estimate the number of 1911 dams within 2011 ward boundaries The number of wells in each ward is then multiplied by the yield of the well to obtain the average yield of all wells in litres in each ward.

construction in certain areas to boost agriculture, industry, and mining, and did not prioritise the homelands in the placement of dams. Thereafter, the analysis assesses whether the construction of dams halted after the Water Act of 1998 changed the focus of WASH policy. Both the 1956 and the 1998 Acts are viewed as treatment effects, where the empirical analysis assesses whether the placement and number of dams constructed is influenced by the first policy change, and whether access to WASH infrastructure was influenced by the second policy change.

The primary outcome variable of interest in the DSA data is the cumulative count of dams built within each ward up to a specific 5-year interval. This variable measures the capacity to provide access to water in households. This analysis therefore investigates water infrastructure, which is only one factor within the composite concept WASH. Water infrastructure provides the quality and quantity of water to enables the provision of sanitation infrastructure and better hygiene practices (Huttinger *et al.*, 2017). However, the outcome variable measured here is not able to take the quality of water into account due to data availability. It is therefore assumed that where dams are built closer to households, the quality of water will improve.

Due to the nature of count variables, a Zero Inflated Poisson (ZIP) regression is estimated[44]. The first step in estimation, which models the structural zeros, uses a control for metro areas, and the spatial lag of the number of dams in neighbouring wards for each 5-year period. These two variables explain why there may be no dams built in some wards if they are densely populated or are in the proximity of a ward with multiple dams. This spatial lag was created using a row normalised queen matrix, taking second-order neighbours into account (LeSage, 1999; StataCorp, 2017). The second step in estimation controls for ruggedness and homeland areas, both with time interactions, to show the difference in the implementation of policy in rugged and/or homeland areas. The final estimation also controls for metro areas and the number of dams in 1911. The control for dams in 1911 is taken as a proxy for the historical institutional capacity for water supply in an area. The control for metros is added to explain why fewer dams are built in some wards, given the higher density of buildings, people, and business.

[44] Poisson regressions are used to model a dependent variable which counts the number of occurrences of an event, and where there are many zero values in the data which are meaningful (Yuan, 2005). Due to the overdispersion of meaningful zeros, a Zero Inflated Poisson regression model is estimated.

3.4.2. Methodology 2: Analysis of WASH infrastructure access in South Africa

The second dataset has been constructed to investigate household access to WASH infrastructure in electoral wards in South Africa. A difference-in-difference style approach is used to estimate the effect of ruggedness and homeland boundaries over time on different outcome variables, including access to sanitation and access to tap water inside the household. The treatment effect under inspection is that of the Water Act of 1998, which focused on providing WASH services to previously un-serviced households. The increase in access is viewed over time, with the 1996 census data serving as the base year. The treatment effect of the 1998 Act is then analysed in the 2001 and 2011 data, comparing the treatment effect across rugged and homeland regions relative to non-rugged, non-homeland regions. In this way, the effect of ruggedness and local state capacity in the homelands can be estimated. This model is given by equation 3.1 below.

Equation 3.1:

$$WASH_w = \beta_0 + \beta_1 HL_w \times Year_t + \beta_2 Rugged_w \times Year_t + \boldsymbol{\delta_1 X} + e_w$$

The dependent variable $WASH_w$ is either (1) access to flush or chemical toilets[45], or (2) access to tap water inside. Both variables are proportions, recording the proportion of households within each ward with access to toilets and taps, respectively. Other forms of absolute improvement in access to WASH infrastructure, such as communal standpipes, are not considered here due to data limitations. The homeland dummy (HL_w) is equal to one for wards which fall in a former homeland, and the $Rugged_w$ variable is equal to one for wards with high levels of ruggedness, as mentioned in the data section above. These two variables are interacted with each year variable as a treatment effect to uncover the progression of WASH access over time in rugged vs. non rugged and homeland vs. non-homeland areas after the 1998 Water Act came into effect. This analysis aims to assess whether ruggedness or homeland boundaries reduce the treatment effect of the 1998 Act. The time periods are 1996, 2001 and 2011 – corresponding with the census years.

[45] These toilet types could not be separated in the source data.

The vector of controls, represented by $\boldsymbol{X}$, includes 5 variables. First, the proportion of formal housing in a ward is added as a control for access to WASH infrastructure because this is an important mechanism through which WASH infrastructure is expanded. Metro areas are controlled for, as well as population density. Because the homeland and ruggedness dummy variables do not change over time, fixed effects cannot be used in this regression. In these types of situations, Wooldridge (2019; 2021) argues that including a Mundlak control approximates fixed effects for variables which do change over time. The Mundlak device takes the average of time-varying covariates and includes this average in the regression as separate controls. The time varying covariate therefore represents the variation from the mean, approximating a panel regression with fixed effects. The Mundlak device for the proportion of formal housing and that for population density is included in the final specification of this model as the final two control variables.

Given the nature of taps and toilets, this model includes a control for formal housing, which acts as a mechanism for supplying WASH infrastructure. A secondary analysis which investigates the influence of ward characteristics on the proportion of households which are formal is included in Appendix 3-D. This secondary analysis is included due to the importance of the mechanism of formal housing in the supply of WASH infrastructure, and because it relates to changes in state capacity (specifically with relation to the RDP). Ruggedness and homeland boundaries are likely to impact this infrastructure as well.

3.5. Results

3.5.1. The impact of terrain ruggedness and local capacity on the construction of dams

Figure 3.2 shows the results of the ZIP regression described above. The first coefficient shows the association between the estimated number of dams in the ward and the total number of dams built in that ward between 1950 and 2015. There is no significant association, which suggests that there is not necessarily historical persistence in dam construction, and that geographic determinism can be discounted. The second coefficient shows that there are

significantly fewer dams built in metro wards[46] between 1950 and 2015 relative to non-metro wards. This finding is likely because dams are often built on the outskirts of metros to supply more densely populated wards.

The progression of dam construction is analysed using time interactions to show the treatment effect of the 1956 Act in different areas which are designated by institutional boundaries and ruggedness. The solid blue line shows the time after which the 1956 Act influenced water policy. The red dotted line shows the treatment effect of the 1998 Act. The reference for all time interaction terms is the number of dams in non-rugged, non-homeland wards in 1955. The time interactions therefore show the statistical differences between reference wards and the time/area combination shown on the x-axis label. The coefficients which show the progression of dams built in non-rugged, non-homeland areas for each 5-year period show a rapid increase in the number of dams built between 1985 and 2000 in comparison to these wards in 1955, and a halt in new dam construction after 2000. These coefficients are statistically significant at the 99% confidence interval. These coefficients show that the treatment effect of the Water Act of 1956 was large in these wards, albeit after an implementation lag.

The dummy for homeland wards shows that there is a large and significant penalty associated with these areas in the base period. The time interactions indicate that, alongside the considerable penalty in terms of the number of dams in these wards, there was a modest increase in the number of dams built in comparison to the base period; however, many of the time interactions are statistically insignificant. The initial homelands disadvantage did not reduce significantly over time. This shows that regions which fell inside the homeland boundaries, which were not necessarily targeted by the 1956 Act, did not receive the treatment effect of the 1996 Act. In short, the homeland areas did not receive any increase in national support to increase the local capacity for water supply infrastructure to be built.

[46] Metropolitan municipalities include Buffalo City, City of Cape Town, City of Ekurhuleni, City of Johannesburg, City of Tshwane, Mangaung, Nelson Mandela Bay, and eThekwini.

Figure 3.3: Coefficients of Poisson regression on the number of dams in built in wards

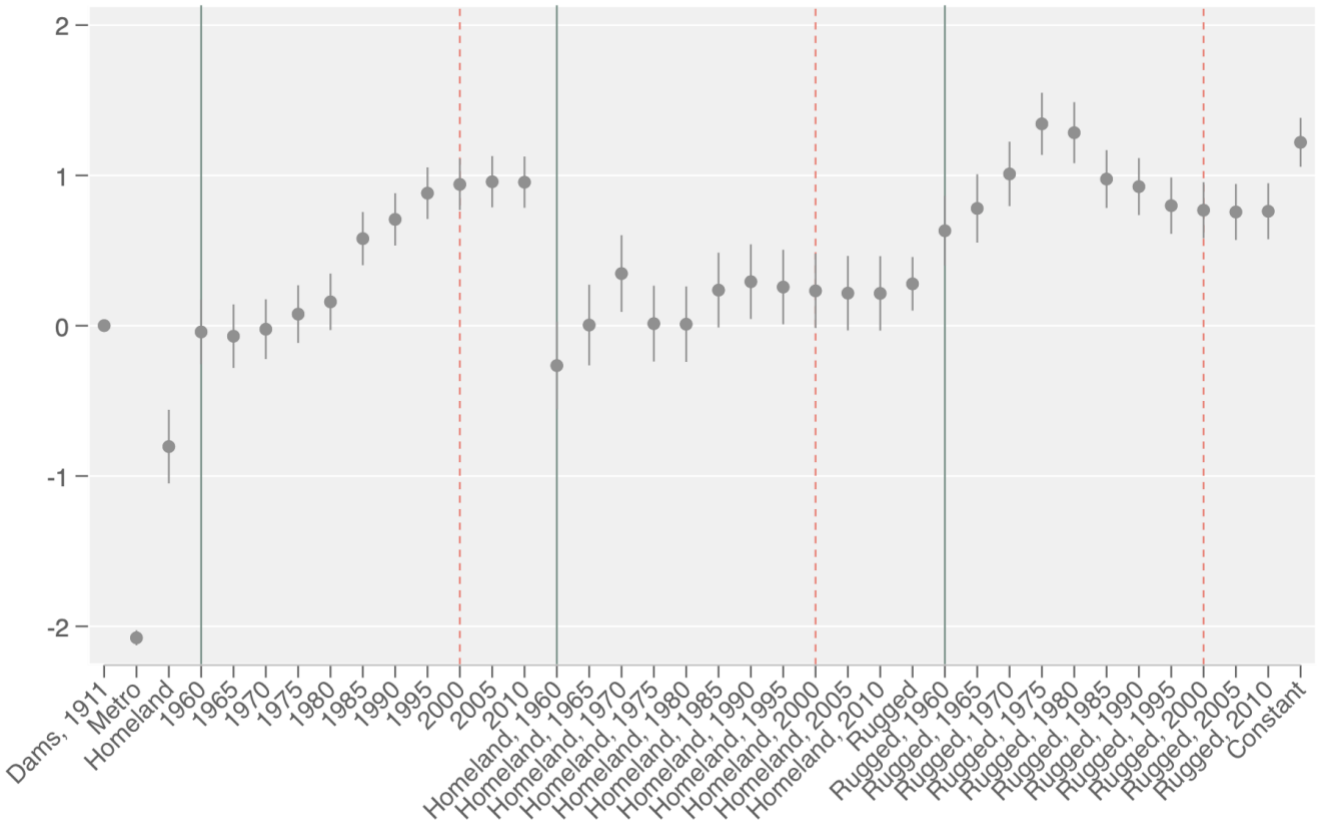

Figure 3.2 Coefficients of Poisson regression on the number of dams in built in wards

The coefficient on the ruggedness dummy is small, indicating that for all non-homeland wards in 1955, rugged and non-rugged areas had a comparable number of dams. The time interactions show that there was a large increase in the number of dams in non-homeland rugged wards between 1960 and 1980 in comparison to non-rugged, non-homeland wards in 1955. While there is no indication that the Water Act of 1956 targeted these areas first, these results indicate that multiple dams were built in non-homeland, rugged areas first, followed by non-rugged, non-homeland areas. This suggests that improvements in local state capacity can be used to improve water supply, overcoming ruggedness. The treatment effect of the 1956 Act was to increase local capacity to supply water in rugged areas, suggesting that local state capacity is a critical feature which either acts as a barrier or a booster to policy implementation. This same regression is computed with the net service capacity in each ward is used as the outcome variable. This figure can be seen in appendix 3-E.

3.5.2. The impact of terrain ruggedness and institutions on WASH infrastructure

The second part of the analysis investigates the impact of terrain ruggedness and institutional boundaries on the treatment effect of the 1998 Water Act, which aimed to improve access to WASH infrastructure in households. Table 3.3 shows the impact of ward characteristics on the proportion of households within each ward with access to a flush or chemical toilet. These models are specified in Equation 3.1 and run as panel regressions with random effects using the census data described above.

Column 1.1 shows that both homeland areas and more rugged areas have lower access to sanitation in comparison to non-rugged, non-homeland areas. Time interactions are added in column 1.2, showing that in comparison to the base year (1996), sanitation access increased in non-rugged, non-homeland areas in both 2001 and 2011. This relates to the time period when the policies from the 1998 Water Act were mobilizing resources to supply WASH services to previously un-serviced households. Access to sanitation in homeland regions increased at a significantly slower rate in comparison to non-rugged non-homeland areas in 1996. However, the homeland dummy variable suggests that this relatively slow increase in access was already from a lower level of access relative to non-homeland, non-rugged areas. Rugged wards saw no significant improvement in access to sanitation relative to non-rugged, non-homeland wards in 1996. Therefore, ruggedness as well as the historically lower local state capacity within former homeland regions reduced the treatment effect of the 1998 Act.

Column 1.3 includes a control for the proportion of households in the ward which are formal, as opposed to traditional or informal. This coefficient is positive, large, and statistically significant, and remains so when the Mundlak device for formal housing is added in column 1.4. This implies that formal housing is an important mechanism for access to sanitation, all else held constant. Column 1.5 includes controls for metro areas, population density and the initial level of access to sanitation in 1996. Both metros and areas with high population density have significantly higher access to sanitation. Access to sanitation in 1996 is also a significant predictor of sanitation access. This control reduces the size of many coefficients, but does not change the conclusion that access to sanitation in wards which fall in the former homelands increases at a slower rate.

Table 3.3: Regression on sanitation access

	(1.1)	(1.2)	(1.3)	(1.4)	(1.5)	(1.6)
	Proportion of households with Flush/Chemical toilets					
Homeland	-0.5206***	-0.4963***	-0.4278***	-0.4210***	-0.0732***	-0.0826***
	(0.0093)	(0.0100)	(0.0089)	(0.0090)	(0.0053)	(0.0079)
Rugged	-0.0280***	-0.0244**	0.0082	0.0143	-0.0048	-0.0117*
	(0.0095)	(0.0102)	(0.0090)	(0.0091)	(0.0047)	(0.0067)
2001		0.0500***	0.0151***	0.0169***	0.0140***	0.0182***
		(0.0056)	(0.0051)	(0.0051)	(0.0051)	(0.0059)
2011		0.1680***	0.0887***	0.0928***	0.0942***	0.1041***
		(0.0056)	(0.0053)	(0.0054)	(0.0055)	(0.0062)
Homeland x 2001		-0.0015	-0.0128**	-0.0122**	-0.0062	-0.0164*
		(0.0064)	(0.0058)	(0.0057)	(0.0057)	(0.0090)
Homeland x 2011		-0.0714***	-0.0985***	-0.0971***	-0.0910***	-0.1151***
		(0.0064)	(0.0058)	(0.0058)	(0.0058)	(0.0090)
Rugged x 2001		-0.0006	0.0113*	0.0107*	0.0126**	0.0038
		(0.0066)	(0.0059)	(0.0059)	(0.0058)	(0.0083)
Rugged x 2011		-0.0104	0.0060	0.0051	0.0075	-0.0132
		(0.0066)	(0.0059)	(0.0059)	(0.0058)	(0.0083)
Proportion Formal Housing			0.4675***	0.4428***	0.4032***	0.4017***
			(0.0087)	(0.0103)	(0.0108)	(0.0108)
Mean Proportion Formal Housing				0.0853***	-0.3567***	-0.3456***
				(0.0192)	(0.0130)	(0.0131)
Metro					0.0091*	0.0097**
					(0.0048)	(0.0048)
Log Population Density					-0.0111***	-0.0103**
					(0.0043)	(0.0043)
Mean Population Density					0.0199***	0.0189***
					(0.0044)	(0.0044)
Access to sanitation 1996					0.7895***	0.7868***
					(0.0062)	(0.0062)
Homeland x Rugged						0.0146
						(0.0095)
Homeland x Rugged x 2001						0.0169
						(0.0116)
Homeland x Rugged x 2011						0.0401***
						(0.0116)
Constant	0.7193***	0.6467***	0.3220***	0.2724***	0.0690***	0.0683***
	(0.0082)	(0.0088)	(0.0098)	(0.0149)	(0.0080)	(0.0082)
R-squared	0.4431	0.4608	0.5804	0.5815	0.8886	0.8890
N	11085	11085	11085	11085	10938	10938

NOTE: * p<0.1, ** p<0.05, *** p<0.01

Table 3.3 Regression on sanitation access.

The final column of table 3.3 shows the triple interaction between ruggedness, homelands and time. The coefficients on homelands and ruggedness are now interpreted as separate effects, and show that there is a disadvantage in non-rugged homelands relative to non-rugged non-homelands, and a disadvantage in rugged non-homelands relative to non-rugged non-homelands in 1996. The coefficients on 2001 and 2011 show there was an increase in access to sanitation in non-rugged non-homelands in 2001 and in 2011 relative to 1996.

The interaction terms between time and homelands remain unchanged from previous specifications, and show that in non-rugged homelands there was a slower increase in access to WASH relative to non-rugged non-homelands. However, the triple interaction between ruggedness, homelands and time show that there was a faster increase in access to sanitation in rugged homelands in 2011 relative to non-rugged homelands.

Table 3.4 shows the impact of the same ward characteristics on the proportion of households with access to tap water inside.[47] The baseline specification in column 1.7 shows that both homeland areas and more rugged areas have lower access to tap water relative to non-rugged, non-homeland areas. The time interactions in column 1.8 show that tap water access increased in non-homeland, non-rugged wards in 2011 relative to these wards in 1996. There was a slower increase in access to tap water in homeland wards relative to non-rugged, non-homeland wards in 1996. The treatment effect of the 1998 Act was thus smaller in homeland areas. More rugged wards experienced a faster increase in access to tap water relative to non-rugged, non-homeland areas in 1996, however. This indicates that the constraint of ruggedness was had less effect, but the constraint in terms of state capacity in homeland wards remained, reducing the 1998 treatment effect to a greater extent in comparison to ruggedness.

While it is difficult to compare the exact magnitudes of these coefficients, higher levels of WASH infrastructure are observed in rugged areas relative to homeland areas in 1996. This difference can be explained in part by the construction of dams in rugged areas noted above. The constraint to supplying water in rugged areas has been resolved in greater part than the constraints placed on WASH infrastructure supply by lower local state capacity in former homeland regions. The significant finding here is that local institutional capacity should

[47] This table is estimated using only 1996 and 2011 census data due to data concerns regarding the question regarding tap water in the 2001 data, as discussed in the data section above.

therefore still be considered a considerable constraint for areas in the former homelands, and a factor which hinders policy implementation.

Columns 1.2 and 1.8 show that there is still a large and negative penalty in terms of WASH infrastructure access in homeland wards, which implies that infrastructure which brings WASH facilities into households may still be lagging in these regions. The control for the proportion of formal housing in column 1.9 shows that formal housing also has a large, significant, positive correlation with access to tap water. But adding this control does not change the core conclusions about state capacity and ruggedness. The Mundlak device added in column 1.10 reduces the formal housing coefficient, but the coefficient remains large and significant, suggesting that formal housing is also an important mechanism for tap water access. Column 1.11 includes controls for metro areas and population density. Both metros and areas with high population density have significantly higher access to tap water. Lastly, a control for the initial access to tap water is included in column 1.12. This control reduces the size of many coefficients, but does not explain the slower increase in access to tap water in wards which fall in the former homelands.

The negative sign on the time interaction in homeland wards in columns 1.8 to 1.10 shows that had formal housing not increased, the homeland areas would have seen a decline in access to tap water relative to the rest of the country in 2011 (which would also have seen a decline in absence of formal housing). Column 1.8 suggests that formal housing is a primary mechanism for water supply in households. The proportion of formal housing remains a large explanatory factor for access to both tap water and sanitation, warranting further exploration. For this reason, a further analysis of the effects of ward characteristics on formal housing is estimated in Appendix 3-D. Once again, ward-level access to tap water in 1996 is a significant predictor of the level of access to tap water in later years, but does not explain the slower increase in access to sanitation in wards which fall in the former homelands.

The final column of table 3.4 again shows the triple interaction between ruggedness, homelands and time. The coefficients on homelands and ruggedness are again interpreted as separate effects in this final column, and show that there is a disadvantage in non-rugged homelands relative to non-rugged non-homelands, but no disadvantage in rugged non-homelands relative to non-rugged non-homelands in 1996. The coefficient on 2011 show there was an increase in access to sanitation in non-rugged non-homelands in 2011 relative to 1996.

The interaction terms between time and homelands remain unchanged from previous specifications, and show that in non-rugged homelands there was a slower increase in access to tap water relative to non-rugged non-homelands. However, the triple interaction between ruggedness, homelands and time show that there was no faster increase in access to sanitation in rugged homelands in relative to non-rugged homelands.

Table 3.4: Regression on tap water access

	(1.7)	(1.8)	(1.9)	(1.10)	(1.11)	(1.12)
	Proportion HH with tap access inside					
Homeland	-0.3774***	-0.3742***	-0.3119***	-0.2905***	-0.0470***	-0.0548***
	(0.0084)	(0.0089)	(0.0074)	(0.0073)	(0.0039)	(0.0058)
Rugged	-0.0133	-0.0152*	0.0145*	0.0350***	0.0009	-0.0052
	(0.0086)	(0.0091)	(0.0075)	(0.0074)	(0.0036)	(0.0050)
2011		0.0184***	-0.0538***	-0.0342***	-0.0153***	-0.0119**
		(0.0047)	(0.0046)	(0.0046)	(0.0046)	(0.0052)
Homeland x 2011		-0.0064	-0.0311***	-0.0243***	-0.0205***	-0.0290***
		(0.0053)	(0.0050)	(0.0049)	(0.0049)	(0.0077)
Rugged x 2011		0.0037	0.0186***	0.0146***	0.0108**	0.0035
		(0.0055)	(0.0051)	(0.0050)	(0.0050)	(0.0071)
Proportion Formal Housing			0.4253***	0.3096***	0.2144***	0.2144***
			(0.0084)	(0.0102)	(0.0100)	(0.0100)
Mean Proportion Formal Housing				0.3119***	-0.1275***	-0.1217***
				(0.0165)	(0.0112)	(0.0112)
Metro					0.0263***	0.0266***
					(0.0036)	(0.0036)
Log Population Density					-0.0036***	-0.0035***
					(0.0011)	(0.0011)
Mean Population Density					0.0046***	0.0044***
					(0.0012)	(0.0012)
Access to sanitation 1996					0.8087***	0.8071***
					(0.0056)	(0.0056)
Homeland x Rugged						0.0128*
						(0.0071)
Homeland x Rugged x 2011						0.0142
						(0.0099)
Constant	0.5423***	0.5331***	0.2377***	0.0740***	0.0362***	0.0368***
	(0.0074)	(0.0078)	(0.0087)	(0.0121)	(0.0060)	(0.0062)
R-squared	0.3508	0.3515	0.5647	0.5834	0.9033	0.9035
N	7390	7390	7390	7390	7390	7390

NOTE: * p<0.1, ** p<0.05, *** p<0.01. Sample size is reduced due to the exclusion of 2001 data.

Table 3.4 Regression on tap water access

Ruggedness acts as a barrier to the development of infrastructure and is likely to cause additional cost. However, this barrier can be overcome by technological innovation, such as low-cost toilets which do not require water or electricity (Parker, 2014; Chand and White, 2015; Andersson, Otoo and Nolasco, 2018). Therefore, while terrain ruggedness reduced the treatment effect of the 1998 Act, these results show that historical institutional capacity reduced the treatment effect more than the ruggedness of the area. The implications of this finding will be discussed below. As a further robustness check, a Spatial Durban Model is computed to account for regional spill-overs due to the spatial nature of this data used in Tables 3.3 and 3.4. These results can be found in appendix 3-E, and show that the overall pattern of the coefficients remain similar, even when spatial autocorrelation is accounted for. Furthermore, the coefficients remain in a similar order of magnitude.

To further understand the constraint of local capacity constraints within institutional boundaries, the change in access to WASH infrastructure in specific former homelands is analysed, both rugged and non-rugged. Table 3.5 and Table 3.6 show the effect of ward characteristics on access to sanitation and tap water in households within specific former homelands relative to other homelands. The sample for each regression is indicated above the regression results, and access to flush toilets and tap water is shown in separate tables. For the models which show the effect in a specific homeland (the Transkei, for example), the reference is all other wards which fall in former homeland areas. The only difference in this model is that the control for ruggedness is a continuous variable, as there is not enough variation in the dummy variable "Rugged" within the separate homelands.

Columns 5.1.1 and 5.2.2 show that there was an increase in sanitation access in the Transkei in 2001, and in 2011 relative to other former homelands in 1996. The same is true for the Ciskei and KwaZulu (columns 5.2.1 to 5.3.2). Venda and Lebowa, and all other former homeland areas, saw a significantly slower increase in access to sanitation over this period relative to 1996, however. Therefore, the policies of the 1998 Act were more successfully implemented in some former homelands relative to others. Table 3.6 presents the same story: access to tap water in the Transkei, the Ciskei and KwaZulu increased more quickly relative to all other former homeland areas. These tables show more specifically that some former homeland areas were targeted by the post-apartheid water and sanitation policy with more attention relative to others. This can be explained by the relative population density in these areas; initial infrastructure spending is more likely to be targeted towards such areas (Dinkelman, 2008).

Alternatively ethnic favouritism or vote buying may have influenced the targeting of these areas which are the ethnic base of the presidents who were incumbent over this period (Walters, Bittencourt and Chisadza, 2023). This finding has critical implications for the health of children in areas that receive slower access to WASH infrastructure, due to the importance of WASH for facilitating a healthy environment.

Table 3-F1 In Appendix 3-F shows the association between former homelands, high ruggedness and the under 5 child stunting prevalence. This table shows that stunting is higher in former homeland regions relative to non-homeland regions but is not significantly higher in rugged regions relative to non-rugged regions. Access to flush toilets and tap water significantly reduces this stunting penalty in the homelands. Once controls for formal housing, household assets and population density are included in the final column, there is no significant association between former homeland wards and stunting. However, *rugged homeland* wards still experience a stunting penalty.

Table 3.5: Flush toilet access (split sample regressions)

	(5.1.1) Transkei	(5.1.2)	(5.2.1) Ciskei	(5.2.2)	(5.3.1) KwaZulu	(5.3.2)	(5.4.1) Venda	(5.4.2)	(5.5.1) Lebowa	(5.5.2)	(5.6.1) Other homelands	(5.6.2)
Specified Homeland Dummy	-0.2199***	0.0013	-0.0480	-0.1059***	-0.1244***	-0.0276**	-0.2598***	-0.3054***	-0.2164***	-0.2043***	-0.0498***	-0.0689***
	(0.0200)	(0.0169)	(0.0390)	(0.0305)	(0.0169)	(0.0135)	(0.0218)	(0.0170)	(0.0497)	(0.0387)	(0.0143)	(0.0125)
HL x 2001	-0.0064	0.0194**	-0.0052	0.0068	0.0407***	0.0299***	-0.0245**	-0.0450***	-0.0165	-0.0671***	-0.0221***	-0.0223***
	(0.0102)	(0.0092)	(0.0196)	(0.0176)	(0.0085)	(0.0077)	(0.0112)	(0.0100)	(0.0250)	(0.0225)	(0.0069)	(0.0068)
HL x 2011	-0.0284***	0.0108	0.0378*	0.0587***	0.0323***	0.0085	-0.0864***	-0.1082***	-0.0616**	-0.1517***	-0.0262***	-0.0294***
	(0.0102)	(0.0092)	(0.0196)	(0.0176)	(0.0085)	(0.0077)	(0.0112)	(0.0100)	(0.0250)	(0.0225)	(0.0069)	(0.0068)
2001	0.0247	-0.0458	0.0341	-0.0754*	0.0863*	-0.0384	0.0333	-0.0798**	0.0330	-0.0854**	0.0146	-0.0160
	(0.0477)	(0.0430)	(0.0450)	(0.0406)	(0.0461)	(0.0416)	(0.0447)	(0.0402)	(0.0450)	(0.0405)	(0.0475)	(0.0467)
2011	0.3211***	0.2320***	0.3728***	0.2251***	0.4070***	0.2263***	0.3603***	0.2073***	0.3588***	0.1957***	0.0319	-0.0006
	(0.0477)	(0.0430)	(0.0450)	(0.0407)	(0.0461)	(0.0417)	(0.0447)	(0.0403)	(0.0450)	(0.0406)	(0.0475)	(0.0467)
Log Ruggedness	-0.1000***	-0.0259***	-0.1307***	-0.0245***	-0.1166***	-0.0234***	-0.1282***	-0.0152**	-0.1290***	-0.0230***	-0.0572***	-0.0044
	(0.0079)	(0.0065)	(0.0075)	(0.0063)	(0.0077)	(0.0064)	(0.0073)	(0.0060)	(0.0075)	(0.0063)	(0.0079)	(0.0074)
Log Ruggedness x 2001	0.0021	0.0049	0.0012	0.0076**	-0.0037	0.0041	0.0015	0.0083**	0.0013	0.0085**	0.0033	0.0048
	(0.0040)	(0.0036)	(0.0038)	(0.0034)	(0.0039)	(0.0035)	(0.0037)	(0.0034)	(0.0038)	(0.0034)	(0.0038)	(0.0037)
Log Ruggedness x 2011	-0.0166***	-0.0161***	-0.0213***	-0.0155***	-0.0245***	-0.0156***	-0.0196***	-0.0132***	-0.0200***	-0.0128***	0.0053	0.0057
	(0.0040)	(0.0036)	(0.0038)	(0.0034)	(0.0039)	(0.0035)	(0.0037)	(0.0034)	(0.0038)	(0.0034)	(0.0038)	(0.0038)
Controls		0.3970***		0.3961***		0.3948***		0.4028***		0.4029***		0.1322***
Constant	1.5608***	-0.0164	1.9022***	-0.0239	1.7534***	-0.0342	1.8926***	-0.1548**	1.8845***	-0.0494	0.8415***	-0.1304
	(0.0935)	(0.0839)	(0.0897)	(0.0830)	(0.0916)	(0.0837)	(0.0873)	(0.0786)	(0.0894)	(0.0827)	(0.0982)	(0.0967)
R-squared	0.131	0.455	0.099	0.456	0.108	0.455	0.143	0.513	0.105	0.463	0.041	0.288
N	11085	11085	11085	11085	11085	11085	11085	11085	11085	11085	6414	6414

NOTE * p<0.1, ** p<0.05, *** p<0.01. Controls include the proportion of formal housing, mean proportion formal housing, metro areas, population density and mean population density.

Table 3.5: Split sample regression – sanitation access

Table 3.6: Tap water access (split sample regressions)

	(6.1.1) Transkei	(6.1.2)	(6.2.1) Ciskei	(6.2.2)	(6.3.1) KwaZulu	(6.3.2)	(6.4.1) Venda	(6.4.2)	(6.5.1) Lebowa	(6.5.2)	(6.6.1) Other homelands	(6.6.2)
Specified Homeland Dummy	-0.0803***	0.0307***	0.0726***	-0.0219	0.0509***	0.0613***	-0.0304**	-0.1121***	0.0149	-0.0281	0.0098	-0.0136
	(0.0121)	(0.0107)	(0.0225)	(0.0190)	(0.0103)	(0.0086)	(0.0133)	(0.0113)	(0.0287)	(0.0235)	(0.0117)	(0.0096)
HL x 2011	-0.0085	0.0083	0.0436***	0.0532***	0.0229***	0.0177***	-0.0278***	-0.0329***	-0.0263*	-0.0520***	-0.0072	-0.0100*
	(0.0062)	(0.0063)	(0.0115)	(0.0112)	(0.0053)	(0.0052)	(0.0067)	(0.0066)	(0.0146)	(0.0144)	(0.0059)	(0.0058)
2011	-0.1214***	-0.1288***	-0.1001***	-0.1389***	-0.0828**	-0.1257***	-0.0921***	-0.1291***	-0.1077***	-0.1504***	-0.0791*	-0.1079***
	(0.0367)	(0.0359)	(0.0346)	(0.0339)	(0.0349)	(0.0344)	(0.0347)	(0.0340)	(0.0347)	(0.0340)	(0.0408)	(0.0400)
Log Ruggedness	-0.0344***	0.0121**	-0.0493***	0.0143***	-0.0536***	0.0116**	-0.0491***	0.0224***	-0.0485***	0.0152***	-0.0456***	0.0111*
	(0.0059)	(0.0052)	(0.0056)	(0.0052)	(0.0057)	(0.0051)	(0.0056)	(0.0051)	(0.0056)	(0.0052)	(0.0065)	(0.0057)
Log Ruggedness x 2011	0.0114***	0.0096***	0.0093***	0.0104***	0.0075***	0.0092***	0.0091***	0.0101***	0.0101***	0.0116***	0.0079**	0.0083***
	(0.0030)	(0.0030)	(0.0028)	(0.0028)	(0.0029)	(0.0028)	(0.0028)	(0.0028)	(0.0029)	(0.0028)	(0.0033)	(0.0032)
Controls		Yes		Yes		Yes		Yes		Yes		Yes
Constant	0.5820***	-0.3610***	0.7432***	-0.3680***	0.7843***	-0.3535***	0.7489***	-0.4807***	0.7361***	-0.3811***	0.6990***	-0.3274***
	(0.0713)	(0.0683)	(0.0680)	(0.0683)	(0.0683)	(0.0672)	(0.0683)	(0.0668)	(0.0683)	(0.0684)	(0.0803)	(0.0744)
R-squared	0.050	0.362	0.037	0.359	0.046	0.378	0.034	0.395	0.029	0.361	0.029	0.360
N	4276	4276	4276	4276	4276	4276	4276	4276	4276	4276	4276	4276

NOTES: * p<0.1, ** p<0.05, *** p<0.01. Controls include the proportion of formal housing, mean proportion formal housing, metro areas, population density and mean population density.

Table 3.6: Split sample regression – tap water access.

3.6. Implications and discussion

These results shed light on several ways in which policy, ruggedness and state capacity have affected WASH infrastructure access in wards in South Africa. The first set of results suggest that the policy changes which came about in 1956 changed the relationship between historical institutions, ruggedness, and infrastructure. The lack of association between historical patterns of dam construction up until 1911 and those built between 1950 and 2015 implies that the treatment effect of the Water Policy Act of 1956 changed the pattern of water supply infrastructure. While rugged terrain acted as an initial constraint to the construction of new dams, coordinated policy, which targeted some areas, was able to progressively overcome this constraint, demonstrated in the large number of dams built in rugged wards between 1960 and 1980. The treatment effect of the 1956 Act was also large in non-rugged, non-homeland regions.

This result is analogous to that found in Fourie and Herranz-Loncan (2015), who find that the construction of railways in the interior of the country in the nineteenth century explicitly bypassed the homelands, which hindered their economic growth potential. Similarly, these regression results indicate that the Water Act of 1956 reduced infrastructure provision in the areas which were not treated by the Act, causing homeland areas to be bypassed. This implies that policy targeting is a driving factor for water supply infrastructure. The constraint of terrain ruggedness, however, was overcome in areas which were targeted by policy.

The second set of results highlights the different rates of increase in access to sanitation and tap water in households in different regions of the country. The largest treatment effect of the 1998 Act was experienced by people living in non-rugged, non-homeland regions, relative to all other regions. Households in these regions experienced the fastest increase in access to WASH, while households in homeland regions saw a slower increase in access relative to non-homeland wards. Rugged, non-homeland wards experienced a comparable increase in access to WASH relative to non-rugged, non-homeland wards, which suggests that ruggedness was no longer a serious constraint in non-homeland wards. Local state capacity remains a constraint, however, in places where its development has been hindered due to past policies. Local capacity constraints in the homelands include inefficient or ineffective elements that are important for the proper functioning of the local administration, including human capacity,

physical infrastructure, and the ability to provide an environment which is conducive to economic growth and human development.

However, the impact of local state capacity is not homogenous across all former homelands. Households in the former Transkei, Ciskei and Kwa-Zulu saw a faster increase in access to sanitation and tap water relative to other homelands, which impressive given the higher terrain ruggedness in these areas. This selective increase in access to WASH suggests that the rollout of WASH infrastructure was targeted in these areas in the post-apartheid era. These former homelands also saw a large roll-out in formal housing under the Reconstruction and Development Programme (RDP) (Melzer and Garbers, 2019) as well. As noted above, such formal housing acts as a primary mechanism for access to WASH. That these areas received a larger initial treatment due to the 1998 policy is to be expected due to the population density and the political importance of these regions (Dinkelman, 2008). Alternatively ethnic favouritism may have influenced the targeting of these areas which are the ethnic base of the presidents who were incumbent over this period (Walters, Bittencourt and Chisadza, 2023). Resolving historical institutional constraints remains critical in improving the necessary rollout of infrastructure.

The significant implication of this is that once local institutional capacity is strengthened, it can be used to leverage technology, recover costs and uphold policy such that ruggedness does not present an insurmountable barrier. Therefore, while ruggedness may have impacted the initial local state capacity formation of an area, exogenous forces which influence local informal and formal institutions can overcome this barrier. This finding is in line with those which confirm that trust is higher inside homeland boundaries relative to other areas of South Africa due to solidarity, even though they are rugged places (Abel, 2019). Local state capacity may also be augmented or strengthened due to political motives, to buy votes, or due to corruption, often with the direct intention to improve service delivery (Reddy, 2016). This analysis does not directly control for political motives due to data availability but considers political motives as possible foundations for strengthened state capacity in some areas relative to others. This has relevance for the strengthening of state capacity in some former homelands relative to others in the period after 1994.

The ZIP model confirms that there was a relative increase in the number of dams in non-homeland areas after the first policy change in 1956, as well as a relative halt in the construction of dams in 1998 after the second policy shock. Homeland regions did not receive the same

treatment as other regions under the 1956 Water Act. The second analysis confirms that there was an increase in access to WASH services in some households due to the 1998 policy change. However, this treatment effect was reduced by local capacity constraints in former homeland regions, and in rugged regions. This gives strong evidence that policy can weaken the ties of past local state capacity constraints, even if these constraints are not fully resolved. Moreover, in the case of WASH infrastructure, network effects and improved technology have lessened the constraint of rugged terrain, implying that the main constraint to be resolved is institutional.

While this analysis does not measure advances in technology, new sanitation technology can be considered as a major factor which can explain why the constraint of ruggedness for the supply of WASH infrastructure is reduced. Multiple new sanitation solutions have been developed which do not require electricity or sewage systems, and which can also benefit communities through processing waste for reuse, as fertiliser for example (Parker, 2014; Chand and White, 2015; Andersson, Otoo and Nolasco, 2018). The application of such sanitation solutions has been politicised in the South African context, however (Reddy, 2016), where service provision and the types of toilets provided to people have been widely protested. It is necessary to engage with "toilet politics" in order to understand how sanitation solutions are perceived, and whether they will be used if provided (Tempelhoff, 2012; Mottiar, 2015). Therefore, the implementation of such solutions must take local preferences and the dignity of those who will use the WASH services into account.

To illustrate the gap in sanitation technologies which still exists, Figure 3.3 shows the proportion of households which use different types of toilets in former homeland wards relative to non-homeland wards. Flush and chemical toilets are the most common type of toilet in non-homeland regions, while pit latrines are the most common type of toilet in homeland regions. The figure shows that the use of pit latrines has also increased in former homeland wards. This has led to devastating child deaths if they fall into the latrine (BBC News, 2018; Aljazeera, 2023; McCain, 2023)[48]. This gap in sanitation technology should be addressed by focusing on increasing local state capacity in homeland regions, improving the rule of law, the collection of service costs and addressing local concerns regarding the dignity in using new sanitation solutions (McDonald and Pape, 2002; van Welie, Truffer and Yap, 2019). This understanding

[48] These newspaper articles report the deaths of 3 children who fell into pit latrines at school and died. This has occurred in many schools, and is a devastating reality of using pit latrines as the primary type of toilet.

of institutional capacity aligns with the notion that the best institutions are those which can adapt as needed in light of changing constrains and incentives (Acemoglu et al., 2020; Sokoloff and Engerman, 2000).

Figure 3.4: Toilet types in homelands and non-homelands[49]

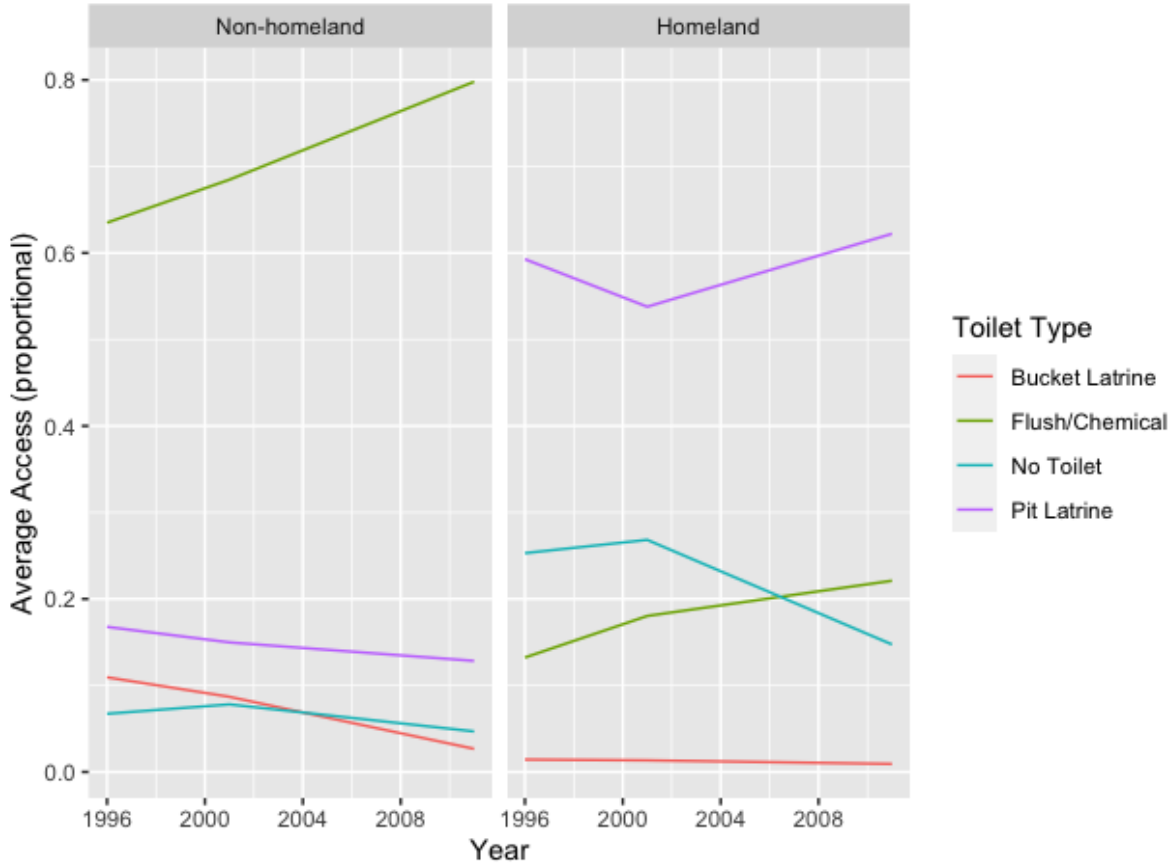

Figure 3.3: Progression of access to different types of toilets in South Africa, 1996 – 2011

3.7. Conclusion

This study used two WASH policy changes in South Africa as a case study to investigate the separate effects of terrain ruggedness and local state capacity on infrastructure development. Both ruggedness and local state capacity reduce the treatment effect of national WASH policy changes which aimed to increase infrastructure capacity. Local state capacity, as determined by historical institutional boundaries, is persistent and remains a critical factor in determining the extent to which national policies can influence local state capacity. However, where local

[49] Source: own calculations from harmonised census data.

institutional capacity grows, the change can overcome barriers presented by past historical constraints and bad geography.

This is in line with the conclusion of von Fintel and Fourie (2019), that institutional capacity is critical in explaining the level of development, and specifically in the former homelands of South Africa. This paper adds to their conclusion that there are two different institutional frameworks which act on South Africa – one within the former homeland areas, and one in former "white South Africa" (von Fintel and Fourie, 2019). Addressing the local institutional capacity within former homelands therefore remains an issue of concern for WASH infrastructure. The literature suggests that a strategic effort to strengthen local capacity will include augmentation of administrative capacity and human capital (Fernandez and Rainey, 2013), as well stronger management to lead the implementation of policy (Coovadia *et al.*, 2009). It will also include investment in network-based infrastructure, which has higher marginal returns than other government investments (Candelon, Colletaz and Hurlin, 2013), but the exact manner of investment which would be appropriate to strengthen local state capacity in South Africa is beyond the capability of the data to determine. Factors which are believed to strengthen government capacity in LMICs include the free-flow of knowledge and ideas, more flexible institutions and enhanced human capital (Eakin and Lemos, 2006). The determination of the factors which can strengthen local state capacity in a South African context would be a fruitful avenue of future research.

In a report on the barriers to sanitation supply in urban areas in South Africa, the Palmer Development Group confirms that several role-players are involved in sanitation provision, including the National Department of Water and Sanitation, local government, the private sector and the National Department of Human Settlements (Paladh, Graham and Kaplan, 2017). Their report argues that the main barriers to sanitation provision are financial and socio-political, rather than technical. Technical barriers to the provision of sanitation and housing are likely to be of primary concern in some rural areas, however (Goebel, 2007). The results of this chapter are consistent with the conclusion that the main barriers to infrastructure development are socio-political. While new sanitation technology which can overcome historical capacity constraints as well as ruggedness may exist, its implementation is yet to be realised in some areas.

These results shed new light on the impacts that the current state of "uncoordinated and fragmented" sanitation policy is likely to have. Given the lack of coordinated sanitation policy

which has been admitted by the Department of Sanitation, the poor state of South African wastewater treatment systems is not surprising (Department of Water and Sanitation, 2016). This lack of coordination should not be ignored. This research points to the importance of harmonised policy for WASH infrastructure, implying that addressing the current fragmentation is of the highest concern. The targeting of sanitation policy is likely to have beneficial effects on the overall health of the South African population, and especially on the welfare of children (van Koppen and Schreiner, 2014; Headey and Palloni, 2019; Bridgman and von Fintel, 2022). Furthermore, since terrain ruggedness is positively correlated with child stunting (Chisadza *et al.*, 2023), improving access to WASH infrastructure in rugged areas is critical for improving child health.

Finally, this paper concludes that while ruggedness contributed to historical local state capacity constraints, the primary barrier to infrastructure development and growth is current local state capacity. This implies that the implementation of new policies may be less well realised where local state capacity is weaker. Focusing on increasing local state capacity is critical to reverse this effect.

CHAPTER FOUR

4. PARENTAL DEATH, PARENTAL ABSENCE AND CHILD HEALTH

4.1. Introduction

Parents play a pivotal role in providing care to their children, in mobilising household socio-economic resources to the benefit of their children's health and education, and in their human capital formation (Chuong and Operario, 2012; Finlay *et al.*, 2016; Beal *et al.*, 2018). It is generally understood that when parents are primarily financially responsible for children, their death or absence reduces the ability of households to provide optimally for children's nutritional needs and to access services that help their children to develop. Where household resources are lacking and parental support is limited due to death or absence, cash transfers can provide key support for households in providing for the children left in their care; this is regardless of whether cash transfers take the form of government-to-person (G2P) transfers or private transfers in the form of remittance payments (Waidler and Devereux, 2019). This paper is based on the premise that parental death and parental absence are both likely to increase children's reliance on cash transfers. Parental death may increase the reliance of G2P transfers, where these are available. Conversely, parental absence alone may increase the likelihood of remittance income flowing from absent working parents to non-biologically related caregivers' households.

When parents die or are absent, they are no longer able to provide the same level of care to their children, and this has negative effects; international studies confirm that children who are either orphans or have living but absent parents are vulnerable to worse health outcomes than children who live with their parents, for instance (Zere and Mcintyre, 2003; Watts *et al.*, 2007; Hall and Proudlock, 2011; Ali *et al.*, 2018). There is little international evidence as to whether the negative effects on children are likely to be more pronounced when parents are deceased relative to when they are living but absent, however. This distinction between parental death and absence offers insights, it is here argued, into the role of parental investment relative to public transfers in promoting child development, but it has not been studied extensively.

That is, when parents are alive but absent, they are still able to invest in their children. This chapter works towards reducing this knowledge gap.

In order to study the distinction in terms of impact on children between parental death and parental absence, and to study the different impacts of each on child development in a LMIC context, South African data is used. South Africa presents a helpful case study for these factors because it has a long history of private transfers within extended family networks, as well as an extensive G2P payment network (Waidler and Devereux, 2019). Furthermore, the majority of children in South Africa have absent or deceased parents; only 34% of children under the age of 18 cohabit with both parents (StatsSA, 2021).

In order to study the distinction in effects between parental death and parental absence on child stunting and hunger, this paper investigates regional inequalities in child nutrition outcomes in relation to the geography of parental absence, and in relation to the geography of paternal or maternal orphanhood. In addition, the spatial distribution of cash transfers is used to investigate the effect of public and private cash transfers on the health of children who are orphaned or have absent parents in South Africa.

Parental death substantially changes household care-giving dynamics. For example, the death of one parent increases the burden of care for surviving family members. In the international literature, maternal orphanhood is consistently linked to poorer long-term health outcomes, but the impact of paternal orphanhood on health outcomes varies according to the country as well as the age of the children studied (Beegle, de Weerdt and Dercon, 2007). Existing South African studies show that the death of the mother, father or both parents has different impacts on children (Hill, Hosegood and Newell, 2008b). In South Africa, paternal orphanhood has been found to negatively impact children primarily through lowering their socioeconomic status, while maternal orphanhood directly impacts children through the loss of care (Case and Ardington, 2006). This paper therefore distinguishes between the impacts of maternal versus paternal absence and death. This is because the differences in how households are composed are likely to have an impact on the health of children who live without one or more of their parents, either because they are absent for extended periods or because they have died (Case and Ardington, 2006; Beegle, de Weerdt and Dercon, 2007; Ardington and Leibbrandt, 2010).

While scholarly literature has shed light on the role of orphanhood on a range of human capital outcomes, less is known about the impact of single orphanhood and parental absence on child

health outcomes[50]. Bridgman and von Fintel (2022) show that rates of orphaned and vulnerable children and stunting are concurrently elevated in South Africa's former homelands – these are impoverished areas that were demarcated for "separate" and discriminatory economic and political development under the policy of apartheid which lasted from 1948 until the early 1990s. One benefit of studying the health outcomes of vulnerable children in such a manner is that it furthers the understanding of why these children fare worse at school and in the labour market, due to the link between poor health and poor school performance (Angrist *et al.*, 2023).

The child outcomes are analysed in this paper are hunger and stunting, which are hereafter referred to as "health outcomes". This paper finds that paternal orphans are more vulnerable to poor chronic health outcomes relative to all other children – including those who have absent mothers and fathers - and that lower household wealth (asset ownership) could be an important mechanism which contributes to the paternal orphan stunting penalty. Of note, the research found that there is no significant association between higher maternal orphanhood in a geographical area and poor health outcomes for children in that geographical area. Secondly, this paper finds that both paternal orphans and children with absent fathers are more likely to experience greater food insecurity than children with fathers present. Paternal orphanhood therefore carries a distinct disadvantage for children's health, but father absenteeism is also associated with worse nutritional inputs that may present in poor health outcomes as children age.

Household income, including remittance income, lessens household hunger as a whole, but does not reduce the significantly increased tendency for paternal orphans and children with absent living fathers to experience hunger. The improvement in household socioeconomic status could be due to remittance income from other family members, labour market income of non-biologically related caregivers, or other grant income, among many factors. Therefore, the results do not point to an exact mechanism, but offer a residual explanation by eliminating a range of factors, including grant income, that can be controlled for using existing data. Even

[50] Evidence from the recent COVID-19 pandemic showed that, in South Africa, negative economic shocks, or crises, are likely to impact single and double orphans to a greater extent than children who live with both parents (van der Berg, Patel and Bridgman, 2022). The question of relative impact of parental death or absence in non-crisis years is not well established, however. This paper therefore analyses both crisis and non-crisis years to reveal the effect of parental absence or parental death on child nutrition, as an indicator of likely health outcomes.

so, the results reveal that there remains an unexplained penalty associated with paternal orphanhood and absence which is not caused by reduced socioeconomic status.

This paper continues with a review of the literature on parental absence and orphanhood, child health outcomes, as well as a brief review of spatial inequality in South Africa in section 2. Section 3 describes the methodology used, and section 4 describes the data. The results are presented in section 5, followed by a discussion of policy implications in section 6. Section 7 concludes.

4.2. Literature review

4.2.1. Orphanhood and Parental absence

Orphanhood and parental absence are both common in South Africa. According to the 2021 General Household Survey, just 1 in 4 children under the age of 5 lives with both of their parents and more than half of children under the age of 5 do not live with their fathers, either because of death or absence (StatsSA, 2021). Of children under the age of 18, 2,9% and 9% are maternal or paternal orphans, respectively, and 3,2% are double orphans. Orphanhood in South Africa increased dramatically between the mid-1990s and 2010 due to the HIV pandemic in South Africa at that time. The halt in the increase in orphanhood is attributed to the successful rollout of Antiretroviral treatment (ART) in 2004 (De Paoli, Mills and Grønningsæter, 2012).[51] Since 2010, orphanhood has remained relatively stable. Paternal absence is particularly high for black African children relative to other race groups in South Africa (Makusha and Richter, 2015). As noted earlier, parents and children do not live together in the majority of households in South Africa; instead, most African children (66%) live in "extended family" household formations that do not include the father or mother, with more than three generations living together (Hall *et al.*, 2018). This unique pattern of household formation is largely attributed to the system of migrant labour which started in the early 20th century in South Africa and which was entrenched for the majority of the rest of the century (Klasen and Woolard, 2009; Hall *et al.*, 2018).

[51] A comparison of the rate of orphanhood as children age between 2001 and 2011 can be seen in Appendix 4-D.

Although the formal laws keeping the migrant labour system in place have been repealed since 1986, economically active parents still tend to migrate to cities in search of work, leaving children behind. After the start of the democratic era in South Africa in 1994, it was assumed that previous real wage differences would equalise across local labour markets as workers migrated to high wage labour markets. However, this has not yet occurred, and the migrant labour system has remained largely intact to this day (Marais, Denoon-Stevens and Cloete, 2020), which has had the consequence of normalising the separation of parents from children (Budlender and Lund, 2011).

Although parental absence and orphanhood carry the same implication in terms of a loss of a parent's physical presence, the question remains as to whether they have similar effects on child health. This difference in effect arises due to the difference in the likelihood of the child benefiting from private transfers (in the case of parental absence) or public transfers (in the case of both absence and orphanhood). In South Africa, the current literature suggests that single orphans are often poorer than double orphans. Only double orphans are able to access the government Foster Care Grant (FCG) which pays a large amount of money relative to the Child Support Grant (CSG), which many more children receive but is less generous. Single orphans are eligible only for the CSG, leaving them in a less advantaged position than double orphans (Hall and Proudlock, 2011).

This leaves single orphans more vulnerable than other children to poor nutrition over and above their vulnerability due to the loss of one of their parents. Children with parents who are absent are also not eligible for the FCG, but may receive the CSG. Single orphans and children with absent parents are therefore in similar circumstances with respect to G2P transfers. This makes them more susceptible to lower development outcomes in South Africa relative to double orphans and children who live with both parents (Hall and Proudlock, 2011). However, where parents are absent from the household because they are working in order to remit money back to their families, parental absence can benefit the child (Lu and Treiman, 2011). In this case, only the care element which parents provide to their children would be lost and financial resources available to invest in children could, in fact, improve.

Previous South African studies confirm that single orphans are more vulnerable to lower educational outcomes than children who live with their parents (Ardington and Leibbrandt, 2010). Within this group, it is important to consider the differences between paternal and maternal orphans. Paternal orphans are vulnerable to lower attendance and educational

attainment relative to maternal orphans due to the increased incidence of poverty for these children (Case and Ardington, 2006). However, evidence from a study in Tanzania finds that maternal orphans have both lower educational outcomes and health outcomes relative to children with both parents living, where the mother's death before the age of 15 has a significant impact on nutritional health (Beegle, de Weerdt and Dercon, 2007), which implies that both maternal and paternal orphanhood may carry a penalty relative to no parental death. Maternal and double orphans in South Africa are more likely to live with extended families relative to paternal orphans, who tend to remain with their mothers (Hill, Hosegood and Newell, 2008b; Makusha and Richter, 2015). Paternal orphans are therefore more likely to live in female-headed households, where their mothers fulfil the roles of both care-giver and breadwinner (Budlender and Lund, 2011). This contrasts with children who have an absent parent (whether mother or father), where the absent parent may be able to increase the household income by sending private cash transfers to their children.

This study focuses on the health outcomes of single orphans and children with absent parents. Little has been confirmed about the health outcomes of single orphans in particular. Furthermore, there are few studies which research this topic more recently in South Africa. This study therefore contributes critical knowledge about how single orphans and children with absent parents fare relative to other children. The following sub-section reviews the measurements used as children's health outcome variables and why they are valid.

4.2.2. Measuring child health outcomes

Stunting, has been used extensively by researchers to measure child health outcomes. Stunting is defined as having a height-for-age Z-score 2 standard deviations below the mean of the World Health Organisation (WHO) 2006 reference population (de Onis *et al.*, 2006). Stunting results from a combination of features, including inadequate nutrition, chronic infection and inadequate stimulation (Headey, Hirvonen and Hoddinott, 2018; Leroy and Frongillo, 2019; Burger *et al.*, 2022). This measure is a marker for living environments that do not encourage optimal childhood development, and in which children experience chronic insults to their development. Stunting should therefore be viewed as an indicator of child ill-health over a longer time period. However, even if a child is not stunted by the formal definition, the insults to development which cause stunting, such as poor nutrition, still negatively impact a child's

health (Cole, 2012; Ekholuenetale *et al.*, 2020). Stunting is therefore seen as an indicator of extreme underdevelopment.

Moreover, stunting and cognitive underdevelopment are often correlated, due to the fact that the multiple factors which contribute towards stunting also hinder cognitive development. Poor nutrition, chronic infection and lack of stimulation are also risk factors for cognitive underdevelopment. Cognitive underdevelopment is known to lead to poorer schooling outcomes and lower lifetime earning potential (Dillingham and Guerrant, 2004; Prendergast and Humphrey, 2014; Beal *et al.*, 2018; Leroy and Frongillo, 2019). Higher rates of stunting in a geographic area therefore acts as a marker that children in that area are exposed to an environment which does not foster ideal long-term childhood development, either physically or cognitively.

In Sub-Saharan Africa, orphaned children are more likely to be stunted than non-orphaned children, and are also more likely to fall behind in school (Coneus and Mühlenweg, 2011). In their study of extremely poor children in Zimbabwe, Watts et al., (2007) confirm that orphaned children are more likely to be stunted, even when compared to equally poor, non-orphaned children. However, orphaned children are no more likely to be underweight than non-orphaned children (Rivers, Mason, Silvestre, Gillespie, Mahy and Monasch, 2008). A range of studies have confirmed this finding, emphasising that orphans in multiple Sub-Saharan African countries are no more likely to be underweight than non-orphaned children of the same socio-economic status and age (Sarker, Neckermann a Mü Ller, 2005; Ali et al., 2018).

Studies that focus on South Africa confirm that there is a high prevalence of stunted children in the country (Zere and Mcintyre, 2003; Toriola *et al.*, 2012; Monyeki *et al.*, 2015), and that stunting has been persistently high for the last four decades (Said-Mohamed *et al.*, 2015). According to the latest Demographic and Health Survey (which was taken in 2016), 27.4% of children are stunted (National Department of Health *et al.*, 2019). There is little evidence as to whether orphaned children are more likely to be stunted in South Africa than other children, however. While Bridgman and von Fintel (2022) confirm that the most vulnerable children (those who are double orphans or have both parents absent) are more likely to live in areas with high stunting prevalence, very little is known as to whether single orphans and children with absent parents fare worse than non-orphans in health measures.

4.2.3. Child welfare in different regions

Child health differs by region in South Africa, and also differs with household income (Zere and Mcintyre, 2003; Barnes *et al.*, 2009; Bridgman and von Fintel, 2022). South Africa's former homelands, which are impoverished areas that were demarcated for "separate" and discriminatory economic and political development under the policy of apartheid, continue to be the poorest areas in the country. Using a multiple deprivation analysis, Barnes et al., (2009) examined the spatial patterns of child poverty in South Africa and found that maps which show the spatial demography of child poverty closely resemble maps of the former homelands. Children who live in these areas are more likely to be the most deprived in terms of their living environment (including access to piped water, sanitation and safe electricity supply), and are also more likely to have lost one or both parents (Barnes *et al.*, 2009). Stunting, wasting and underweight prevalence for children under 5 is also higher in these regions (McLennan, Noble and Wright, 2016; Osgood-Zimmerman *et al.*, 2018). Approximately 51% of children under the age of four in South Africa live in regions which fell into the former homelands and surrounding regions, and 65% of children live in non-metro local municipalities (StatsSA, 2011b), which implies that reducing poverty in rural and homeland regions is critical for children. What remains to be seen, however, is the different factors which influence child health for single orphans specifically, and if they are more or less likely to experience poor health relative to double orphans who also live in homelands.

Orphanhood and parental absence follow similar geographic patterns in South Africa. The reasons for this are not clearly delineated in the literature; these may, however, be explained by household formation around the elderly who are concentrated in rural areas (Klasen and Woolard, 2009). Additionally, there has been a proliferation of child-headed households in South Africa from the late 1990s. This changed after 2009, when the rate of deaths attributed to HIV/AIDS declined due to the rollout of antiretroviral treatment in South Africa (Simelela *et al.*, 2015). Child-headed households due to HIV pose an additional layer of complexity to household formation in South Africa (Mturi, 2012). Households may also form around cash transfers given to support children and orphans specifically (Hall and Proudlock, 2011), which could explain why orphans are also concentrated in homeland areas. These cash grants and

other public services are targeted towards areas of greatest vulnerability and are designed to mitigate the effects of socioeconomic constraints[52].

The current research findings suggest that poorer South African regions continue to have lower levels of public service provision, such as WASH infrastructure, but are well targeted by means-tested cash grants (Barrientos and DeJong, 2006; Nnadozie, 2013; Bridgman and von Fintel, 2022). South Africa's cash grant system has been found to be critical in reducing child poverty and food insecurity (van der Berg, Patel and Bridgman, 2022). However, orphaned children tend to live in the poorest areas of the country, making them more likely than other children to experience chronic illness due to poor services and lack of nutrition which can lead to stunting (Dillingham and Guerrant, 2004; Fink, Günther and Hill, 2011; Spears, 2013; Badriyah and Syafiq, 2017).

4.3. Data

Three sources of data are consulted; data on Orphaned and Vulnerable Children in South Africa, various years of the National Income Dynamics Study from 2010 to 2012, and the General Household Survey data from 2010 to 2021. These are each described below.

4.3.1. Data on Orphaned and Vulnerable Children in South Africa

The data used in the first analysis is adapted from Bridgman and von Fintel (2022). This dataset combines information from multiple publicly available sources focused on orphaned and vulnerable children (OVC) and service provision in South Africa, and will be referred to as the data on Orphaned and Vulnerable Children in South Africa (OVCSA). The original OVCSA data takes each 2011 electoral ward in South Africa as the unit of observation and contains ward level statistics on multiple geographic and anthropometric features, which can be seen in Table 4.1. In this study, only children aged 0 to 4 are analysed.

The GIS data collection technique has allowed for multiple sources to be linked to enable a spatial analysis of orphanhood, child health outcomes and service provision, as well as the inequalities in these measures. The sources that have been used to create the original OCVSA

[52] This is explicitly stated in South African policy. See the Reconstruction and Development Plan of the Republic of South Africa, (1994), as an example.

dataset include the 2011 South African Community Census, the 2013/14 Audit of Early Childhood Development (ECD) facilities in South Africa, a comprehensive geospatial estimation of child growth failure in South Africa (StatsSA, 2011c; DSD, 2013; Osgood-Zimmerman *et al.*, 2018), and multiple publicly available lists of government facilities.

A household asset index has been created in the data which is used to control for average household asset ownership in an electoral ward. In the 2011 census, ownership of a fridge, an electric or gas stove, washing machine, computer, telephone, TV and/or a radio was ascertained during the survey. The asset index varies between zero and one, and is monotonically increasing in asset ownership, such that higher values indicate that more households in the ward own more of the possible assets, and lower values indicate that fewer households own household assets. For example, a value of one would indicate that all households in the ward own all of the listed assets. The Gini coefficient across wards for this asset index is 0,34, which is lower than the Gini coefficient across individuals for South African income in 2011 (The World Bank, 2020), indicating that this index smooths over variation in individual asset ownership by aggregating at higher spatial units. This results in a lower-bound estimate of the effect of household asset ownership. For a complete description of the asset index construction, see Bridgman and von Fintel (2022). Lastly, regional provision of public infrastructure in the form of tap water and sanitation infrastructure is accounted for to understand whether the effects of household formation and orphanhood can be offset by public social safety nets other than G2P cash transfers.

The original OVCSA uses an online relational database called SuperWeb to access the 2011 South African census, which does not include a measure for parental absence (StatsSA, 2011d). While the 10% sample of the 2011 South African Census has no child health indicators at the ward level, it has information on parental presence at the level of individual children. Furthermore, the individual sample indicates in which local municipalities children live. To acquire child health outcome variables at the local municipal level, the OVCSA ward level data (N=4267) was aggregated to the level of local municipalities in South Africa (N=234) using population weights; this was merged with the aggregated municipal data from the census 10% sample. A more complete description of both data sources can be found in Appendix 4-A.

A variable was constructed with mutually exclusive categories of parental status for individual children in the 10% census sample. There are seven categories: (1) children who live with both parents; (2) children whose parents are alive but the mother is absent; (3) children whose

parents are alive but the father is absent; (4) Children whose both parents are alive but are both absent; (5) maternal orphans; (6) paternal orphans; and (7) double orphans. These mutually exclusive categories are hereafter referred to as a child's "parental status", and are aggregated to municipal level to enable their integration with the spatial stunting data. Critically, the previous paper which uses this data (Bridgman and von Fintel, 2022), does not distinguish between orphanhood and parental absence, and combines the categories "both parents absent" and "double orphan". This current analysis now specifically distinguishes between parental absence and orphanhood and therefore separates these instances into different categories.

The share of children in each local municipality falling into each category was constructed. These categories enable the differences in health outcomes to be assessed depending on whether absent parents remain alive (and are in a position to contribute financially to children's upbringing), or whether they are deceased and no longer able to make financial investments or provide personal care. Figure 4.1 shows the share of children who fall into each category by age. Fewer than 40% of children in South Africa live with both their parents, and this rate does not change considerably as children age, showing that parental absence is a permanent feature of children's living arrangements across the life course. Infants are most likely to live only with their mothers. But as children age, their mothers also become more likely to be absent – likely because they re-enter the labour market. Rates of orphanhood naturally increase as children grow older, with paternal orphanhood being the most severe.

Additionally, information on public and private transfers by municipality was taken from the 2011 General Household Survey (GHS), because this information was not recorded in the census data (StatsSA, 2011a). GHS enumerators ask respondents whether they receive a CSG, an FCG or an Old Age Grant (OAG), among others. Receipt of a CSG and an FCG is identified, and then, following von Fintel and Moses, (2017), grant receipt is aggregated to the local municipality level. This enables the analysis to include a measure of social security receipt at the localised level. The same is done for remittance income, which allows for a measure of private transfer receipt in a municipality. In the data used for this analysis, grant or remittance receipt is defined by the percentage of households who receive a G2P transfer or private transfer, respectively, in the local municipality. The sample of households with children under the age of 4 who live in households that receive each of these transfers was not large enough to be nationally representative. Instead, the percentage of *all* households in the municipality in

receipt of each grant is used to proxy for the level of social security and/or private transfers that flow to benefit children within the municipality.

Figure 4.1: The share of children with absent or deceased parents[53].

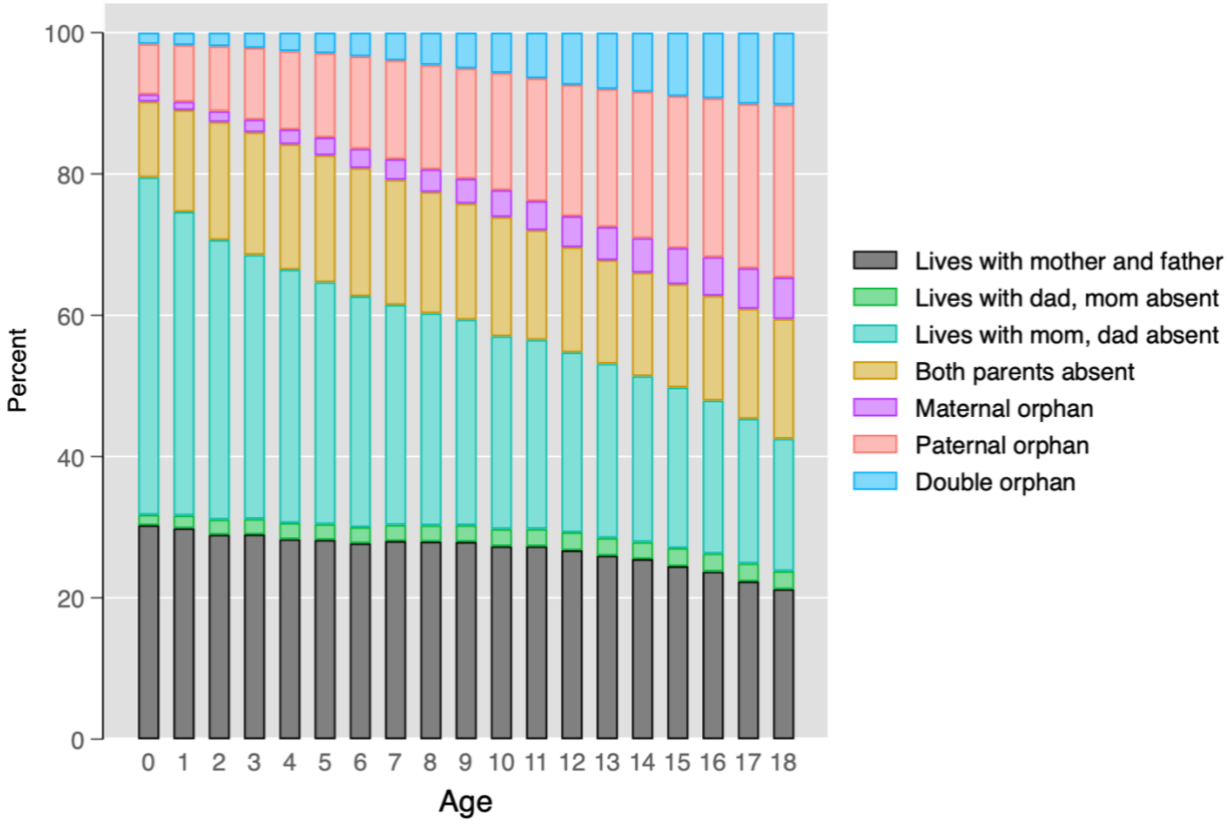

Figure 4.1: The shares of children with absent or deceased mothers and/or fathers.

The primary variables used to measure stunting among OVC in South Africa are the weighted ward-level stunting prevalence rate of children under 5, aggregated to the local municipal level[54]. This variable was acquired from datasets that were estimated by Osgood-Zimmerman *et al*. (2018). A full description of the data compilation and any constructed variables can be seen in Bridgman and von Fintel (2022).

Table 4.1 presents the key descriptive statistics for single orphanhood and parental absence in South Africa in 2011. Paternal, maternal and double orphanhood or parental absence are

[53] The source for all figures in this chapter is from the data described and produced from the author's calculations, unless otherwise stated.
[54] The ward-level population of children aged 0 to 4 was used to weight the ward level estimate of stunting to the level of the local municipality.

mutually exclusive categories – in other words "absence" refers only to children with at least one living parent, where that surviving parent is absent. The national stunting prevalence in 2013 is also provided. These statistics show that paternal absence and paternal orphanhood is more prevalent than maternal absence and maternal orphanhood: in South African municipalities, on average, 9% of children under the age of 4 are paternal orphans and 2% are maternal orphans. Table 4.1 also highlights that having an absent but living father is the most common household configuration for children under the age of 4 (41% of children under 4 on average across municipalities), whereas only 2% of children have an absent but living mother.

Table 4.1: Descriptive statistics of single orphanhood and parental absence by local municipality.

The proportion of children age 0 to 4 who are:	N	Mean	Standard Deviation	Min	Max
Living with both parents	234	27%	0,13	0,06	0,60
Mother absent	234	2%	0,01	0,00	0,04
Father absent	234	41%	0,05	0,24	0,56
Both parents absent	234	17%	0,07	0,04	0,38
Maternal orphan	234	2%	0,01	0,00	0,04
Paternal orphan	234	9%	0,04	0,00	0,28
Double orphan	234	2%	0,01	0,00	0,05
Stunting prevalence 2013	234	28%	0,05	0,19	0,39
Geographic features	N	Proportion of children			
Metro municipalities	8	35%			
Non-metro municipalities	226	65%			
Homeland municipalities	105	51%			

Table 4.1: Descriptive statistics of single orphanhood and parental absence.

Figure 4.2 shows the spatial distribution of stunting prevalence by electoral ward in South Africa. Stunting is concentrated in former homeland regions, but is also high in regions in the centre of the country. Figure 4.3 and Figure 4.4 use the 10% sample of the 2011 census aggregated at the local municipality level to show geographic patterns of parental absence and single orphanhood. Paternal orphanhood is concentrated in the homeland regions. There are higher rates of paternal absence in rural areas relative to urban areas, which is likely due to the history of migrant labour (Budlender and Lund, 2011). While paternal orphanhood is geographically concentrated in homelands, maternal orphanhood is evenly spread across the

country. In some wards, 28% of the children are paternal orphans; in some wards, up to 56% of the children have absent fathers. This geography of orphanhood may be related to child migration, where paternal orphans are sent to live with extended family networks in rural areas. Child migration impacts household composition, but also influences access to services for children, and other factors associated with health ECD such as ELP attendance (Hall and Posel, 2019). The impact of child migration on early childhood developmental outcomes is not in the scope of this chapter, but is a fruitful topic for further research. Please note that the scales of the legends are different.

Figure 4.2: Stunting and underweight by local municipality

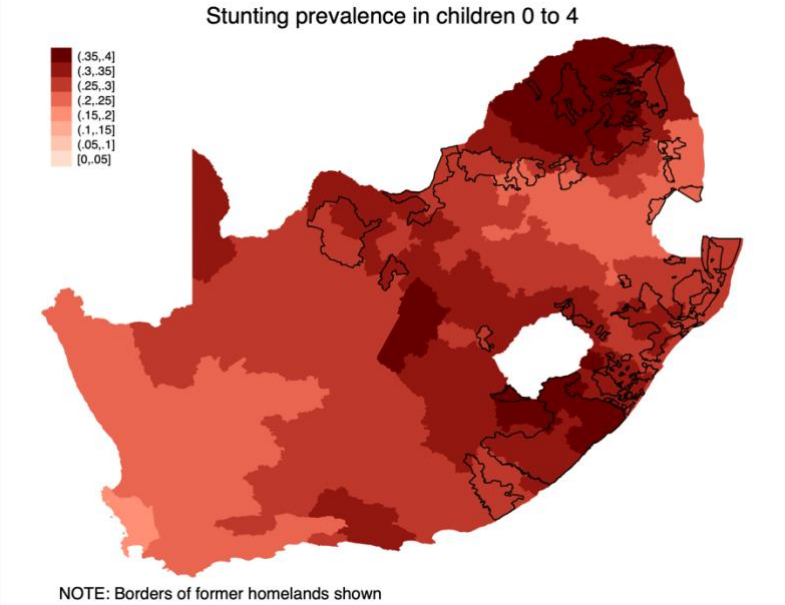

Figure 4.2: Stunting prevalence in children 0 to 4 years

Figure 4.3: Geographic patterns of paternal absence and orphanhood by local municipality.

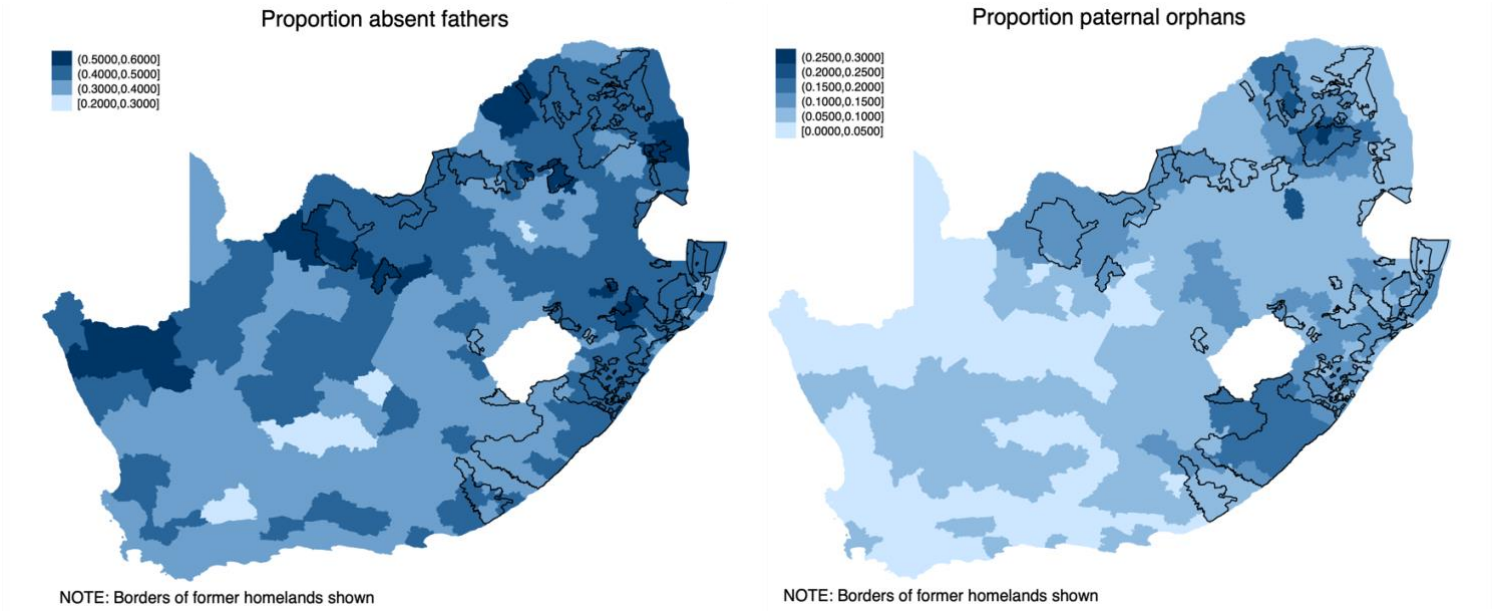

Figure 4.3: Mapping of paternal orphanhood and absence.

Figure 4.4: Geographic patterns of maternal absence and orphanhood by local municipality.

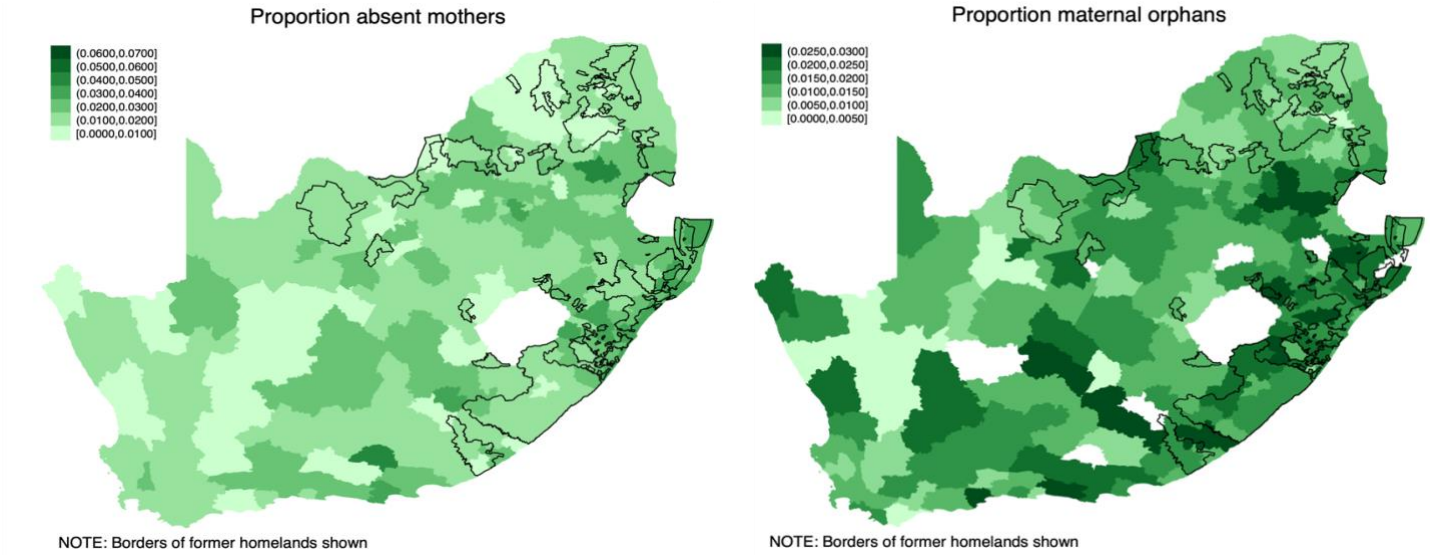

Figure 4.4: Mapping of maternal orphanhood and absence.

As previously noted, children who live in former homeland regions are more likely to live in poorer health-promoting environments (Noble and Wright, 2013; McLennan, Noble and Wright, 2016). Figure 4.3 shows that the probability of orphanhood also carries a significant spatial dimension, where children who live in the former homeland regions are more likely to be paternal orphans relative to children who live in other areas of the country. Due to the lifelong impact of childhood development, this spatial inequality is likely to perpetuate unequal outcomes throughout an individual's life, even if they move to more prosperous regions in adulthood (Shonkoff *et al.*, 2012). Therefore, reducing spatial inequality underlying child health measures will contribute towards reducing overall levels of inequality in South Africa.

Taken together these maps show that there is a strong spatial association between stunting and paternal orphanhood, but the exact relationship between these phenomena is yet to be determined. Both panels in Figure 4.5 present maps of cash transfer receipt. These maps are shaded darker purple where larger proportions of households in a municipality receive a CSG, FCG, OAG or remittance income; those showing "no data" are areas where the 2011 GHS did not survey any households in the local municipality. These figures reveal that there is low FCG receipt in most local municipalities relative to CSG receipt, and that remittance receipt is concentrated in former homeland area.

Figure 4.5: Geographic patterns of cash transfer receipt by local municipality

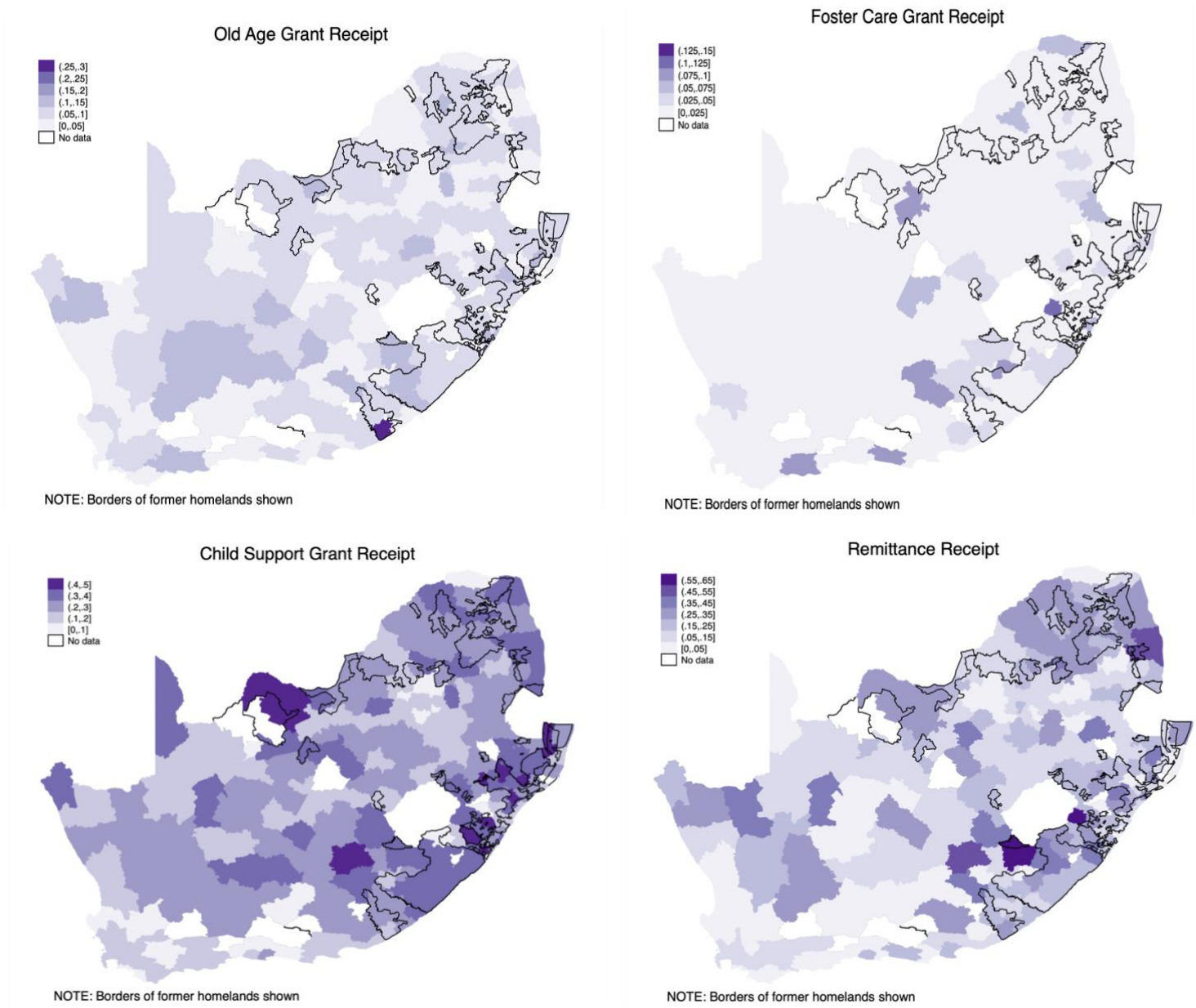

Figure 4.5: Mapping of cash transfers by municipality in South Africa.

4.3.2. The National Income Dynamics Study

The National Income Dynamics Study (NIDS) is used to test the robustness of the stunting results. NIDS data was collected in 5 waves in 2008, 2010/2011, 2012/2013, 2014/2015 and 2016/2017, and has information on the parental status of individual children as well as their stunting status. While this data holds all the information of interest, the significance of the results and the strength of the conclusions drawn from this analysis are hindered by the small sample sizes – the sample sizes are considerably smaller in some categories compared to those in the GHS data described below[55]. The analysis of the NIDS data is used to investigate the impact of parental status on child stunting but should not be consulted for nationally representative results or policy guidance. The first three waves of the NIDS are analysed and presented here; the results of waves 4 and 5 produced null results due to small sample sizes. The results of all 5 waves are available upon request.

There is a multitude of factors which can influence child stunting, including chronic illness, poor nutrition, hidden hunger and air pollution, which may each be influenced by parental status and household income (Aguayo and Menon, 2016; Burger *et al.*, 2022). Therefore, in order to analyse a more straightforward relationship, the relationship between parental status and child *hunger* can be analysed. The relationship between parental status and child stunting is more complex than the relationship between parental status and child hunger (May, 2021; Burger *et al.*, 2022). Child hunger is assumed to be more immediate (relative to stunting, which is a the result of chronic insults to development). Child hunger is also a less complex outcome variable relative to stunting, as there are fewer factors which cause hunger relative to stunting. Therefore, the analysis which uses the General Household Survey (GHS), described below, data captures a more straightforward relationship; as such the analysis of the GHS data is seen as the primary individual-level result from which inference is drawn.

4.3.3. The General Household Survey (GHS)

The individual level GHS data, in multiple years between 2010 and 2021, is used to analyse the effect of parental status on hunger prevalence, a variable not contained in the 2011 census and other sources. This analysis is conducted at the level of individual children. 2010, 2011

[55] For exact cell sizes, please see table C4 in Appendix C.

and 2021 are assumed to be crisis years corresponding to the 2008 Global Financial Crisis and the COVID-19 pandemic, respectively (Maisonnave *et al.*, 2015; Van der Berg, Zuze and Bridgman, 2020; van der Berg, Patel and Bridgman, 2022). 2014, 2015, 2018 and 2019 are considered non-crisis years due to the fact that there were no major economic shocks in these years in South Africa. These repeated cross-sections therefore reveal the effects of parental status in both crisis and non-crisis years.

The GHS does not have data on the health status of individual children, but it does have information on whether or not the household ran out of money for food in the past month and also whether or not a child went hungry. If a child did go hungry, the survey records how often this happened on a 5-point scale from "Never" to "Always". For the purpose of the analysis, a dummy variable is created which indicates if the child went hungry "sometimes", "often" or "always", relative to the child having gone hungry "never" or "seldom". Grant receipt and household remittance receipt is also recorded in the GHS and can be used to control for public and/or private cash transfer receipt.

The GHS data identifies the parental status of individual children such that a comparable parental status variable is constructed in this data corresponding to that in the municipal-level OVCSA data. A variable with mutually exclusive categories of parental status for individual children is created with the same seven categories. As in the OVCSA data, the parental status variable is restricted to children aged 0 to 4 years. Finally, there is a variable that records whether or not the household is urban or rural, as well as a variable which records the monthly household income.

Figure 4.6 shows the proportion of children in each parental status category in each GHS year which is analysed. Between 2010 and 2021, the share of children who have one parent living but absent increased; the share of children with both parents living but absent remained fairly consistent; but the share of paternal orphans decreased from 5,6% to 2,64% over these years. This relative decline in the share of paternal orphans may be due to issues of sampling, whereby the surveys where not designed to detect effects on this specific group, or it may be due to the incidence of fewer paternal orphans in South Africa. The latter reason is more likely due to the relative decline in orphanhood in South Africa because of the rollout of ART treatment for HIV positive parents (Mejia-Pailles *et al.*, 2020). The sample size of paternal orphans aged 0 to 4 was 665 children in 2010; by 2021 that number the sample size was only 77 children.

While this individual level data contains useful information on parental status and hunger for 0 to 4 year olds, the number of children in this age group that fall into each of the seven parental status categories is low, and varies between years, as seen in Figure 4.6. The small sample sizes are understandable given that there are not many children in this age group who fall into some of the categories, but this compromises the statistical power in any given year. Furthermore, the sample size variability limits the confidence with which policy conclusions can be drawn. Therefore, this data is used as a secondary data source to explain the impact of parental status on children alongside the spatial analysis, which is more nationally representative. A table with the exact shares of each parental status can be found in Appendix 4-B.

Figure 4.6: proportion of sampled children in each parental status category

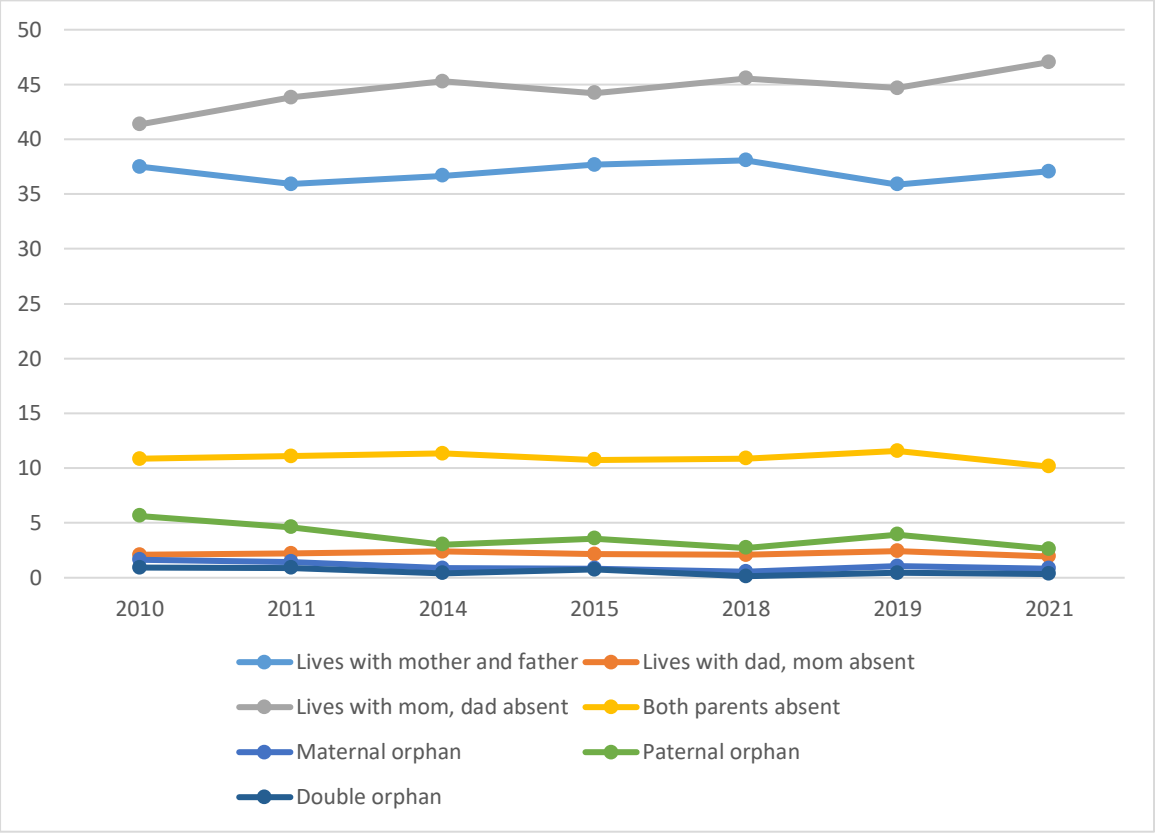

Figure 4.6: sample size for each GHS parental status category.

4.4. Methodology

This paper uses multiple models to analyse the effects of parental status (in terms of whether they are deceased, and whether they are absent) on chronic child health outcomes in children

aged 0 to 4 years in South Africa. The analysis also investigates whether increased receipt of private and/or public cash transfers mitigates the effect of parental status.

The first analysis uses spatial patterns in stunting prevalence to measure chronic child ill-health. The effects are estimated with spatial autocorrelation regression (SAR) models, which account for statistical biases which arise from spatial data. The following equation is estimated:

Equation 4.1:

$$child\ nutrition_i = \beta_0 + \beta_1 parental\_status + \boldsymbol{\delta}'_i \boldsymbol{x}_i + \boldsymbol{\beta}'_2 W \boldsymbol{x}_i + (I - \rho W)^{-1} u_i ;$$

where the child nutrition outcome is stunting prevalence by local municipality. Spatial econometric models are estimated, where South African local municipalities (i) are the unit of analysis. Control variables ($\boldsymbol{x}$) include regional access to social protection infrastructure. The control variables are included to assess whether social safety nets mitigate the impacts of household formation. The row-normalised rook weighting matrix (W) is used to model geographic spill overs from neighbouring regions in both unobservable regional characteristics (u_i) and other covariates. Spatial weighting introduces regional network effects to the model, absorbing a range of statistical biases, including spatially correlated error terms (Anselin, 1999, 2010; Anselin, Gallo and Jayet, 2008). The association between parental status in 2011 and stunting in 2013 is estimated. The time difference between the treatment and outcome is introduced because stunting is a measure of chronic poor health, which is only likely to present over a longer period of time (de Onis and Branca, 2016).

The second set of analyses utilise multiple years in the GHS and NIDS wave 1 to 3. These individual-level data allow for the following specification:

Equation 4:2

$$child\ nutrition_i = \beta_0 + \beta_1 parental\_status + \boldsymbol{\delta}'_i \boldsymbol{x}_i + u_i ;$$

where child nutrition is either child hunger or stunting in the GHS and NIDS data, respectively. Ordinary least square regressions are estimated, which may not account for biases associated with spatial dependence. The models which use the GHS data are Linear Probability Models. Where child hunger is used as an outcome, the variable is an indicator variable which is equal to one when it is reported that the child experienced hunger sometimes, often, or always.

Control variables ($\boldsymbol{x}$) include the log of household income, household receipt of FCG, CSG and/or and OAG, and a control for the receipt of remittance income. Household access to tap water less than 200m from the house as well as a flush toilet are also included as control variables.

4.5. Results

4.5.1. Spatial municipal-level analysis of stunting rates

This section presents findings on how chronic ill-health outcomes and child hunger are associated with parental status. The geographic patterns shown in section 3 raise a number of possible explanations for spatial inequality in nutrition outcomes in South Africa which will be explored. Table 4.2. displays the associations between parental status in 2011, and municipal stunting prevalence in 2013. All specifications include a spatially weighted error term, which is warranted by the high and significant estimates of residual autocorrelation estimates ($\boldsymbol{\rho}$) of above 0,85 in each specification. Column 1 confirms that stunting is significantly lower where a higher share of children live with both parents, relative to all other parental status shares. The share of children living with both parents is not included in columns 2 – 8, because it is the reference category[56].

Column 2 includes the share of maternal, paternal and double orphans in a municipality. Stunting is significantly higher in regions with higher paternal orphan shares relative to regions with higher rates of absent *or* present living parents. Appendix 4-E shows that a 1-standard-deviation change in the share of children who are paternal orphans is associated with a 0,65% increase in stunting in an area. Column 3 goes on to include the share of children with absent but living mothers and/or fathers. These results reveal that areas with higher shares of paternal orphanhood have significantly higher stunting prevalence relative to the reference category. A high share of double absenteeism is positively associated with stunting prevalence. This

[56] A robustness check is presented in Appendix 4-E that shows the associations between each share of parental status separately using standardised parental status shares. The results confirm those discussed in this section.

corresponds with the higher vulnerability that children face with neither parent present in the home (Bridgman and von Fintel, 2022)[57].

Columns 4, 5 and 6 include CSG receipt, FCG receipt and OAG receipt in the local municipality. CSG receipt has a positive association with stunting prevalence, which suggests that the CSG is targeted to regions with elevated stunting rates. This indicates that the grant is well targeted, but may not be large enough to reduce stunting. There is no significant relationship between FCG receipt and stunting in this model. This does not imply that the grant is ineffective, but rather that the grant value is not high enough, or is not received by enough children to have a significant effect on local stunting rates. The OAG has a negative and significant relationship with stunting. This relationship is consistent with the literature that shows that there is a positive association between OAG receipt and child health, especially in households where the OAG recipient is female (Duflo, 2000). These controls do little to change the core relationships identified between regional parental status shares and stunting rates, suggesting that G2P payments do not systematically break the link between these factors. There continues to be a positive association between higher shares of paternal orphans and stunting prevalence; one exception is that the control for CSG receipt in the municipality removes the significance of the stunting penalty associated with double absenteeism. This indicates that CSG receipt is well targeted to these children, and may aid their long-term development (Agüero, Carter and Woolard, 2006; Waidler and Devereux, 2019).

Column 7 controls for the average level of household asset ownership in a local municipality. This variable accounts for household resources more generally. In other words, these assets may have been generated not only by G2P payments, but may arise from other sources of income, including from *local* employment and private remittances from other locations. With the addition of this control, the stunting penalty experienced by paternal orphans becomes statistically insignificant. This finding is consistent with the hypothesis that lower household asset ownership could be an important mechanism which contributes to the paternal orphan stunting penalty.

[57] Critically, this previous paper does not distinguish between orphanhood and parental absence, having combined the categories "both parents living but absent" and "double orphan". This current analysis now distinguishes between parental absence and orphanhood.

Table 4.2: Stunting and parental status

	Child Stunting Prevalence								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Share lives with both parents	-0.0416**								
	(0.0162)								
Share double orphan		0.0594	-0.0149	0.0696	0.0959	0.0707	-0.1299	0.1836	0.0880
		(0.1516)	(0.1547)	(0.1667)	(0.1712)	(0.1665)	(0.1341)	(0.1718)	(0.1106)
Share paternal orphan		0.1393***	0.0920*	0.1279**	0.1487***	0.1438***	0.0672	0.1356**	0.0516
		(0.0503)	(0.0524)	(0.0550)	(0.0559)	(0.0556)	(0.0462)	(0.0556)	(0.0362)
Share maternal orphan		0.0115	-0.0995	-0.0388	-0.2032	-0.0713	-0.0594	-0.1449	0.1240
		(0.2160)	(0.2173)	(0.2363)	(0.2446)	(0.2339)	(0.1869)	(0.2380)	(0.1532)
Share both absent			0.0810***	0.0370	0.0650**	0.0794**	-0.0084	0.0453	0.0041
			(0.0310)	(0.0343)	(0.0330)	(0.0335)	(0.0296)	(0.0335)	(0.0248)
Share dad absent			-0.0265	-0.0227	-0.0086	-0.0086	-0.0539**	-0.0194	-0.0041
			(0.0286)	(0.0315)	(0.0320)	(0.0311)	(0.0249)	(0.0319)	(0.0216)
Share mom absent			-0.3158	-0.2210	-0.2498	-0.3411	-0.2037	-0.2077	0.1356
			(0.1927)	(0.2177)	(0.2225)	(0.2202)	(0.1681)	(0.2211)	(0.1481)
Municipality CSG receipt				0.0394**					0.0228*
				(0.0180)					(0.0119)
Municipality FCG receipt					0.1165				0.0332
					(0.0760)				(0.0483)
Municipality OAG receipt						-0.0833*			-0.0406
						(0.0496)			(0.0328)
HH asset index							-0.0358***		-0.0201***
							(0.0050)		(0.0051)
MN Remittance receipt								0.0318**	0.0236***
								(0.0129)	(0.0082)
Metro									-0.0186***
									(0.0047)
Homeland									-0.0007
									(0.0053)
Provincial fixed effects									Yes
WASH Controls									Yes
Constant	0.2987***	0.2739***	0.2849***	0.2739***	0.2724***	0.2768***	0.2611***	0.2742***	0.2697***
	(0.0096)	(0.0091)	(0.0161)	(0.0171)	(0.0173)	(0.0171)	(0.0155)	(0.0172)	(0.0180)
N	234	234	234	222	222	222	234	222	222

NOTE: * p<0.1, ** p<0.05, *** p<0.01. Source: own calculations. ρ varies between 0.91 and 0.89 for all specifications.

Table 4.2: Stunting and parental status: Spatial Autocorrelation Regression results.

While grants do not remove the stunting penalty in areas with higher shares of paternal orphans relative to the reference category, the general household environment does remove this penalty. This finding points to a role for material household circumstances as a critical factor in improving child health for vulnerable children, but not from G2P. This finding corresponds with the literature on education outcomes for single orphans, which concludes that paternal orphans are more likely to have lower educational outcomes because of reduced socioeconomic status (Case and Ardington, 2006; Ardington and Leibbrandt, 2010). Likewise, Table 4.2 suggests that paternal orphans are more vulnerable to lower health outcomes due to reduced socioeconomic status. We are, however, unable to use the spatial data to verify what aspects of household socioeconomic status determine the overlap between household composition and stunting rates. Later analysis using micro data will explore this proposition in finer detail, albeit acknowledging other weaknesses in that data.

Column 8 includes controls for remittance receipt, which is significantly positively associated with stunting prevalence, but does not change the relationship between regional parental status shares and stunting. Remittances are therefore well-targeted to areas with higher stunting prevalence, but child stunting remains high in areas with higher shares of paternal orphans even when they benefit from this type of income. This is consistent with the hypothesis that orphans are less likely to receive *private* transfers. The positive effect of remittance income on child education and food security is, however, confirmed in the literature (Lu and Treiman, 2011; Waidler and Devereux, 2019).

Column 9 in Table 4.2. includes controls for grant receipt, household asset ownership and remittance receipt, and includes access to public WASH infrastructure and provincial fixed effects. Access to water and sanitation is particularly important in reducing stunting (Dillingham and Guerrant, 2004). With the inclusion of provincial fixed effects, there no longer a paternal orphan stunting penalty. Remittance income alone is no longer significantly associated with stunting in this final specification, but household asset ownership overall is again negatively and significantly associated with stunting. By implication, stunting is reduced in households with higher asset ownership. This suggests that other factors as well as remittance income improve household socioeconomic circumstances to the extent that it can mitigate a stunting penalty. The factors which improve household circumstances remain unexplained here. A natural experiment in Gambia confirms that a relatively high socioeconomic status threshold exists before significant gains in child nutritional outcomes are

realised (Husseini *et al.*, 2018), a hypothesis which is consistent with results in this final specification.

Crucially, when provincial fixed effects are included in the model the paternal orphan stunting penalty is no longer statistically significant, which suggests that the provincial differences in stunting rates largely explains why paternal orphanhood shares and stunting prevalence are concurrently elevated. This finding suggests that provincial administration is critical in supporting paternal orphans. This finding is consistent with the hypothesis that strong local state capacity is critical for child development. Provincial administration could support healthcare and educational services towards paternal orphans more specifically in provinces where paternal orphanhood is more common. The policies should be provincially-specific and developed in collaboration with local communities, taking into account cultural nuances and the unique challenges faced by paternal orphans in a particular region.

4.5.1. Individual level analysis

For a robustness test of the spatial analysis of stunting, comparable regressions are estimated using individual level data. The same sets of regressions are estimated using data from waves 1 to 3 of the National Income Dynamics Study (NIDS) in South Africa. The parental status of individual children is identified exactly as in the OVCSA data, and stunting is used as the outcome variable. As discussed above, the small sample size reduces the power of statistical tests, but the overall patterns in these results remain the same. The signs of the coefficients are comparable, but insignificant in all waves but wave 2 in 2010. Table 4-B2 indicates that in 2010, there was a significant stunting penalty for paternal orphans, for children with living but absent fathers, and for children with both parents living but absent[58]. Please see Appendix 4-C for these results and a further discussion.

Further individual level regressions are estimated using the GHS. OLS regressions are used with standard errors clustered at the household level. Table 4.3 includes the full specifications for each year, which is comparable to the final specification in Table 4.2. The full tables using

[58] The small sample size renders further discussion of these results unwise. The effect of the 2008 financial crisis may have influenced the sample as well as the result.

GHS data with specifications as in the full version of Table 4.2. for each year can be found in Appendix 4-B.

Table 4.3: Child hunger and parental status – individual level results

	Child Hunger (sometimes, often, or always)						
	2021	2019	2018	2015	2014	2011	2010
Mom absent	0.0463	0.1055***	0.0186	0.0836**	0.0570	0.0516	0.0678
	(0.0631)	(0.0377)	(0.0414)	(0.0423)	(0.0442)	(0.0415)	(0.0604)
Dad absent	0.0479*	0.0645***	0.0451***	0.0467***	0.0487***	0.0144	0.0531***
	(0.0247)	(0.0140)	(0.0137)	(0.0144)	(0.0152)	(0.0158)	(0.0168)
Both absent	0.0380	0.0627***	0.0292	0.0396**	0.0172	0.0101	0.0196
	(0.0345)	(0.0180)	(0.0183)	(0.0183)	(0.0176)	(0.0204)	(0.0216)
Maternal orphan	-0.0835***	-0.0194	0.0780	0.0260	0.1110**	0.0455	0.1531***
	(0.0272)	(0.0301)	(0.0676)	(0.0469)	(0.0540)	(0.0465)	(0.0570)
Paternal orphan	0.1827**	0.0801***	0.0036	0.0759***	0.0663**	0.0443*	0.0703**
	(0.0724)	(0.0304)	(0.0262)	(0.0270)	(0.0304)	(0.0267)	(0.0325)
Double orphan	-0.0509	0.0923	0.1830	0.0280	-0.0112	0.0304	0.0636
	(0.0504)	(0.0726)	(0.1250)	(0.0868)	(0.0397)	(0.0711)	(0.0594)
Log HH Income[1]	-0.0515***	-0.0370***	-0.0357***	-0.0391***	-0.0617***	-0.0545***	-0.0585***
	(0.0144)	(0.0057)	(0.0057)	(0.0072)	(0.0081)	(0.0074)	(0.0083)
CSG receipt	0.6541**	0.0384	-0.0036	0.0859**	0.0281	0.0936	0.0911
	(0.3143)	(0.0580)	(0.0491)	(0.0336)	(0.0541)	(0.0604)	(0.0661)
FCG receipt	0.5480*	-0.0832	0.0979	0.0873	-0.1305**	0.1787	0.1118
	(0.2991)	(0.0667)	(0.1209)	(0.0893)	(0.0616)	(0.1212)	(0.0942)
Remittance receipt	-0.0608**	-0.0047	-0.0676***	-0.0423***	-0.0276*	-0.0404**	-0.0898***
	(0.0256)	(0.0177)	(0.0155)	(0.0156)	(0.0166)	(0.0160)	(0.0192)
Urban control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Flush Toilet	0.0010	0.0327	-0.0584***	-0.0808***	-0.0354	-0.0111	-0.0320
	(0.0407)	(0.0218)	(0.0217)	(0.0219)	(0.0257)	(0.0259)	(0.0247)
Tap water	0.0037	-0.0409**	-0.0474***	-0.0650***	-0.0142	-0.0552***	-0.0722***
	(0.0274)	(0.0167)	(0.0172)	(0.0173)	(0.0187)	(0.0184)	(0.0185)
Provincial Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.0254	0.4220***	0.5492***	0.6028***	0.7569***	0.6177***	0.7130***
	(0.3531)	(0.0866)	(0.0803)	(0.0771)	(0.0958)	(0.0954)	(0.1036)
R-squared	0.034	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262
N	7477	7052	7052	7052	7052	7052	7052

* p<0.1, ** p<0.05, *** p<0.01. [1] The natural logarithm of HH income is used.

Table 4.3: Child hunger and parental status – individual level results

The results in Table 4.3 reveal that paternal orphans are more likely to go hungry than children who live with both of their parents in 6 out of these 7 years which are analysed[59]. Children with absent fathers are also more likely to go hungry in 6 out of 7 years. Since food security is critical in promoting child health, these individual-level results reveal that children without fathers – either due to death or absence – are more vulnerable to poor health outcomes, regardless of whether they are observed in crisis or non-crisis years. As in Table 4.2, the control for CSG receipt in Table 4.3 is positive and significant, and the control for FCG receipt is insignificant. This corresponds with columns 4 and 5 in Table 4.2.

Controlling for G2P transfers does not alter the associations between household composition and the outcome, in this case hunger. The coefficient on household income is negative and significant in each year, and remittance income is negative and significant in 6 out of 7 years. This suggests that both of these factors significantly reduce hunger in a household, but that more than remittance income alone is important for the overall effect of household income on hunger. There may be other mechanisms such as labour market income which accounts for the reduced hunger in households with higher household income. In these regressions, the hunger penalty associated with paternal orphanhood and paternal absence remains significant once provincial fixed effects are included.

4.6. The importance of household environment on child health: a discussion

The findings in the spatial analysis show that paternal orphans are more likely to be stunted relative to children with another parental status. Areas with higher rates of paternal absence do not have higher stunting prevalence. However, children without fathers – either because of death or absence – are significantly more vulnerable to hunger relative to other children of the same socioeconomic status in the individual-level results. Poor nutrition is likely to lead to poor chronic health outcomes for both these groups of children in later years (Muthayya *et al.*, 2013).

[59] The insignificant result on paternal orphanhood in 2018 could be due to a low sample size in that year. See table B9 in the appendix.

The spatial analysis uses data that is over 10 years old, because updated data with the necessary detail are not yet available. However, the individual level results in Table 3 using data from 2010 to 2021 show that paternal orphans were more likely to live in households where children went hungry in 2011, and are still more likely to be hungry relative to other children a decade later. Inadequate nutrition, even if the child went hungry (or received inadequate food) only once a week, can lead to malnutrition and hidden hunger which leads to stunting (Muthayya *et al.*, 2013; Roser and Richie, 2019). Hidden hunger occurs when a child does not have sufficient vitamin intake to allow them to grow to their full potential. Therefore, food insecurity in a household can decrease food diversity and increase hidden hunger, leading to stunting (van der Berg, Patel and Bridgman, 2022). This implies that even in more recent years, paternal orphans have a nutritional disadvantage.

Therefore, taken together and with the timing of the data in mind, these results reveal that paternal orphans were severely disadvantaged by the age of 4 in terms of stunting in 2011 and are likely to still be severely disadvantaged in 2021. The results further reveal that father absenteeism may cause poor health in later years due to malnutrition and hunger, and that these children may also become stunted.

Private household resources moderate the association between paternal orphanhood and stunting in the spatial analysis but do not fully moderate the hunger penalty in the individual level results. This result seems incongruent since household resources decrease the likelihood of stunting, but do not decrease the likelihood of hunger which is a contributing factor to child stunting. The incongruence may be explained by the fact that there are many known causes of stunting, including chronic diarrhoeal illness, hidden hunger, and air pollution (Aguayo and Menon, 2016; Burger *et al.*, 2022), and is also a condition which presents itself after chronic insults to development (Leroy and Frongillo, 2019). Household resources may help to moderate the increased likelihood for paternal orphans to be exposed to other risk factors which are associated with child stunting, thereby moderating the association between paternal orphanhood and stunting. Alternatively, since stunting is defined as a height-for-age z-score of less than two standard deviations from the mean of the 2006 WHO reference population, additional private household resources may help to reduce hunger to the extent that children may not be stunted by the formal definition (i.e.. they may be between -1 and -2 standard deviations). Therefore, while household resources moderate the stunting penalty for paternal orphans, it is conceivable that household resources would not counteract the absent father

hunger penalty, especially if there is an unexplained additional burden associated with paternal absence which leads to child hunger. Even if a child is not stunted by the formal definition, the insults to development which cause stunting, such as poor nutrition, still negatively impact a child's health (Cole, 2012; Ekholuenetale *et al.*, 2020).

This indicates that the household resources are an important influence which counteracts the paternal orphan stunting penalty. However, household income and grant income do not mitigate the hunger penalty for paternal orphans in the GHS hunger results; and neither household income, grant income nor remittance income moderate the hunger penalty associated with father absenteeism in the GHS results. This reveals that there remains an unexplained penalty associated with paternal orphanhood and absence which is not caused by reduced socioeconomic status. While absent fathers still have the ability to contribute financially to invest in their children's health, there is no evidence in these results that remittance income from absent fathers improves child health. Grant income and access to WASH services does not moderate stunting penalties associated with paternal orphanhood in the spatial analysis or the individual level analysis.

The lack of association between higher rates of maternal orphanhood and stunting prevalence could be explained by the increased tendency for children to migrate to different areas to live with extended family networks to best care for the child (Hall and Posel, 2019). Individual level results from 2021 show that maternal and double orphans are less likely to go hungry sometimes, often or always, relative to other children. This result could indicate that maternal and double orphans benefited from the relief measures put in place by the South African government in 2020 and 2021 to mitigate the effects of the COVID-19 pandemic and related lockdown measures (van der Berg, Patel and Bridgman, 2022). This points towards the complex and dynamic way in which many households in South Africa form to protect the most vulnerable (Budlender and Lund, 2011; Hall and Posel, 2019), and specifically the way in which extended family networks absorb children who have lost their parents.

These models do not control for socioeconomic status beyond the average household asset ownership (in the spatial models) or average monthly income (in the GHS models). Therefore, while material household circumstances moderate the stunting penalty, the question as to how the household environment improves nutrition outcomes remains unclear. The household environment could be improved through remittance income from other family members, labour market income, or other grant income among other factors. While G2P are eliminated as a

moderating factor in child stunting and for the paternal orphan hunger penalty, there is compelling evidence that cash transfers in South Africa are crucial poverty alleviation mechanisms. This is especially true of the CSG, which is well targeted to the poorest households (Patel, Knijn and Van Wel, 2015), increases child school enrolment and attendance for disadvantaged children (Case, Hosegood and Lund, 2005), and significantly improve rural living conditions and livelihoods (Hajdu *et al.*, 2020). Improving socioeconomic status in other ways does correlate strongly with child outcomes and parental status. We infer that remittances may play an important role in this regard due to the significant and negative coefficients in Table 3, but this residual explanation does not necessarily eliminate other possible channels.

A feature of this residual explanation could be the mis-targeting of Foster Care Grants. The FCG is larger than the CSG, standing at R 1070 (USD 59) per month per child in 2022, in comparison to the R480 (USD 27) CSG per child per month (Republic of South Africa, 2022). While many children receive the FCG, it is not necessarily well targeted to those children who are most in need of greater financial assistance (Hall and Proudlock, 2011). In 2002, the Foster Care Grant (FCG) eligibility criteria changed in order to allow relatives who cared for orphaned children to receive the grant. While this increased the reach of the grant, the involved administrative process and renewal procedure of the FCG created an insurmountable administrative burden after more people became eligible. This caused many FCGs to lapse if the Children's Court was overwhelmed, potentially allowing the most vulnerable children to fall through the cracks (Hall and Proudlock, 2011). These time lags in receiving the grant have not yet been resolved, with the result that many children do not receive the FCG because of administrative lags (Sibanda and Ndamba, 2023).

Therefore, the insignificant effect of FCG receipt on child stunting and hunger could be explained by administrative lags that prevent eligible children from receiving the FCG. This administrative lag was severe in 2011, at the time when the data used in the OVCSA data was collected. However, the insignificant effect of FCG receipt in the 2021 GHS hunger results supports the notion that there is still, one decade later, an administrative lag in eligible children receiving a FCG. The results of this analysis show that this type of transfer, which is directly targeted at improving the household environment, could work towards improving chronic child health outcomes.

This study shows that two in five South African children under the age of four have living but absent fathers. Staggeringly, every second child in South Africa under the age of four grows

up without their father in the household either because he is absent or deceased. Tables 4.2 and 4.3 show that father absence and death is negatively related to child health outcomes (hunger and stunting), and there is reason to believe that there are other negative consequences of father absence. Father involvement in infancy is linked to improved emotional security in children and more confidence in exploration of their environment (Yeung, Duncan and Hill, 2000), while children playing with their father is further linked to emotional and behavioural regulation (Weatherspoon *et al.*, 2015). Multiple other studies confirm that greater father involvement in a child's life is associated with higher academic achievement, greater readiness for school, stronger development in mathematics and verbal skills, higher self-esteem, and a lower likelihood of exhibiting problematic behaviour (Volling and Belsky, 1992; Yeung, Duncan and Hill, 2000; Flouri and Buchanan, 2003; Sarkadi *et al.*, 2007).

These studies largely come from HIC contexts, where the household income and environment may be less critical in determining child health because the household environment is healthier in general. However, the mechanism through which these outcomes are caused is linked to the difference in father-interactions relative to mother-interactions. This mechanism is also likely to be present in South African contexts, over and above the impact of the household environment. Therefore, further research needs to be conducted in a South African context regarding the effect of the significant paternal absence which characterises South African society (Makusha and Richter, 2015), over and above the importance of household environment. These results reveal that the household environment is more critical to child health in South Africa relative to HIC contexts, but the lack of father-interactions for many children in South Africa is likely to have comparable effects to those demonstrated in HIC contexts (Ward, Makusha and Bray, 2015).

Finally, it is important to note that the primary analysis in this study is a spatial analysis, which has drawn conclusions based on the significant spatial associations that have been found. This particular analysis is not an analysis of individual children, which implies single orphanhood and parental absence of individual children has not been associated with their own nutrition and food security outcomes, but rather a representative group from their regions. However, individual-level results using other data (from sources which have their own deficiencies) support the spatial results. Still neither can be considered causal estimates because of standard econometric biases. Small sample sizes in the individual level data have the consequence of limiting the representativeness of the findings for particular parental status groups. This field

of research regarding the health impact of parental status on children remains underdeveloped; these findings are preliminary associations that improve the understanding of the spatial demography of single orphanhood and parental absence.

4.7. Conclusion

This paper sheds light on the impacts of parental death or absence on child health outcomes of hunger and stunting in South Africa. The results highlight that paternal orphans and children with absent fathers are vulnerable to worse nutritional outcomes relative to all other children; additionally, paternal orphans have a significant stunting penalty. With the addition of a control for higher socioeconomic status, the stunting penalty experienced by paternal orphans becomes statistically insignificant. This finding is consistent with the hypothesis that lower household asset ownership could be an important mechanism which contributes to the paternal orphan stunting penalty. The household resource base could be improved through remittance income from other family members, labour market income, or other grant income among other factors.

These findings are consistent with those from a natural experiment in Gambia which reveals that a relatively high socioeconomic status threshold exists before significant gains in child nutritional status are realised (Husseini *et al.*, 2018). Therefore, while these multiple income sources significantly reduce hunger in a household, more than remittance income or grant income alone is important for the overall effect of household income on hunger. While G2P was eliminated as a moderating factor, the analysis finds that improving socioeconomic status in other ways does correlate strongly with child outcomes and parental status. Remittances may play an important role in this regard due to the significance of remittance income in reducing hunger, as seen in the analysis of individual child outcomes, but this residual explanation does not necessarily eliminate other possible channels.

Children with absent parents are more likely to benefit from private cash transfers relative to those who are orphans. Orphans are more likely to receive larger public G2P transfers. However, the data points to an insignificant effect of FCG receipt, even in 2021; this may be due to an administrative lag in eligible children receiving an FCG. This is reportedly still the case almost two decades after the renewal procedures of this grant were changed in 2002. The results of this analysis show that this type of grant, which is directly targeted at improving the household environment, could work towards improving chronic child health outcomes. However, the administrative process in these types of grants must be improved in LMIC

contexts for these grants to be effective in the broader target population. The results in this chapter suggest that allocating resources and research towards addressing these administrative backlogs significantly improve many children's lives. These results indicate that, in the meantime, private transfers may be more effective in improving household environment relative to G2P transfers in developing contexts. The improvement in household environment, when it does occur, improves child health.

This research contributes to the literature on child nutrition inequalities, focusing particularly on the regional dimensions of stunting and parental absence or death. Due to the lifelong impact of childhood development, this inequality in health outcomes due to spatial inequality is likely to be perpetuated throughout the child's life, even if that child moves to more prosperous regions in adulthood (Shonkoff *et al.*, 2012). The aim of mitigating policy should be to reduce spatial inequality in child health measures in order to contribute towards reducing overall levels of inequality in South Africa. The spatial analysis in this chapter allow for targeted intervention in municipalities with higher paternal orphanhood, and also aids policymaking which is spatially nuanced and appropriate.

CHAPTER FIVE

5. CONCLUSION

There is increasing consensus regarding the multiple inputs that children need for healthy development (Britto *et al.*, 2017), but there is a gap in the literature as to *how* these elements can successfully be provided, especially in LMICs. The research presented in this thesis contributes towards a bank of evidence which addresses this knowledge gap by exploring how children in LMICs can be provided with the necessary context for healthy development. The thesis does so by measuring service provision for children which supports healthy ECD and by identifying barriers to the successful provision of services which support nurturing care in LMIC contexts, seeking to bridge the gap between policy and implementation. The thesis also adds to the growing literature on the importance of a comprehensive approach to ECD – rather than only ECE – and emphasises the need for a broader approach to ensure healthy child development.

In 2022, a significant number of children in LMICs had not reached their full potential, primarily due to environmental risk factors that they experience in their home and neighbourhood, and due to poor local government capacity for service delivery (Walker *et al.*, 2007). The foundations are laid for human development later in life during early childhood, which makes the provision of a context for healthy early development in LMICs a pressing concern. As such, healthy cognitive and physical child development in LMICs will benefit both the children and the economies of these countries, boosting long-term productivity.

The foundations which are laid in early childhood include increased capacity to learn (Britto *et al.*, 2017); lower risk of non-communicable diseases and heart disease (García *et al.*, 2020); a higher capacity for children to unlock their full potential even in the face of adversity (Daelmans, Manji and Raina, 2021); and the capacity for higher life-time earnings (Gertler *et al.*, 2014). While healthy ECD is beneficial to individual children for these reasons, it also benefits society. The public benefits of ECD include lower public health care spending, higher productivity, and lower crime rates (Dewey and Begum, 2011; Karoly, 2012; García *et al.*, 2020), as well as higher potential economic growth. Conversely, poor ECD hinders individual flourishing, but also reduces labour market productivity and economic growth potential. Because ECD services produce public benefits, it should be viewed as a public good which

falls into the category of services which need coordination for equitable provision. The economic framework therefore provides an essential toolkit to study the efficient and equitable provision of ECD.

Access to high-quality ECD support for disadvantaged children enables greater parental labour market participation, thus potentially boosting productivity in the short-term, but also reduces the gap between rich and poor children, reducing inequality of opportunity (J. Heckman, 2008; Magnuson and Duncan, 2016). Poor health and poor cognitive development are cited as two of the leading causes for the generational transmission of poverty (Del Boca, Flinn and Wiswall, 2014; Liao, Zhang and Zhang, 2022). Therefore, investing in young children towards the improvement of their long-term health and cognitive development holds the potential to overcome vicious cycles of intergenerational poverty (Heckman and Karapakula, 2019).

5.1. Chapter summaries

Three separate but related research questions are investigated in chapters two, three and four of this thesis. Chapter two investigates *where* children receive the services required to provide a context which enables healthy childhood development and goes on to validate this measure. Chapter three builds on the findings of chapter two and investigates the barriers to public service provision. Chapter four turns toward internal household caregiving dynamics based on a spatial analysis of the health implications of parental death or absence.

5.1.1. Chapter two

Chapter two is motivated by the growing understanding of nurturing care and starts by conceptualising the multiple features which make up nurturing care as concurrently complementary inputs. There is a gap in the current literature on how the provision of ECD services is measured, and as such, the first chapter focuses on proposing a measurement of ECD service provision which takes the combination of services which are needed into account and validating the index which is created. This paper is a response to the call to broaden data- and evidence-gathering systems, and foster multisectoral programming for ECD (UNICEF, 2017).

The chapter proposes that Multidimensional Poverty Index (MPI) methodology can be used to create an index of multidimensional service delivery for children in LMIC contexts at a sub-

national level. This exercise is successfully completed using South African data and shows that many children in South Africa do not receive the full complement of the services they need to grow healthily.

A first validation of this measure is provided by assessing whether the ECD services index correlates with individual child outcomes. The chapter demonstrates a positive correlation between public infrastructure service delivery and child cognitive outcomes, suggesting that improved municipal environments complement ELP attendance. This chapter reveals that public infrastructure services such as water and sanitation services, waste removal, roads, municipal electricity provision, and safety are concurrently complementary inputs to ELP attendance, but are not well provided in many regions of South Africa. These services require a network of infrastructure.

5.1.2. Chapter three

Following on from this finding, chapter three investigates the barriers to the provision of services which require a network of infrastructure, such as water and sanitation, roads, electricity and so forth. The uneven provision of these services in developing regions perpetuates regional inequalities in realising children's developmental potential (Chisadza *et al.*, 2023). This paper was motivated by the need to improve delivery of these essential services through system strengthening, which is an essential requirement to improved nurturing care (UNICEF, 2017).

This chapter draws on two original datasets and an institutional economics approach to examine the impacts of terrain ruggedness and spatial variation in local state capacity on the implementation of national development policies and access to public health infrastructure. This chapter defines local state capacity as all the elements that are important for the proper functioning of the state, including human capacity, physical infrastructure, and the ability to provide an environment which is conducive to economic growth (Acemoglu, 2005; Besley, 2011). To account for differing levels of local state capacity, the analysis uses former homeland boundaries. Former South African homelands, or “Bantustans”, were subject to decades of discriminatory policies during the apartheid era that designated areas in which black South Africans could live. In many of these homelands the legacies of those policies have endured to the present, preventing these areas from developing a strong state apparatus – at least to the

extent that they are likely to have developed in the absence of this disadvantage (von Fintel, 2018).

The analysis uses the provision of WASH infrastructure as an outcome variable as an example of other services which require a network of infrastructure that is expensive to install, and which require maintenance to function properly. The findings indicate that rugged places and areas within the former homelands have lower implementation of national policies and poor access to WASH infrastructure relative to non-homeland regions. The findings reveal that regional inequalities in access to public health infrastructure are in fact largely explained by local state capacity (i.e., former homeland boundaries).

The increased access to infrastructure which was experienced in rugged homelands between 1996 and 2011 suggests that once local institutional capacity is strengthened, it can be used to leverage technology, recover costs, and uphold policy such that ruggedness does not present an insurmountable barrier to the provision of services which require a network of infrastructure. Therefore, while ruggedness may have had an impact on the initial local state capacity formation of an area, exogenous forces which influence local informal and formal institutions can overcome this barrier.

5.1.3. Chapter four

Where poor service provision interacts with poverty, it creates an additional layer of complexity in providing nurturing care. While chapters two and three focus on the infrastructure and service provision which enables caregivers to provide nurturing care for children, chapter four turns toward private caregiving dynamics, and investigates the health implications of parental absence or death. Chapter four acknowledges the critical role parents play in providing care and mobilising household resources for children's development; it follows that orphanhood and parental absence create a challenge to providing nurturing care for children.

Both parental absence and death reduce the care which parents are able to provide to their children, and existing international studies confirm that both orphans and children with living but absent parents are vulnerable to worse health outcomes than children who live with their parents (Zere and Mcintyre, 2003; Watts *et al.*, 2007; Hall and Proudlock, 2011; Ali *et al.*, 2018). There is little international evidence as to whether the negative effects on children, in

terms of early child development, are likely to be more pronounced when parents are deceased relative to when they are absent, however. Making this distinction offers insights into the role of parental investment relative to public and private transfers in promoting child development but has not been studied extensively. This study works towards reducing this knowledge gap.

The analysis revealed that paternal orphans are severely disadvantaged by the age of 4, in terms of their chronic health, and that children without fathers (due to death or absence) are significantly more likely to go hungry relative to other children. Therefore, father absenteeism by the age of four is likely to contribute to poor health in later years due to early malnutrition. Private household resources moderate the association between paternal orphanhood and stunting but do not fully moderate the hunger penalty. Private household resources moderate the association between paternal orphanhood and stunting in the spatial analysis but do not fully moderate the hunger penalty in the individual level results. This result seems incongruent since household resources decrease the likelihood of stunting, but do not decrease the likelihood of hunger which is a contributing factor to child stunting. The incongruence may be explained by the fact that there are many known causes of stunting, including chronic diarrhoeal illness, hidden hunger, and air pollution (Aguayo and Menon, 2016; Burger et al., 2022); stunting is also a condition which presents itself after chronic insults to development (Leroy and Frongillo, 2019).

Household resources may help to moderate the increased likelihood for paternal orphans to be exposed to other risk factors which are associated with child stunting, thereby moderating the association between paternal orphanhood and stunting. Alternatively, since stunting is defined as a height-for-age Z-score of less than two standard deviations from the mean of the 2006 WHO reference population, additional private household resources may help to reduce hunger to the extent that children may not be stunted by the formal definition (i.e., they may be between -1 and -2 standard deviations). Therefore, while household resources moderate the stunting penalty for paternal orphans, it is conceivable that household resources would not counteract the absent father hunger penalty, especially if there is an unexplained additional burden associated with paternal absence which leads to child hunger. Even if a child is not stunted by the formal definition, the insults to development which can lead to stunting, such as poor nutrition, still negatively impact a child's health (Cole, 2012; Ekholuenetale *et al.*, 2020).

This indicates that the household environment is an important influence which counteracts the paternal orphan stunting penalty. This finding is consistent with the hypothesis that lower

household asset ownership could be an important mechanism which contributes towards poor child health. Even so, household income and income from government cash transfers do not mitigate the hunger penalty for paternal orphans; and neither household income, cash transfer income nor remittance income moderate the hunger penalty associated with father absenteeism. This reveals that there remains an unexplained penalty associated with paternal orphanhood and absence, which is caused by something other than reduced socioeconomic status.

Chapter four further emphasises the importance of the household environment as a critical factor enabling healthy child development. A natural experiment in Gambia provides evidence that a relatively high socioeconomic threshold exists before substantial declines in malnutrition and stunting are observed (Husseini *et al.*, 2018), which is consistent with the premise that children need multiple good-quality inputs, provided at the same time, to thrive.

5.2. Recommendations

The evidence presented in chapters two, three and four add to the international bank of evidence regarding how nurturing care can be provided to all children in both HIC and LMIC. While there is growing medical understanding of what children need for healthy ECD, this thesis is an important contribution in the implementation of that medical knowledge within a wider context which remains less well documented. This section offers recommendations based on the findings in chapters two, three and four.

5.2.1. Standard measurement of ECD provision

The measurement of ECD service provision is an important first step in documenting gaps in its provision. Only once services for ECD are measured with a validated metric will it be possible to systematically gauge where services must be improved, and to gauge improved access to these services which support nurturing care for all children. Chapter two presents such a measurement technique and validates the measure. The MPI measurement approach is both a conceptual tool to understand the multiple factors which comprise ECD services, as well as a measure of service provision. This implies that this tool can assist policymakers to target ECD services spatially.

The evidence from chapter two shows that MPI methodology can be used for this purpose, and where this measurement is applied spatially, can provide a helpful visual for where services

are lacking. Furthermore, the MPI methodology creates an index which intuitively captures the complementarity of the inputs to nurturing care. This methodology has a lower data burden compared to individual- or household level poverty or deprivation measurement, and results can be achieved by using a combination of survey and administrative records that are collected at municipal level.

One recommendation for future research would be to perform similar analyses on data from other LMICs. If the methodology used in chapter two is replicated, including the dimensions of service provision as well as the cut-off criteria for poor service, this measure could provide a picture of where services for children are lacking in LMICs.

5.2.2. Public service provision as critical elements of ECD

This thesis adds evidence to the growing literature regarding the importance of public service provision as a critical element to support healthy ECD (Republic of South Africa, 2015; Cumming and Cairncross, 2016). Public services such as WASH services, transport, and communications require a network of services for effective provision. For example, it is ineffectual to provide a flush toilet requiring a sewage system to a house in an area where there is no waste treatment plant and no underground network of pipes. The network of functional infrastructure must first be built before such a toilet can be used. It should be noted that multiple new sanitation solutions have been developed which do not require electricity or sewage systems, and which can also benefit communities through processing waste for reuse, as fertiliser for example (Parker, 2014; Chand and White, 2015; Andersson, Otoo and Nolasco, 2018). However, if these new technologies are to be successfully integrated, the implementation of such solutions must take local preferences and the dignity of those who will use the WASH services into account (Tempelhoff, 2012).

While policies which make provision for ECD support, both in South Africa and internationally, do emphasise the importance of network infrastructure, this thesis discusses the framework used in institutional economics to model barriers to the provision of this infrastructure. In doing so, this thesis can suggest two ways which may help to overcome barriers to development policy implementation. First, the ruggedness of an area presents an additional cost in providing network infrastructure, which must be explicitly accounted for. Second, this thesis identifies the ability (or lack thereof) of a local, rather than national, state apparatus to implement policy as a key feature which affects successful implementation. The

findings in this thesis cannot give exact recommendations with regards to the best way to strengthen local state capacity, however, the literature suggests that a strategic effort to strengthen local capacity will include augmentation of administrative capacity and human capital (Fernandez and Rainey, 2013), as well stronger management to lead the implementation of policy (Coovadia *et al.*, 2009). It will also include investment in network-based infrastructure, which has higher marginal returns than other government investments (Candelon, Colletaz and Hurlin, 2013), but the exact manner of investment which would be appropriate in South Africa is beyond the capability of the data to determine. The determination of such would be a fruitful avenue of future research.

The spatial analysis employed in this study further adds to the understanding of how the interrelatedness of national, provincial, and municipal government serve some municipalities better than others. Various government departments are engaged in delivering these services, organized at the provincial level. Nevertheless, disparities in policy implementation exist within provinces. This discrepancy is likely attributed to factors such as the Group Areas Act and the establishment of homelands, which favoured specific regions of the country, resulting in varying levels of infrastructure. Consequently, although many policies are administered provincially, the local administrative capacity within municipalities is recognized as a crucial obstacle to the effective provision of services (Oosthuizen and Thornhill, 2017). The municipal-level analysis therefore allows the analyst to observe where the administrative systems are working, and target interventions toward those municipalities in which services are not being provided.

This has implications for national and international development policies which aim to improve access to public health infrastructure. While detailed recommendations on how to improve state capacity are outside the scope of this research, the findings in this chapter confirm that both ruggedness and historical state capacity are barriers for public service provision, but that ruggedness need not present an insurmountable barrier any longer. The focus therefore rests on improving local state capacity.

5.2.3. A “whole-of-society” approach to ECD

While a child’s caregiver bears a large responsibility for providing a child with care, adequate provision of public services enables caregivers to provide nurturing care and lessens the burden on caregivers. This is especially important in places where most households live in poverty.

Many factors are involved in nurturing care that complement each other, which implies that it becomes more complex to provide wholistic nurturing care in resource constrained environments. For example, it is difficult to provide healthy food and medical care where there is a limited budget. ECD needs to be emphasised as a "whole-of-government" and a "whole-of-society" approach to improve the mental, physical, and emotional development of a child (UNICEF, 2017).

Neglecting one aspect of a child's development is detrimental to other developmental spheres. The findings of this thesis are therefore applicable to government health, education, infrastructure, security and housing policy, but are not limited to government policy. Rather, the call for a "whole-of-society" approach to ECD for all children includes many other agents in society such as NGOs, faith-based organisations and private companies who may have the agency to support caregivers in providing nurturing care. For example, the expansion of public-private parentships which aim to address challenges in the provision of ECD is a natural recommendation along the "whole-of-society" approach to ECD (Gustafsson-Wright, Smith and Gardiner, 2017).

5.2.4. Specific South African policy recommendations

The evidence presented in this thesis supports the following policy guidance specific to South Africa. The policy guidance is fourfold.

First, for attendance at an early educational facility to be effective, the home and neighbourhood environment must also support ECD. This practical support for caregivers is more critical in neighbourhoods where the incidence of poverty is higher. Government spending in line with these recommendations could expect returns to investment as high as ten to one (Karoly, 2012; Gertler *et al.*, 2014). The efficiency-equity trade-off of this spending is also favourable relative to labour market interventions, or schooling interventions at higher grades.

Second, and linking to the first recommendation, the findings in this thesis are consistent with the argument that improved access to WASH infrastructure is a vital part of ECD policy (Momberg, May and Said-Mohamed, 2020). Expanded provision of WASH infrastructure enables caregivers to provide a clean environment inside the home, but also enables children to experience a pathogen-free neighbourhood where a network of WASH infrastructure is

successfully provided. This type of service provision is a key element for improving child health (Aguayo and Menon, 2016; Cumming and Cairncross, 2016; Badriyah and Syafiq, 2017; Bridgman and von Fintel, 2022)

Third, there is evidence in chapter three that strategic targeting of funds and national government focus to areas with weak local capacity has the potential to overcome inequality in access to public infrastructure services. National South African policy continues to support the process of addressing inequality in access to public infrastructure after the transition to democracy in 1994 (National Planning Commission, 2010). This process could be aided by top-level career civil servants working in areas with low access to public services (Fernandez and Rainey, 2013). This would support caregivers in poor neighbourhoods, rural areas and former homeland regions.

Fourth, given that paternal orphans and children with absent fathers are vulnerable to poor health outcomes, support should be better targeted towards these children. The current arrangement for delivery of support is via the administratively cumbersome Foster Care Grant. This specific grant has not been administered suitably in the past (Tladi and Setlalentoa, 2020), and caregivers continue to experience lags in receiving the grant after application. Specific recommendations on how to improve the administration and implementation of this grant are outside the scope of this research, as the data does not provide insight as to why administration lags may have occurred. In the interests of better care for these children, research on ways to improve the administration and implementation of the FCG in South Africa is a critical area of future analysis.

5.3. Limitations

The analyses presented in chapters two, three and four are subject to limitations. Firstly, this study of early childhood development outcomes in South Africa was limited by the fact that there has been no nationally representative measurement of stunting prevalence in children since the 2016 Demographic and Health Survey[60]. Moreover, a census report for South Africa

[60] A National Dietary Intake Survey was done in 2022, but the data has not yet been released at the time of writing. While this survey aims to be provincially representative, it is not designed to be representative at the sub-provincial level – a prerequisite for inclusion in this PhD analysis.

has not been released since 2011[61]. These data limitations prevent any analysis of child health in the aftermath of the COVID-19 pandemic. This data limitation suggests that an update of statistics presented in this work is recommended should more recent data become available.

Secondly, due to data limitations, much of the statistical analysis in these chapters relies on spatial analysis, and not on a study of individuals. This technique is employed due to the limited data available. However, GIS data gathering techniques allow for the analyst to combine multiple sources of data, thus enabling research which could not otherwise be conducted. To account for the spatial autocorrelation that is present in this data, spatial econometric analysis is used. This reduces the spatial biases present in the data, but causal estimates are not assumed.

Thirdly, a natural limitation of using a specific country as a case study is that the findings cannot be generalised without careful interpretation. South Africa is a unique country with a complex history and is different from other LMICs, even within the Southern African region. Even so, the evidence which can be gleaned from South Africa as a case study is valuable in advancing knowledge and informing effective policies and practices to support healthy child development in diverse contexts.

5.4. Concluding remarks

This thesis intended to build on the understanding of *what* children need for ECD by investigating the complexities of *how* these elements can be provided. The thesis starts from the perspective that early childhood development is a process which is enabled by nurturing care, which is made up of many concurrently necessary inputs that support the healthy cognitive, physical, and emotional development of children. The provision of services which enable healthy ECD is a public good which produces significant positive externalities for a society. As such, there is both an economic and a moral imperative to provide equitable and affordable ECD services to all children.

[61] In 2016 a large sample Community Survey was enumerated. A census was enumerated in 2022, but the data has not yet been released at the time of writing in July 2023.

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APPENDICES

APPENDICES FOR CHAPTER TWO:

Appendix 2-A: Documentation of the choice of cut-offs

The cut-offs for each indicator are as follows:

1. National policy stipulates that all children should receive a "Road to Health" booklet. Therefore, where fewer than 95% of children receive their Road to Health booklet, service delivery is considered poor (Department of Health, 2018).
2. UNICEF stipulates that the global target for immunisation of children is that 90% of children should be fully immunised (UNICEF, 2017). Therefore, where fewer than 90% of children have received full immunisation, service delivery in the municipality is considered poor. This applies for immunisation at 9 (minimum immunisation) and 24 months (full immunisation).
3. Municipalities are considered to have poor access to healthcare facilities where there is less than 1 clinic for 500 children under the age of 5. There are no international guidelines for the acceptable number of clinics by population. This has been calculated based on a subjective cut-off of how many children under the age of 5 a single clinic could serve in a four week period.
4. Where more than 10% of households run out of money for food in a month, the food security in a municipality is considered poor. This is motivated by the constitution which stipulates that all children have the right to adequate nutrition (Republic of South Africa, 1996).
5. Where less than 80% of households have access to a flush toilet (connected to a municipal sewage system or a septic tank), sanitation provision is considered poor. Where fewer than 90% of households have access to safe tap water less that 200 meters from their home, water provision is considered poor. Access to a flush toilet and water less than 200m from the dwelling are the WHO minimum standards for sanitation and water access respectively. The municipal provision of 85% and 90% for sanitation and water respectively is guided by the National Development plan which states that "Before 2030, all South Africans will have affordable, reliable access to sufficient safe

water and hygienic sanitation" (Republic of South Africa, 2012:178). Given that there are still 7 years in order for the 100% standard to be met, the cut-off is set below 100%.

6. Where fewer than 80% of households have their waste removed on a weekly basis, waste removal services are considered poor. This is guided by the Municipal Systems Act (2000) and the NDP, which both state that municipalities have the responsibility to provide clean, healthy and waste free environments (Republic of South Africa, 2012:404).
7. Where less than 85% of households in a municipality have access to electricity, provision is considered poor. This is motivated by the NDP which states that "The proportion of people with access to the electricity grid should rise to at least 90 percent by 2030, with non-grid options available for the rest" (Republic of South Africa, 2012: 65).
8. Where less than 50% of households feel safe during the day and during the night in a municipality, the municipality is considered to have poor safety. This cut-off is subjective.
9. Where there is less than 1 ELP for 100 children under the age of 5, access to early learning facilities is considered poor. This cut-off is calculated using a practitioner to child ratio of 1:25, and an average of 4 practitioners in an ELP. This practitioner to child ratio is considered fair for LMIC contexts (van Ravens *et al.*, 2023).
10. Where less than 3 in 4 ELP facilities meet 75% of government regulations for ELPs, ELP quality is considered poor. Meeting 75% of government regulations is considered to be a signal of a better quality facility, taken from Kika-Mistry and Wills (2022), who find that "programmes meeting three quarters of the norms and standards is established as our benchmark for programming of some reasonable standard, even if just attaining a level of structural quality" (Kika-Mistry and Wills, 2022)
11. Municipalities where any primary school has an educator to learner ratio higher than 1:40 are considered to have poor access to primary schooling. This cut-off is guided by the government regulations which stipulate that an education to learner ratio of 1:40 is the maximum ratio which should be allowed in government schools (Education Labour Relations Council, 2003).

The level ELP quality by municipality is constructed to measure how well South African ELPs meet the regulation norms and standards for ECCE facilities set out in the Children's Act (ACT 38 of 2005). In order to do so, the 2021 Census of ECD facilities in South Africa is analysed.

As documented by Kika-Mistry and Wills, (2022), the Children's Act sets out the norms and standards for Partial Care Facilities and Early Childhood Development Programmes. These norms and standards are supplemented by the General Regulations regarding the Children's Act (2010). Together, these documents set out the standards to which ELP facilities should adhere in order to register with the Department of Social Development. Once a facility is registered, they become eligible to receive the subsidy of R17 per child per day (Wills and Kika-Mistry, 2021).

First, facility level services are quantified using the methodology in Kika-Mistry and Wills (2022). The data used in the first part of the facility level analysis is the 2021 Census of ECD facilities, undertaken by the Department of Basic Education (Department of Basic Education, 2022). The General Regulations regarding the Children's Act (2010) set out a number of specific regulations that ECCE facilities must meet. Second, the proportion of facilities which meet 75% of these regulations per municipality is calculated. This final proportion is the final measure which is used.

Table 2-A1 sets out 20 of these specific regulations for which there was data. Importantly, this data exists for over 42 000 facilities.

Table 2-A1: Facilities in the 2021 ECD Audit data meeting regulations for ELPs

Regulation	Description of variable in data	Compliant
ECD programme has outside fence 1.8m high	There is a fence or around the premises used by the ECD Programme	93,92%
ECD programme has enough educational materials	Facility has children's books, storybooks, any books with text or pictures, any materials for counting, picture cards, posters, charts and/or theme tables.	92,34%
ECD programme provides meals or snacks.	Facility serves at least one meal.	91,80%
Staff have an ECD specialisation (certificate. diploma or degree).	All of the staff have at least one ECD qualification.	90,50%
ECD programme has outside gate	Is there a lockable gate to prevent unauthorised access to the premises?	88,69%
ECD programme has enough art materials.	Facility has pens, pencils, glue, scissors for children, paper, paint, crayons, chalk and/or tape.	84,62%
ECD programme has enough furniture	Facility has chairs, desks or tables for children	83,69%
Centre does not have dangerous obstacles that prevent children from playing.	Is the indoor play areas floor space large enough for children to safely move?	82,83%
ECD programme operates in a formally built structure	ECD Programme operates in conventional or prefab building.	82,22%
Food is prepared separately and away from children	Area for cooking and preparing meals separated from where the children are.	80,21%
ECD programme has enough puzzles	Facility has puzzles and/or games with numbers or shapes.	71,29%
ECD programme has tap water on-site	The main water source is tap water in the building or tap water on-site.	69,74%
ECD programme has enough fantasy materials	Facility has dress up clothes, masks, pretend food, pots and pans, clay and/or playdough.	64,54%
The staff to child ratio is 1:20 or less	The staff to child ratio is 1:20 or less	63,93%
ECD programme has enough outdoor materials	Facility has balls, hula-hoops, sandbags, buckets, spades, sand moulds, kipping ropes and/or scooters.	61,40%
Practitioners received first aid training.	The appointed first aid officer has received first aid training	60,98%
ECD programme has a flush toilet.	Flush toilet connected to public sewer system or connected to septic tank.	59,66%
Evidence of a structured learning programme	Practitioner organises activities according to an integrated weekly and daily plan (recorded as adequate or good)	52,68%
ECD programme has enough construction materials	Facility has LEGO or any other wooden or plastic blocks children can play with.	52,20%
ECD programme has enough music materials	Facility has drums, triangles, cymbals, maracas, bells, shakers and/or tambourines.	37,49%

Appendix 2-B

The following municipalities provide the highest level of service delivery in healthcare, public services and education. The municipalities on this list provide a level of service that is above the minimum standard required for that specific service according to the definitions given in appendix 2-A. These municipalities provide adequate service in at least 4 out of 5 sub-domains in the health service and public infrastructure service domains, and at least 2 out of 3 sub-domains in the education service domain.

Table 2-B1: Individual municipalities with the best service provision by domain

Best municipal service delivery		
Health Services	Public Infrastructure services	Education Services
Cape Winelands	Cape Winelands	Cape Winelands
Central Karoo	Central Karoo	Central Karoo
John Taolo Gaetsewe	City of Cape Town	City of Cape Town
	City of Johannesburg	City of Johannesburg
	Dr Kenneth Kaunda	City of Tshwane
	Ekurhuleni	Ekurhuleni
	Fezile Dabi	Fezile Dabi
	Garden Route	Garden Route
	Lejweleputswa	Namakwa
	Namakwa	Overberg
	Nelson Mandela Bay	Pixley ka Seme
	Overberg	Sarah Baartman
	Pixley ka Seme	Sedibeng
	Sarah Baartman	West Coast
	Sedibeng	West Rand
	West Coast	
	Xhariep	

The following municipalities provide the lowest level of service delivery in healthcare, public services and education. The municipalities on this list provide a level of service that is below the minimum standard required for that specific sub-domain according to the definitions given in appendix 2-A. These municipalities provide inadequate service in 4 or 5 out of 5 sub-domains in the health service and public service domains, and 3 out of 3 sub-domains in the education service domain.

Table 2-B2: Individual municipalities with the worst service provision by domain

Worst municipal service delivery		
Health Services	Public Infrastructure services	Education Services
Alfred Nzo	Alfred Nzo	Alfred Nzo
Amajuba	Amathole	Amajuba
Bojanala	Harry Gwala	Bojanala
Buffalo City	Joe Gqabi	Dr Kenneth Kaunda
City of Johannesburg	O.R.Tambo	Dr Ruth Segomotsi Mompati
City of Tshwane	Ugu	Ehlanzeni
Dr Kenneth Kaunda	Umgungundlovu	Ngaka Modiri Molema
Dr Ruth Segomotsi Mompati	Umkhanyakude	O.R.Tambo
Ekurhuleni	Umzinyathi	Vhembe
Fezile Dabi	Uthukela	Zululand
Gert Sibande	Zululand	
Mangaung	iLembe	
Mopani		
Nelson Mandela Bay		
Ngaka Modiri Molema		
Nkangala		
O.R.Tambo		
Sekhukhune		
Uthukela		
Vhembe		
West Rand		
Xhariep		
Z F Mgcawu		
Zululand		
iLembe		

Figures 2-B1 to 2-B3 show maps of South Africa, with indications of poor service delivery for children in each sub-domain by municipality. The maps are shaded red where service delivery for children is below the minimum standard.

Figure 2-B1: Health Services (municipalities with below minimum standards in sub-domain)

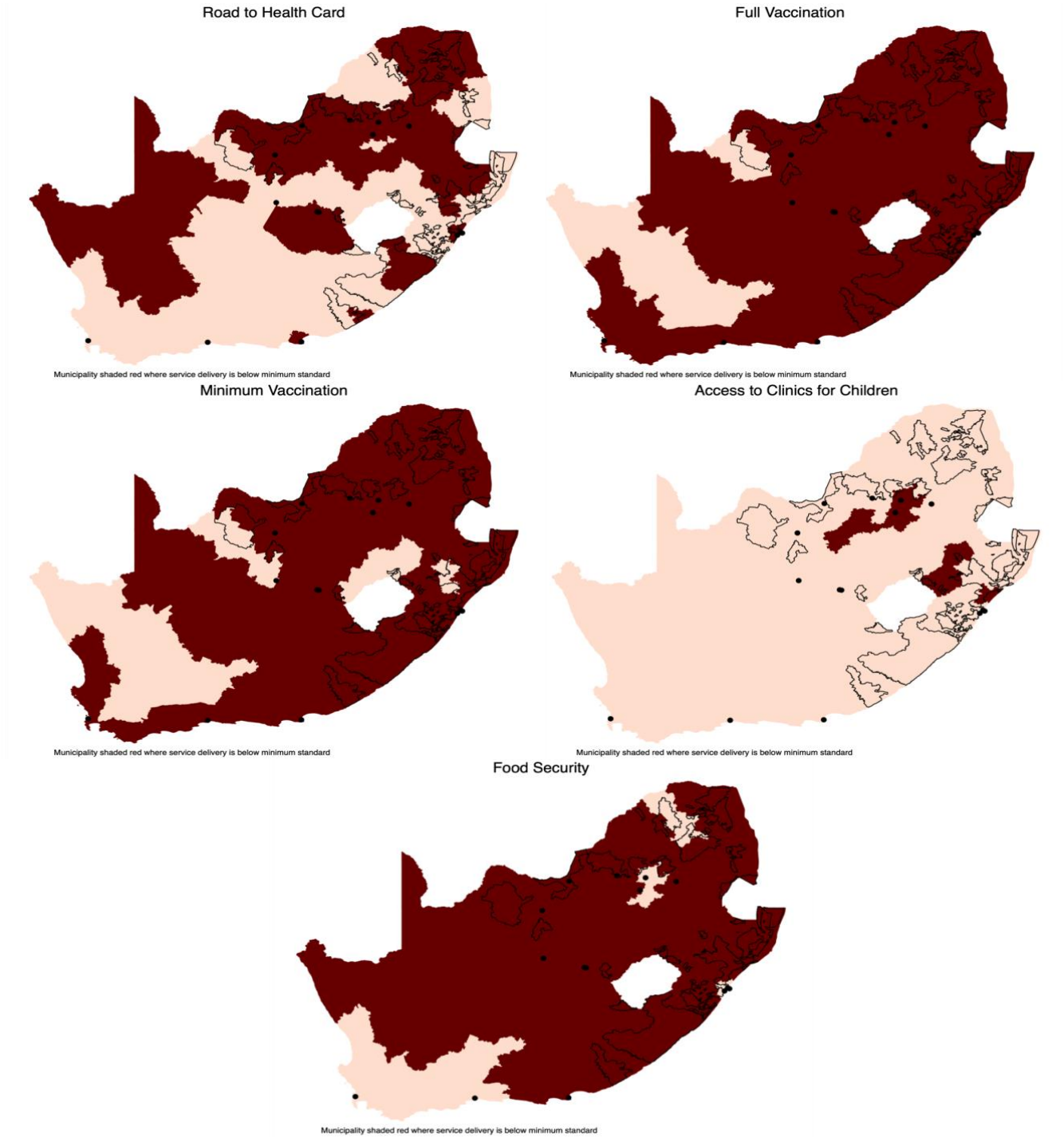


Figure 2-B2: Public Infrastructure services (municipalities with below minimum standards in sub-domain)

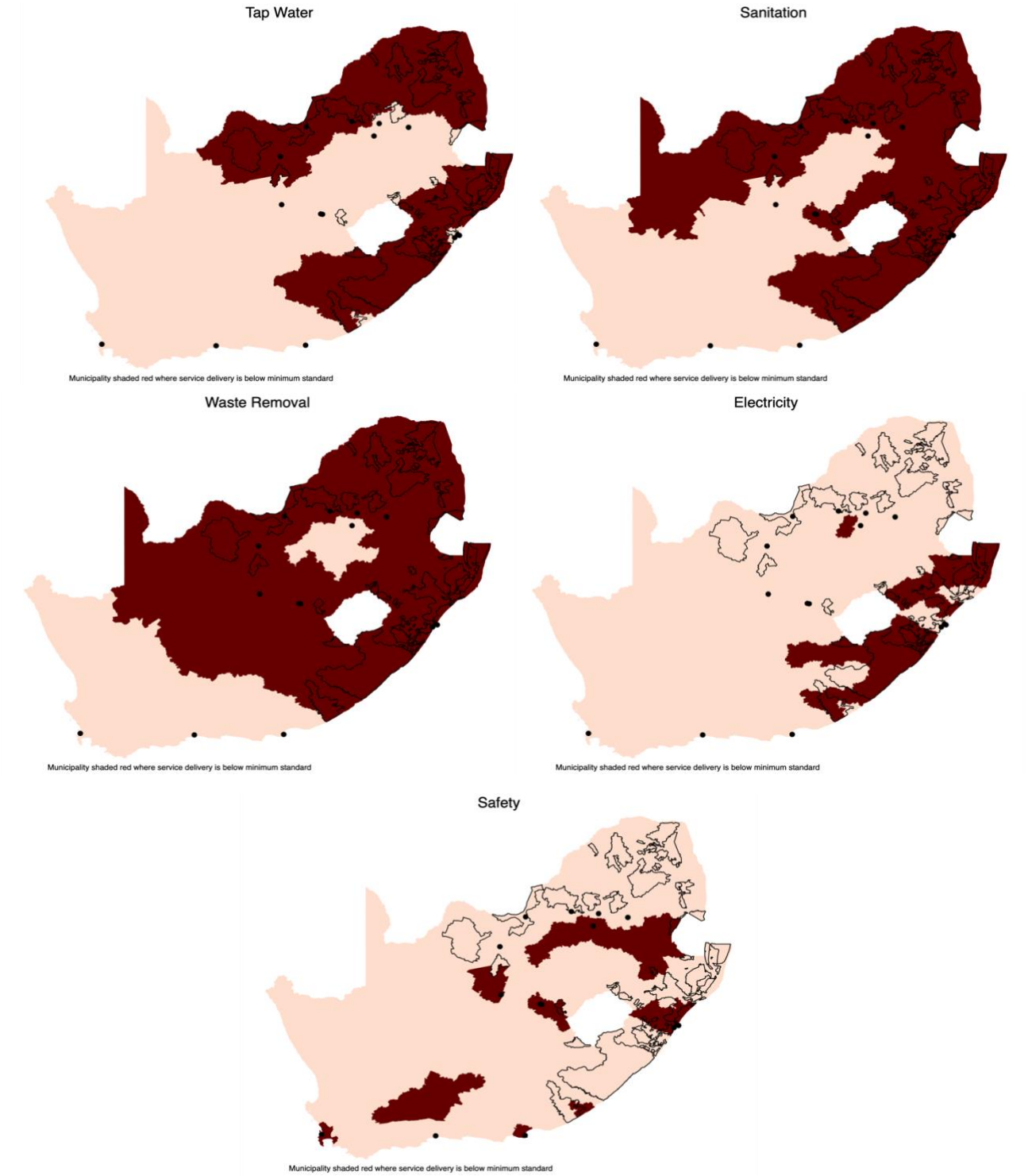
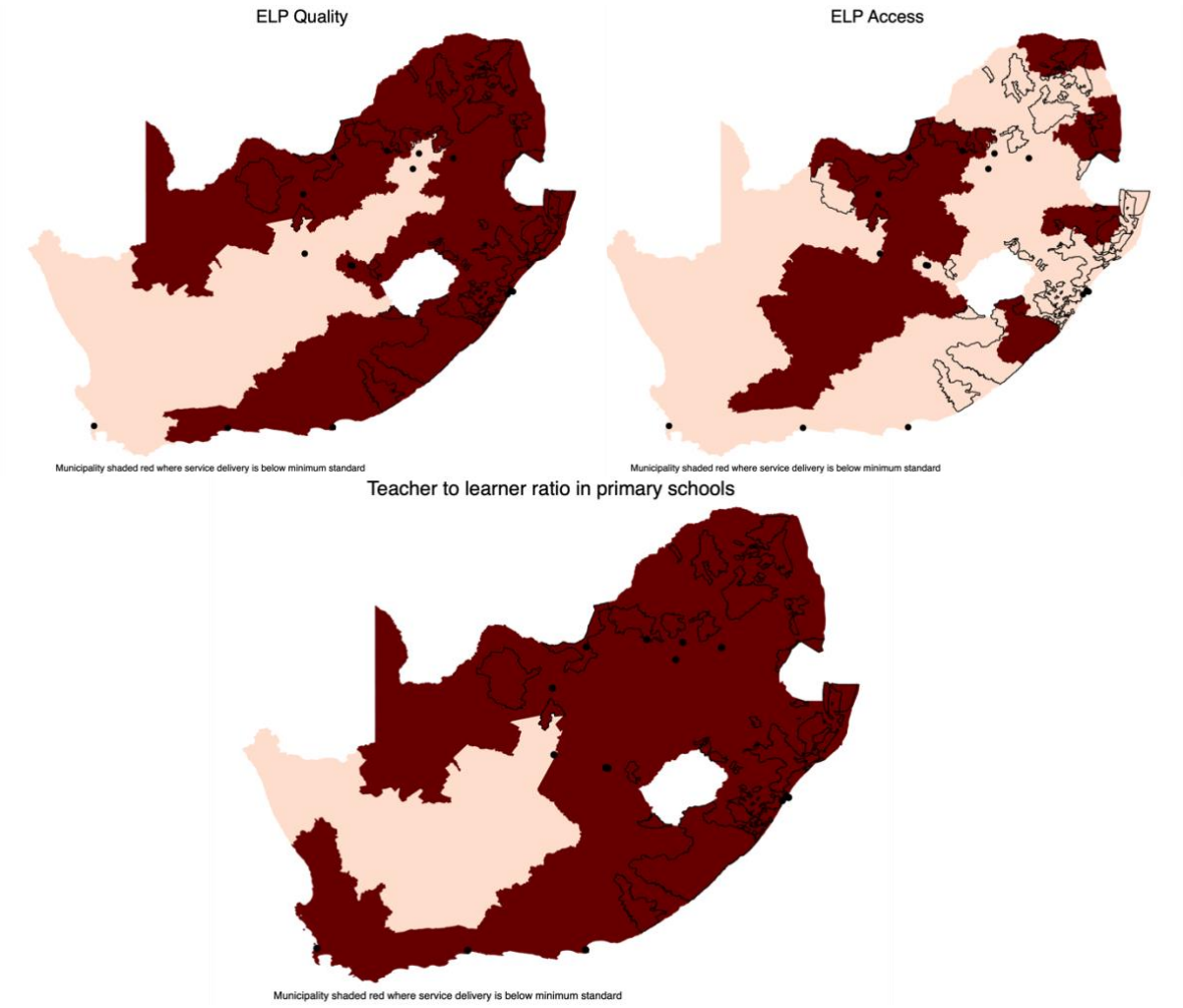


Figure 2-B3: Education Services (municipalities with below minimum standards in sub-domain)



Appendix 2-C: Facility level service delivery for children

The aim of this section is to investigate whether or not municipality-level service provision is related to facility level services. The key question is "Does municipal level service provision impact the services that ELPs can provide?"

Table 4 shows the pairwise correlation coefficients between municipal level service delivery and facility level compliance. The level of statistical significance of the correlation is also indicated. Individual correlational regressions which confirm these relationships can be found in appendix D. Table 4 shows that facility level compliance with the regulations in the Children's Act is dependent on municipal service provision in some service areas more than other service areas.

Where municipal sanitation is poor, facilities are significantly less likely to have a flush toilet. Likewise, where access to tap water is poor in a municipality, facilities are significantly less likely to have tap water. There is no economically or statistically significant correlation between food insecurity in a municipality and whether or not a meal is served at the ELP facility. There is also no significant correlation between food insecurity in a municipality and whether or not a meal is provided at the ELP facility. These results suggest that facility compliance is relatively more dependent on municipal service provision in domain 2 (public services) relative to domain 1 (healthcare services).

There are significant negative correlations between poor service in domain 3 (education services) and facility level provision. That is, where educational services are poor, individual facilities are more likely to struggle to meet norms and standards for quality programming, such as having educational materials or qualified staff. It should be noted that one of the indicators in domain 3 is whether or not facilities comply with norms and standards. Therefore, there is natural auto-correlation in this regard. The significant pairwise correlations between the number of regulations met and poor education service should be seen in light of network effects.

Table 2-C1: Correlation between municipality-level service provision and facility compliance

Facility level provision [a]	Healthcare Services Poor	Facility level provision	Public Services Poor	Facility level provision	Educational Services Poor
Immunisation Records	0,02	Tap Water	-0,35***	Number of regulations met	-0,33***
Clinic Close By	0,01	Flush Toilets	-0,44***	Educational materials	-0,04***
Meal Served	0,01	Formal Structure	-0,03***	Staff Qualified	-0,05***
		Food Prep Space	-0,04***		

NOTE: *p<0.1, ** p<0.05, *** p<0.01. [a] These measures of facility level compliance are taken from the facilities interviewed in the Thrive by 5 baseline study. There were no indicators of facility compliance that were related to Domain 1 in the 2021 ECD Audit.

Appendix 2-D: regulation compliance and ELOM score

Table 2-D1: regulation compliance and ELOM score

	Total ELOM Score		
Child age	1.0195***	0.9994***	0.9927***
	(0.1537)	(0.1496)	(0.1488)
Female	1.8599**	1.8605**	1.8273**
	(0.8943)	(0.8979)	(0.8960)
Fees charged	3.6146**	3.6458**	4.0213**
	(1.6077)	(1.6161)	(1.6814)
Play space	-0.3385	-0.7810	-0.8032
	(1.3945)	(1.3922)	(1.3958)
Meal served	3.3520	3.6575	3.0848
	(2.8950)	(3.1570)	(3.2405)
Gate	1.6405	1.9327	2.1114
	(2.8275)	(2.8914)	(2.9123)
PC ratio below 1:20	1.6110	1.0277	0.7120
	(1.8746)	(1.8831)	(1.8764)
Formal building structure	0.2824	-0.0857	-0.2973
	(1.4784)	(1.5165)	(1.4736)
Food prep space	1.2428	1.0487	0.9234
	(1.5632)	(1.6349)	(1.6272)
Fence	0.7868	1.2638	1.2096
	(2.2533)	(2.1269)	(2.1816)
Tap water	1.4285	1.5465	1.3873
	(1.1822)	(1.0840)	(1.0682)
Reports cards	1.0270	0.7749	0.6345
	(1.4360)	(1.3818)	(1.3917)
Curriculum	0.6290	0.5969	0.6731
	(1.5001)	(1.4638)	(1.4370)
Parent feedback	-1.6609	-1.9677	-2.5230
	(2.5284)	(2.5443)	(2.6258)
First aid kit	0.4596	0.3407	0.0831
	(1.3194)	(1.3116)	(1.3065)
Refrigeration	-0.1266	-0.4799	-0.4356
	(1.5383)	(1.5124)	(1.5114)
Emergency contact list	-0.5079	-0.5416	-0.7945
	(1.1651)	(1.1587)	(1.2078)
Immunisation records	0.4203	0.6766	0.6032
	(1.6934)	(1.6267)	(1.5956)
Fire extinguisher	-1.4176	-1.2470	-1.3488
	(1.2604)	(1.2191)	(1.2025)
Injury file kept	-0.2224	-0.3778	-0.5735
	(1.4307)	(1.3628)	(1.3818)
Flush toilet	1.5683	1.1290	0.8065
	(1.3973)	(1.3346)	(1.3442)
Clinic close by	-0.8076	-1.2721	-1.4125
	(1.1032)	(1.0787)	(1.0582)
Evacuation plan	-0.9215	-1.4347	-1.8047
	(1.4902)	(1.4721)	(1.6126)
Art materials	2.2654	2.0045	2.2339
	(1.8863)	(1.8888)	(1.8996)
Furniture for children	-0.3222	0.0351	0.0840
	(1.6337)	(1.6502)	(1.6165)
Educational materials	2.6959	2.8160	2.8601
	(2.2725)	(2.3199)	(2.3137)
Puzzles	0.8666	0.9589	0.6849

	(1.3646)	(1.3557)	(1.3601)
Fantasy materials	-1.9171	-1.7039	-2.0309
	(1.3098)	(1.2992)	(1.3044)
Building materials	-1.8844	-1.8116	-2.1123
	(1.3862)	(1.3410)	(1.3928)
Outdoor materials	1.6620	1.3356	1.1474
	(1.2177)	(1.2007)	(1.2028)
Music materials	0.9814	1.1679	0.9827
	(1.4233)	(1.3676)	(1.3762)
Qualified staff	0.1637		
	(1.5788)		
Number of staff: accredited		0.0591	0.0789
		(0.4802)	(0.4761)
Number of staff: NQF level 4and5		0.0827	0.0018
		(0.3790)	(0.3672)
Number of staff: NQF level 6 to 9		2.2930***	2.3218***
		(0.5864)	(0.6019)
Above 75% of regulations met			1.8641
			(1.9174)
Constant	-27.3373***	-26.1150***	-23.8323**
	(10.0012)	(9.7919)	(9.7077)
R-squared	0.079	0.093	0.094
N	1918	1918	1918

* p<0.1, ** p<0.05, *** p<0.01. Sample weights applied. Source: own calculations.

Appendix 2-E: regressions of municipal and facility services on child stunting

Table 2-E1: Effects of health services for children on stunting

	Stunting					
	Models using Health Services Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	-0.0265	-0.0103	-0.0165	-0.0100	-0.0221	-0.0290
	(0.0203)	(0.0232)	(0.0263)	(0.0251)	(0.0261)	(0.0267)
Child age	0.0024	0.0025	0.0015	0.0015	0.0015	0.0015
	(0.0022)	(0.0022)	(0.0020)	(0.0020)	(0.0020)	(0.0020)
Female	0.0051	0.0040	0.0009	0.0004	0.0017	0.0016
	(0.0114)	(0.0115)	(0.0086)	(0.0087)	(0.0085)	(0.0085)
Metro	0.0023	0.0005	0.0023	0.0000	-0.0127	-0.0170
	(0.0224)	(0.0200)	(0.0192)	(0.0192)	(0.0131)	(0.0159)
Subsidy received	0.0104	0.0128	-0.0032	-0.0026	-0.0016	-0.0010
	(0.0163)	(0.0156)	(0.0113)	(0.0109)	(0.0117)	(0.0114)
Immunisation records kept		-0.0445		-0.0190		
		(0.0271)		(0.0149)		
Clinic close to ELP		0.0121		0.0072		
		(0.0133)		(0.0088)		
Facility serves meal		-0.0102		-0.0022		
		(0.0245)		(0.0193)		
Municipality food insecure			0.0074	0.0050		
			(0.0158)	(0.0197)		
Access to clinics poor			-0.0339**	-0.0346*		
			(0.0131)	(0.0175)		
Full vaccination poor			-0.0019	-0.0112		
			(0.0148)	(0.0221)		
Minimum vaccination poor			0.0137	0.0121		
			(0.0158)	(0.0209)		
Health services poor				0.0027	0.0004	0.0016
				(0.0113)	(0.0048)	(0.0047)
Public services poor						-0.0046
						(0.0054)
Education Services poor						-0.0000
						(0.0107)
Constant	-0.0614	-0.0409	-0.0186	-0.0082	-0.0034	0.0095
	(0.1175)	(0.1229)	(0.1205)	(0.1241)	(0.1186)	(0.1220)
R-squared	0.0023	0.0078	0.0038	0.0048	0.0014	0.0019
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the municipal and at the municipal level for the remaining columns.

Table 2-E2: Effects of public infrastructure services for children on stunting

	Stunting					
	Models using Public Service Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	-0.0265	-0.0186	-0.0425	-0.0401	-0.0288	-0.0399
	(0.0203)	(0.0214)	(0.0259)	(0.0259)	(0.0263)	(0.0260)
Child age	0.0024	0.0024	0.0014	0.0014	0.0015	0.0014
	(0.0022)	(0.0022)	(0.0020)	(0.0020)	(0.0020)	(0.0020)
Female	0.0051	0.0054	0.0014	0.0013	0.0016	0.0013
	(0.0114)	(0.0114)	(0.0085)	(0.0085)	(0.0085)	(0.0085)
Metro	0.0023	0.0090	-0.0085	-0.0087	-0.0163	-0.0076
	(0.0224)	(0.0231)	(0.0173)	(0.0173)	(0.0147)	(0.0164)
Subsidy received	0.0104	0.0111	-0.0017	-0.0018	-0.0010	-0.0018
	(0.0163)	(0.0161)	(0.0117)	(0.0120)	(0.0118)	(0.0120)
ELP has flush toilet		-0.0226		-0.0202		-0.0203
		(0.0156)		(0.0134)		(0.0135)
ELP has tap water		0.0095		0.0157		0.0156
		(0.0148)		(0.0107)		(0.0108)
Municipal sanitation poor			-0.0325***	-0.0316***		-0.0300*
			(0.0102)	(0.0107)		(0.0166)
Municipal tap water poor			0.0123	0.0056		0.0074
			(0.0124)	(0.0139)		(0.0166)
Municipal electricity poor			-0.0265**	-0.0248*		-0.0226
			(0.0124)	(0.0131)		(0.0186)
Municipal waste removal poor			0.0274	0.0265		0.0283
			(0.0188)	(0.0190)		(0.0186)
Public services poor					-0.0042	-0.0020
					(0.0050)	(0.0135)
Constant	-0.0614	-0.0649	0.0192	0.0210	0.0147	0.0213
	(0.1175)	(0.1166)	(0.1274)	(0.1272)	(0.1248)	(0.1276)
R-squared	0.0023	0.0037	0.0039	0.0050	0.0018	0.0050
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the municipal and at the municipal level for the remaining columns.

Table 2-E3: Effects of education services for children on stunting

	Stunting					
	Models using Education Service Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	-0.0265	-0.0170	-0.0226	-0.0209	-0.0233	-0.0209
	(0.0203)	(0.0223)	(0.0258)	(0.0266)	(0.0253)	(0.0266)
Child age	0.0024	0.0023	0.0014	0.0014	0.0015	0.0014
	(0.0022)	(0.0022)	(0.0020)	(0.0020)	(0.0020)	(0.0020)
Female	0.0051	0.0048	0.0014	0.0013	0.0016	0.0013
	(0.0114)	(0.0114)	(0.0085)	(0.0085)	(0.0085)	(0.0085)
Metro	0.0023	0.0061	-0.0065	-0.0061	-0.0156	-0.0061
	(0.0224)	(0.0231)	(0.0195)	(0.0194)	(0.0158)	(0.0194)
Subsidy received	0.0104	0.0185	-0.0028	-0.0018	-0.0019	-0.0018
	(0.0163)	(0.0168)	(0.0114)	(0.0115)	(0.0116)	(0.0115)
Facility has acceptable PC ratio		0.6561		0.0962		0.0962
		(0.4608)		(0.3658)		(0.3658)
Facility has educational materials		0.0185		-0.0029		-0.0029
		(0.0182)		(0.0226)		(0.0226)
Municipal primary school TL ratio poor			-0.0336*	-0.0335*		-0.0335*
			(0.0192)	(0.0195)		(0.0195)
Municipal ELP access poor			-0.0015	-0.0015		-0.0015
			(0.0128)	(0.0125)		(0.0125)
Municipal ELP quality poor			0.0082	0.0075		0.0075
			(0.0176)	(0.0180)		(0.0180)
Education services poor					-0.0031	0.0000
					(0.0089)	(.)
Constant	-0.0614	-0.1074	0.0318	0.0294	0.0059	0.0294
	(0.1175)	(0.1214)	(0.1196)	(0.1168)	(0.1202)	(0.1168)
R-squared	0.0023	0.0039	0.0023	0.0023	0.0015	0.0023
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the municipal and at the municipal level for the remaining columns.

Table 2-E4: Provincial fixed effects applied

	ELOM Score					
	Models using Public Service Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	0.1569	-0.0183	-0.0391	-0.1143	0.0638	-0.1697
	(0.4218)	(0.4127)	(0.3775)	(0.3620)	(0.3527)	(0.3512)
Child age	2.4586***	2.4431***	2.4216***	2.4156***	2.4364***	2.4093***
	(0.3978)	(0.3978)	(0.4001)	(0.4027)	(0.4067)	(0.3984)
Female	0.9338**	0.9340**	0.9358**	0.9363**	0.9387**	0.9323**
	(0.3972)	(0.3991)	(0.3539)	(0.3551)	(0.3525)	(0.3544)
Metro	0.5251	0.3883	-0.6861	-0.6742	0.5454	-0.8383
	(0.7624)	(0.7644)	(0.8794)	(0.8669)	(0.6349)	(0.8188)
Subsidy received	-1.7671***	-1.8719***	-1.8914***	-1.9401***	-1.8506***	-1.9467***
	(0.5451)	(0.5385)	(0.6415)	(0.6305)	(0.6476)	(0.6231)
ELP has flush toilet		0.8530		0.3825		0.4215
		(0.6187)		(0.7097)		(0.6835)
ELP has tap water		0.2870		0.2871		0.3106
		(0.5112)		(0.5247)		(0.4969)
Municipal sanitation poor			-0.7925	-0.8108		-2.4886
			(1.3072)	(1.3174)		(1.6021)
Municipal tap water poor			-0.9878	-0.7688		-3.1334
			(1.5235)	(1.5325)		(2.0304)
Municipal electricity poor			-0.6815	-0.6548		-2.2348*
			(0.7538)	(0.7846)		(1.1646)
Municipal waste removal poor			0.2470	0.2789		-0.7679
			(0.9290)	(0.9537)		(1.1969)
Municipal child safety poor			-1.3176	-1.2733		0.1913
			(0.8928)	(0.8835)		(0.9549)
Public services poor					-0.9283	4.2164**
					(0.8207)	(2.0902)
Province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Constant	42.1603***	42.8184***	44.0873***	44.3212***	45.4182***	34.2505***
	(1.6682)	(1.8532)	(1.5125)	(1.6372)	(3.0695)	(5.4875)
R-squared	0.111	0.116	0.133	0.134	0.118	0.134
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, and at the municipal level for the remaining columns.

Table 2-E5: Variables aggregated at the provincial level where appropriate.

	ELOM Score					
	Models using Public Service Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	0.8882**	0.2500	-0.0746	0.0560	0.4177	0.1569**
	(0.3588)	(0.3067)	(0.0860)	(0.0695)	(0.3701)	(0.0642)
Child age	2.4797***	2.5067***	2.4876***	2.4475***	2.5030***	2.4586***
	(0.2132)	(0.2219)	(0.2360)	(0.2308)	(0.2217)	(0.2337)
Female	1.0213**	1.0146**	1.0035**	0.9432**	1.0019**	0.9338**
	(0.3598)	(0.3546)	(0.3941)	(0.3830)	(0.3552)	(0.3796)
Metro	0.4440	-0.1630	0.3422	0.5134	-0.3648	0.5251
	(0.8872)	(0.9906)	(0.6400)	(0.6275)	(0.9075)	(0.6313)
Subsidy received	-2.2922**	-1.9879**	-1.5417**	-1.7821**	-1.9395**	-1.7671**
	(0.8039)	(0.8165)	(0.5516)	(0.6305)	(0.7785)	(0.6372)
Provincial averages applied						
ELP has flush toilet		-0.0327		14.2296***		19.8563***
		(4.6832)		(3.0064)		(1.4839)
ELP has tap water		7.6755		-135.1302***		-127.3964***
		(4.5691)		(4.0920)		(4.4126)
Municipal sanitation poor			9.7195	3.5124		11.7524***
			(10.7306)	(2.2021)		(1.3047)
Municipal tap water poor			0.9894	-33.3544***		-24.3223***
			(5.9011)	(1.9772)		(2.5573)
Municipal electricity poor			-10.7615**	-70.1121***		-58.8374***
			(3.4675)	(1.6523)		(2.6424)
Municipal waste removal poor			0.2814	3.7748		-0.1321
			(6.2175)	(3.7400)		(3.4750)
Municipal child safety poor			-82.0773**	-114.9807***		-92.1103***
			(30.9349)	(11.6716)		(9.9984)
Public services poor					-1.8819	-4.3479***
					(1.0279)	(0.3731)
Constant	44.8641***	39.7767***	106.7939***	250.3539***	49.6232***	223.8367***
	(1.3122)	(2.0684)	(22.4767)	(9.3867)	(3.3007)	(10.3062)
R-squared	0.073	0.087	0.122	0.141	0.091	0.142
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the provincial level.

The associations between provincial service provision and ELOM score become very large, are more significant in many cases.

Table 2-E6: Replication of table 2.5 using children under 5 to define households with children

	ELOM Score					
	Models using Health Services Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	0.8882***	0.5677*	0.7248**	0.3448	0.7135**	0.4651
	(0.3010)	(0.3410)	(0.2968)	(0.3513)	(0.2741)	(0.3122)
Child age	2.4797***	2.4660***	2.7044***	2.6954***	2.6790***	2.6781***
	(0.4197)	(0.4173)	(0.3740)	(0.3637)	(0.3769)	(0.3809)
Female	1.0213**	1.0344**	1.3435***	1.3799***	1.3644***	1.3566***
	(0.4051)	(0.4059)	(0.2602)	(0.2457)	(0.2670)	(0.2611)
Metro	0.4440	0.3994	1.3969	1.4024	1.2283	1.0569
	(0.6549)	(0.6310)	(0.8880)	(0.8871)	(0.8277)	(1.0678)
Subsidy received	-2.2922***	-2.2828***	-2.1734***	-2.2669***	-2.3144***	-2.2514***
	(0.6194)	(0.6532)	(0.5285)	(0.5019)	(0.5556)	(0.5314)
Immunisation records kept		0.9345*		1.1480**		
		(0.5291)		(0.5405)		
Clinic close to ELP		0.4900		0.1930		
		(0.6290)		(0.4826)		
Facility serves meal		-0.2585		0.1230		
		(0.7262)		(0.6277)		
Municipality food insecure			-1.4705*	-1.5861		
			(0.7773)	(0.9620)		
Access to clinics poor			-1.1010	-1.2912		
			(0.7889)	(0.9323)		
Full vaccination poor			0.0045	-0.0048		
			(0.6119)	(0.7507)		
Minimum vaccination poor			0.1702	0.0871		
			(1.0400)	(1.2668)		
Health services poor				0.2134	-0.5703	-0.4669
				(1.5731)	(0.9277)	(0.9993)
Public services poor						-0.7204
						(0.7068)
Education Services poor						0.2898
						(1.2628)
Constant	44.8641***	44.8240***	44.7717***	43.9377***	46.6985***	47.4628***
	(0.5886)	(0.5874)	(0.7511)	(5.4317)	(3.3710)	(3.5777)
R-squared	0.0730	0.0777	0.0938	0.0991	0.0849	0.0875
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the municipal and at the municipal level for the remaining columns.

Table 2-E7: Replication of table 2.6 using children under 5 to define households with children

	ELOM Score					
	Models using Public Service Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	0.8882***	0.3984	0.1388	0.1288	0.4644	0.0974
	(0.3010)	(0.3229)	(0.2924)	(0.2871)	(0.3049)	(0.2846)
Child age	2.4797***	2.4590***	2.6530***	2.6528***	2.6950***	2.6449***
	(0.4197)	(0.4204)	(0.3513)	(0.3515)	(0.3868)	(0.3489)
Female	1.0213**	1.0179**	1.3928***	1.3931***	1.3585***	1.3938***
	(0.4051)	(0.4058)	(0.2391)	(0.2398)	(0.2629)	(0.2393)
Metro	0.4440	-0.1286	-1.0309	-1.0277	0.8297	-1.1366
	(0.6549)	(0.6635)	(1.0168)	(1.0203)	(0.8943)	(1.0321)
Subsidy received	-2.2922***	-2.3616***	-1.7306***	-1.7316***	-2.2544***	-1.7515***
	(0.6194)	(0.5941)	(0.4636)	(0.4646)	(0.5343)	(0.4672)
ELP has flush toilet		1.2106*		0.1265		0.1214
		(0.6375)		(0.4776)		(0.4710)
ELP has tap water		0.6801		-0.0294		-0.0169
		(0.5401)		(0.5172)		(0.5147)
Municipal sanitation poor			1.1872	1.1859		0.8792
			(2.0243)	(2.0399)		(2.2981)
Municipal tap water poor			1.0057	1.0664		0.5613
			(1.7562)	(1.7655)		(1.8344)
Municipal electricity poor			-1.4458***	-1.4356***		-1.7899*
			(0.4648)	(0.5284)		(0.9692)
Municipal waste removal poor			-2.5182*	-2.5131*		-2.9266**
			(1.3135)	(1.3177)		(1.3380)
Municipal child safety poor			-2.3714***	-2.3665***		-2.1602**
			(0.8597)	(0.8600)		(0.8144)
Public services poor					-0.7106	0.9082
					(0.7349)	(1.9884)
Constant	44.8641***	44.9214***	44.8232***	44.8260***	46.4356***	42.6537***
	(0.5886)	(0.5680)	(0.5945)	(0.5963)	(2.1847)	(4.8049)
R-squared	0.0730	0.0836	0.1214	0.1215	0.0868	0.1218
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the municipal and at the municipal level for the remaining columns.

Table 2-E8: Replication of table 2.7 using children under 5 to define households with children

	ELOM Score					
	Models using Education Service Indicators					
	(1)	(2)	(3)	(4)	(5)	(6)
Fees charged	0.8882***	0.6115*	0.7162**	0.5484	0.6833***	0.5484
	(0.3010)	(0.3511)	(0.2982)	(0.3273)	(0.2381)	(0.3273)
Child age	2.4797***	2.4725***	2.7727***	2.7498***	2.6992***	2.7498***
	(0.4197)	(0.4171)	(0.3531)	(0.3538)	(0.3884)	(0.3538)
Female	1.0213**	1.0566***	1.3995***	1.4252***	1.3628***	1.4252***
	(0.4051)	(0.4069)	(0.2389)	(0.2398)	(0.2606)	(0.2398)
Metro	0.4440	0.2787	0.0719	0.0214	0.8505	0.0214
	(0.6549)	(0.6224)	(0.9537)	(0.9585)	(0.9923)	(0.9585)
Subsidy received	-2.2922***	-2.5209***	-2.3076***	-2.4504***	-2.3307***	-2.4504***
	(0.6194)	(0.6801)	(0.5249)	(0.4790)	(0.5559)	(0.4790)
Facility has acceptable PC ratio		-0.7683		-0.4788		-0.4788
		(0.7144)		(0.5792)		(0.5792)
Facility has educational materials		0.7139		0.5268		0.5268
		(0.4824)		(0.4016)		(0.4016)
Municipal primary school TL ratio poor			1.3986	1.3995		1.3995
			(1.0629)	(1.0506)		(1.0506)
Municipal ELP access poor			-1.1173	-1.1090		-1.1090
			(0.6960)	(0.7070)		(0.7070)
Municipal ELP quality poor			-0.9544	-0.8234		-0.8234
			(0.8558)	(0.8414)		(0.8414)
Education services poor					-0.6227	0.0000
					(1.0767)	(.)
Constant	44.8641***	44.8109***	44.7742***	44.7837***	45.9886***	44.7837***
	(0.5886)	(0.5744)	(0.7555)	(0.7613)	(2.6172)	(0.7613)
R-squared	0.0730	0.0773	0.0987	0.1011	0.0845	0.1011
N	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the municipal and at the municipal level for the remaining columns.

Table 2-E9: Replication of table 2.7 with controls for population density

	ELOM Score						
	Models using Public Service Indicators						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Population Density	0.1494	0.6090	1.2205	1.2552	2.0528**	1.2437	1.4967
	(0.6615)	(0.6896)	(0.7885)	(0.8041)	(0.8454)	(0.8533)	(0.9461)
Fees charged	0.8965***	0.3941	0.0486	0.0206	0.5395	0.0159	-0.1074
	(0.3031)	(0.3233)	(0.2888)	(0.2819)	(0.3327)	(0.2819)	(0.3077)
Child age	2.4802***	2.4590***	2.6882***	2.6883***	2.7615***	2.6866***	2.7628***
	(0.4195)	(0.4199)	(0.3489)	(0.3502)	(0.3567)	(0.3485)	(0.3379)
Female	1.0242**	1.0301**	1.4390***	1.4399***	1.4528***	1.4396***	1.4473***
	(0.4066)	(0.4077)	(0.2291)	(0.2303)	(0.2279)	(0.2299)	(0.2309)
Metro	0.2807	-0.8376	-2.3200	-2.3515	-1.7947	-2.3593	-1.7372
	(0.9609)	(1.0181)	(1.5632)	(1.5924)	(1.2843)	(1.5733)	(2.5472)
Subsidy received	-2.2810***	-2.3209***	-1.7179***	-1.7222***	-2.0380***	-1.7259***	-1.7966***
	(0.6187)	(0.5972)	(0.4537)	(0.4526)	(0.4979)	(0.4557)	(0.4530)
ELP has flush toilet		1.2673*		0.2820		0.2796	0.3556
		(0.6509)		(0.4790)		(0.4784)	(0.4531)
ELP has tap water		0.7768		0.0394		0.0411	0.0973
		(0.5581)		(0.5217)		(0.5188)	(0.5169)
Municipal sanitation poor			0.8294	0.8280		0.7753	-0.8252
			(1.6470)	(1.6649)		(2.0303)	(1.9966)
Municipal tap water poor			0.4978	0.6469		0.5586	0.5198
			(1.8231)	(1.8043)		(1.7609)	(1.5908)
Municipal electricity poor			-1.7454***	-1.7014***		-1.7635*	-2.7145**
			(0.4771)	(0.5080)		(0.9963)	(1.1653)
Municipal waste removal poor			-1.9412	-1.9123		-1.9932	-2.2313
			(1.2009)	(1.2009)		(1.3859)	(1.6321)
Municipal child safety poor			-1.9526***	-1.9303***		-1.8966***	0.3117
			(0.6947)	(0.6856)		(0.6573)	(1.9277)
Public services poor					-1.2814*	0.1657	1.0645
					(0.7006)	(2.2276)	(2.0962)
Municipal sanitation poor x Population Density							-1.9750**
							(0.9425)
Municipal tap water poor x Population Density							-0.2838
							(0.8067)
Municipal electricity poor x Population Density							0.5078
							(0.6599)
Municipal waste removal poor x Population Density							2.4640**
							(1.0650)
Municipal child safety poor x Population Density							-0.6664
							(0.6050)
Constant	44.6421***	44.0218***	43.3218***	43.2844***	45.2861***	42.9023***	40.7614***
	(1.1150)	(1.1315)	(1.0055)	(1.0063)	(2.0719)	(5.0162)	(4.5486)
R-squared	0.0731	0.0847	0.1261	0.1263	0.1048	0.1263	0.1355
N	2172	2172	2172	2172	2172	2172	2172

* p<0.1, ** p<0.05, *** p<0.01. All measures of service delivery are standardised. Standard errors are clustered at the facility level for columns 1 and 2, double-clustered at the municipal and at the municipal level for the remaining columns.

This table shows that the interaction term between population density and municipal sanitation, and the interaction between population density and municipal waste removal are significant predictors of ELOM scores. These same interaction terms are not significant predictors of child stunting. Table 2-E9 indicates that where there is higher population density, poor sanitation is associated with lower ELOM scores; but higher population density and poor waste removal is associated with higher ELOM scores. This last association may be due to collinearity between high population density and urban areas. Overall, the control for population density does not change the statistical interpretation of the results.

APPENDICES FOR CHAPTER THREE:

Appendix 3-A: The history of water and sanitation policy

In order to determine how differing levels of state capacity has impacted infrastructure development, it is critical to review the history of the policies regarding water and sanitation. South Africa is classified as a water scarce country, with an average annual rainfall well below the global average, and the distribution of rainfall is uneven, with the majority falling on the East and South-East coast. This fact has made access to water an important policy issue in the country throughout its history. At her union, there was a system of riparian water rights in South Africa, where the water flowing on or over a property was also owned by the property owner. Land tenure followed the British colonial system which granted land ownership largely to white settlers. The Water Act of 1912 made some provision for non-riparian water use, where some streams were classified as "public flows" and available for common use, but riparian rights remained dominant (Nunes, 1975).

The political shift in South Africa which occurred in 1948, with the introduction of Apartheid under the National Party, also had implications for the governance of water and sanitation. The National Party retained the system of riparian water rights, and water ownership continued to be contingent on land tenure which was only possible for white South Africans. Black South Africans were functionally excluded from water rights under this system (van Koppen, 2005). The Water Act of 1956 harmonised water and sanitation policy, and targeted economically important sectors including mining, agriculture, and industry (Perret, 2002). The 1956 Act focused on the provision of small-scale irrigation systems and infrastructure in areas which were designated for white-owned farms and industry, and neglected areas which later became demarcated as homelands, or Apartheid Bantustans (Perret, 2002; Bodurtha Qua-Enoo et al., 2006). The Water Act of 1956 also set new minimum standards for wastewater treatment, and made provisions for the development of coordinated sewage treatment, especially in urban areas (MacKay, 2003). These provisions also functionally excluded sanitation control in the homelands. This state of affairs continued until the onset of the new democratic era.

In November 1994, the Reconstruction and Development Plan (RDP) changed the face of national policy. This document made commitments to address poverty and inequality on all levels, including equitable access to housing, water, and sanitation (Republic of South Africa,

1994). The Water Management Act of 1998 ended the system of riparian water rights, and declared water to be a national asset which should be maintained and distributed to all citizens (Movik, 2011). This Act included provision for Catchment Management Areas (CMAs) which came into effect in 2009, and which formed part of an Integrated Water Management (IWM) plan. However, IWM has since been criticised for a lack of practical contextualisation. The ideals and theoretical best practice of IWM are difficult to put into practice in terms of on-the-ground basin management, environmental flows, systems of fees and permits as well as community participation (van Koppen and Schreiner, 2014). The World Bank also warns that IWM can often be "the enemy of the good" and proposes a "principled but more pragmatic" approach to water management (World Bank, 2004). The IWM approach has also been criticised in South Africa specifically in having led to "paralysis" (Merrey, 2008).

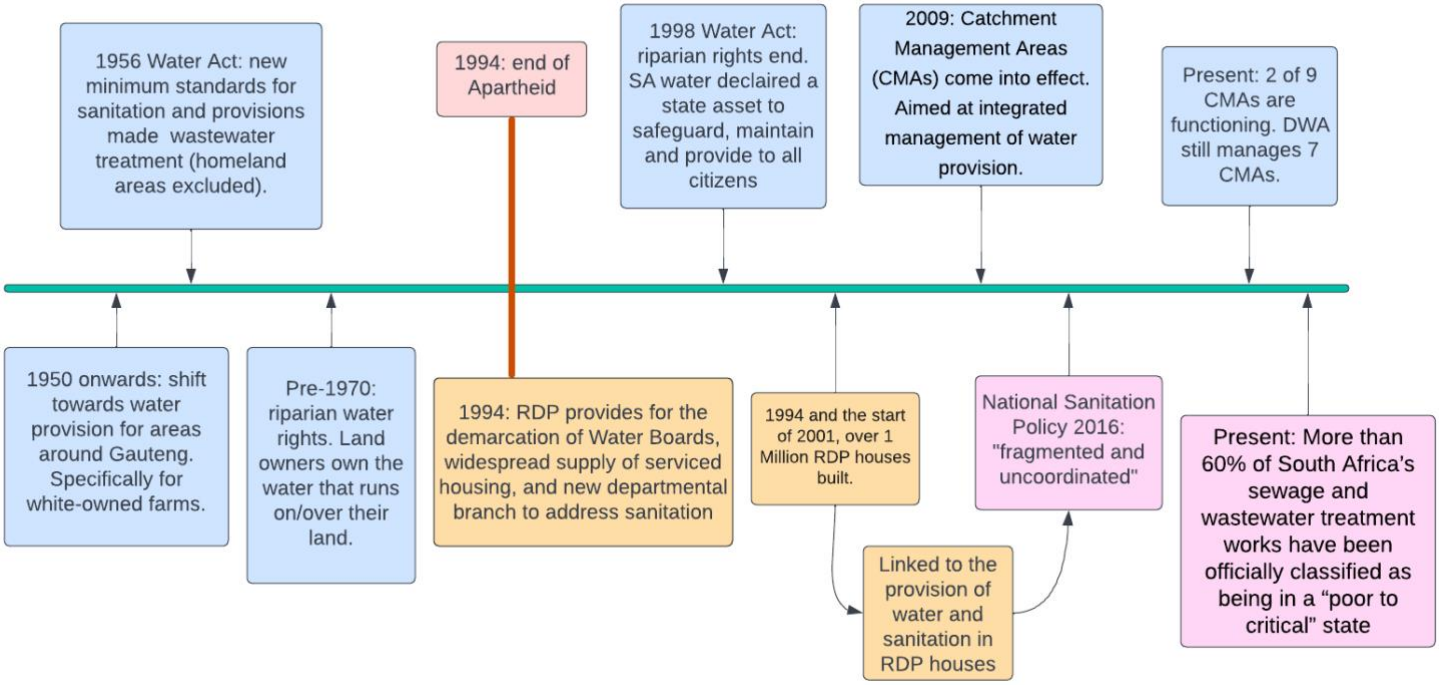
Due to the lack of practical application of IWMP, the approach to water management changed to a developmental water management plan in 2013 with the Second National Water Resource Strategy, which takes a more guided approach to the provision of water (van Koppen and Schreiner, 2014), while it still has IWM ideology as an overarching guide. Even so, the current state of water management lacks guidance and cohesion, and has not been able to supply adequate water in some instances (Hollingworth and Matsetela, 2008). Only two of the nine CMAs are functioning as intended at present. The Department of Water Affairs (DWA) continues to manage seven of the CMAs, which has resulted in poor application of water management principles, and a lack of overall guidance for the interdepartmental collaboration required for water management (Bourblanc and Blanchon, 2014).

Furthermore, with the Water Management Act of 1998, the focus of South African water policy shifted from the creation and development of water supply infrastructure to an expansion of the existing system, focusing on the supply of water to previously excluded households. This is partially due to the fact than much of the infrastructure and water storage had been completed, and also due to the reprioritisation of government spending. The Act aimed to generate the financing for the expansion of the network through service cost recovery from existing water users, but the financial viability of the sector continues to be put under strain due to funding gaps (Department of Water Affairs, 2022). This shift in national policy can be viewed as a treatment that effected regional state capacity for managing and supplying water resources.

The second important policy sphere which was affected by the RDP regards the minimum standards for sanitation, as well as the provisions for wastewater and effluent treatment. Policy mandates for sanitation can be found in the Act of 1998, but have been revised in the White Paper on Basic Household Sanitation in 2001, the Strategic Framework for Water Services in 2003, the National Resource Strategy (Second Edition) in 2013 and finally in the National Sanitation Policy in 2016. Each of these documents continues to guide different parts of water and sanitation policy. Additionally, there are multiple pieces of legislation which have implications for sanitation, including The Broad-Based Black Economic Empowerment Act of 2003, the National Youth Policy 2015-2019 and the Spatial Planning and Land Use Management Act of 2013 among others. There are also many government departments who have a mandate to provide or maintain sanitation, resulting in the sector being "fragmented and uncoordinated" (Department of Water and Sanitation, 2016).

In their review of the state of sanitation and water policy, the Department of Water and Sanitation notes the complication which arises due to the dual mandate to provide sanitation from the Department itself, and from the Department of Human Settlement (which is responsible to provide low-cost government housing). The Department of Water and Sanitation notes that "sanitation needs to be provided as part of a package of municipal services associated with housing" (Department of Water and Sanitation, 2016), which requires high levels of policy coordination and interdepartmental cooperation.

Sanitation and water policy timeline



The figure above summarises the policy landscape detailed above, showing the have two critical changes in water and sanitation policy in 1956 and in 1998 respectively. These changes allow the analysis below to determine the impacts of changes in state capacity on access to WASH infrastructure. The following section describes the complimentary datasets which have been constructed to uncover whether these policies have had the intended effect.

sAppendix 3-B: analysis of missing year entries

The data taken from the DWA website has information on the year in which each dam was constructed. This data has a non-trivial number of missing entries; 1007 of 5529 dam construction dates are missing. To proceed with the data, it must be established that this data is missing at random. Figure B1 shows the spatial distribution of wards in which all of the dams built have missing years of construction. That is to say, these wards have zero dams with any records of the year of construction. There are 172 dams with registered dams built in them that do not have any years or registration recorded (this is 0,04% of wards). The distribution of these wards is taken to be random based on this figure, as there is no evidence of spatial clustering. While the missing year information is not ideal, the number of dams which remain after dropping missing year information is still high.

Figure 3B-1: Wards with missing dam information

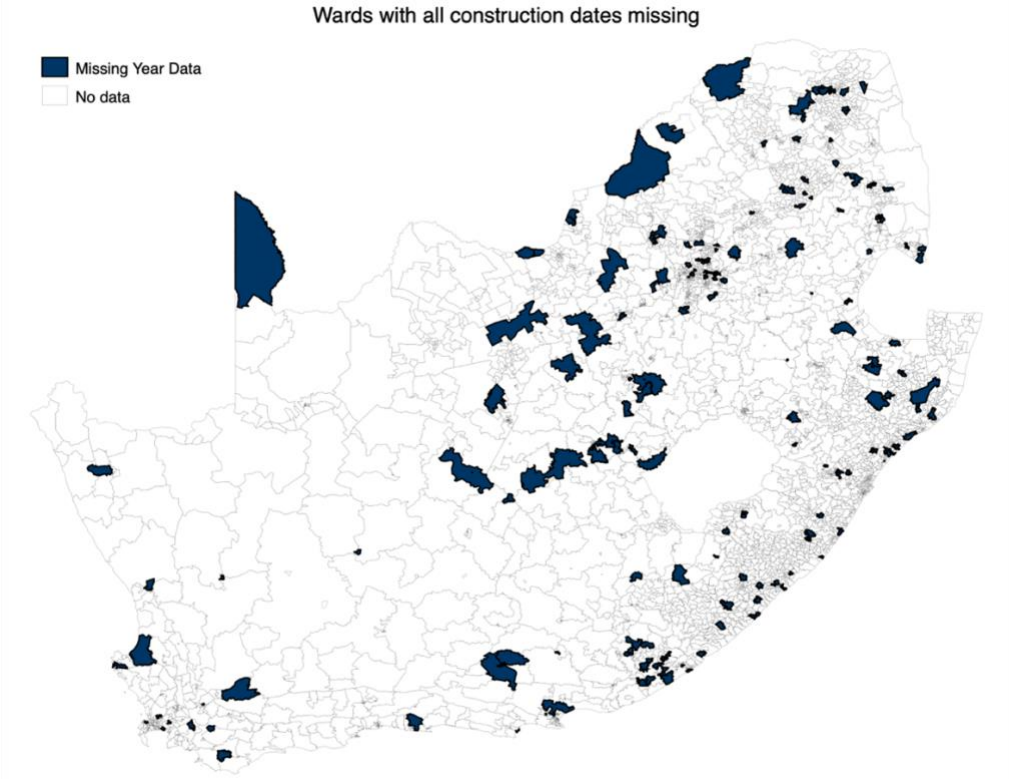


Figure 3B-2: Distribution of dam count variable

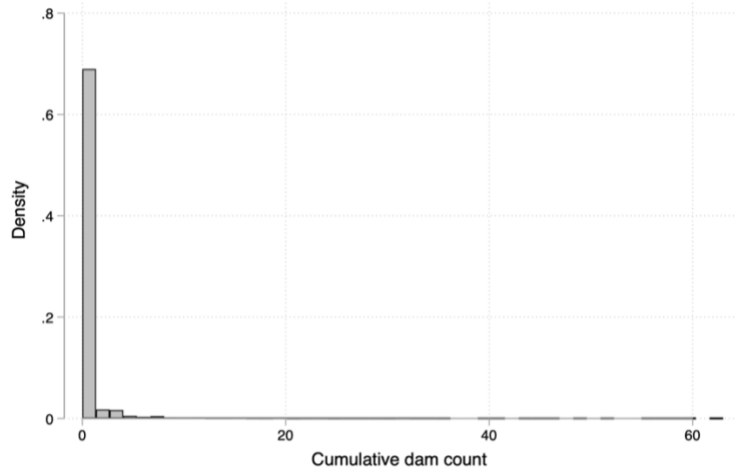


Figure 0.1. Distribution of the dam count variable.

Figure 0.1 shows the distribution of the dam count variable. This variable counts the number of dams built in each ward in 5-year intervals. There are 23% of wards with a positive count for the number of dams constructed, and 0.04% of wards with missing information. The rest of the electoral wards have a zero count of dams. This zero count of dams in some wards is statistically and economically meaningful. However, the distribution of the count variable indicates that there is an overdispersion which needs to be considered. This feature of the data must be explicitly modelled using a Zero Inflated Poisson regression model.

Appendix 3-C: analysis of the dummy for ruggedness

Figure 3-C1 shows that the relationship between ruggedness and the proportion of formal or traditional housing changes dramatically at a log ruggedness of 11.75. This change is especially strong for the proportion of formal and traditional housing within homelands.

Figure 3-C2 shows that the average proportion of households with access to sanitation and tap water increases in both homeland and non-homeland wards which have a log ruggedness value below 11.75, but this relationship reverses at log ruggedness values beyond 11.75. The average access to flush/chemical toilets and tap water between 1996 and 2011 was used. For this reason, ruggedness is included as a dummy variable, where wards with a log ruggedness above 11.75 are coded as rugged, and all other wards are non-rugged.

Figure 3-C1: Terrain ruggedness and average proportion of formal and traditional housing

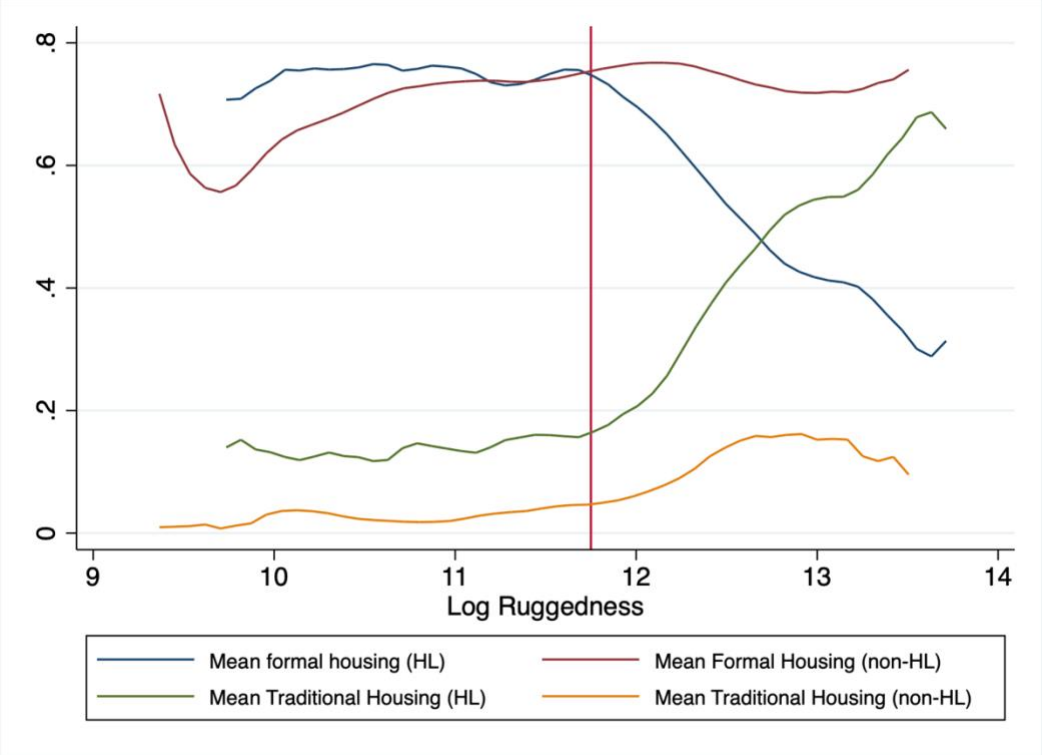
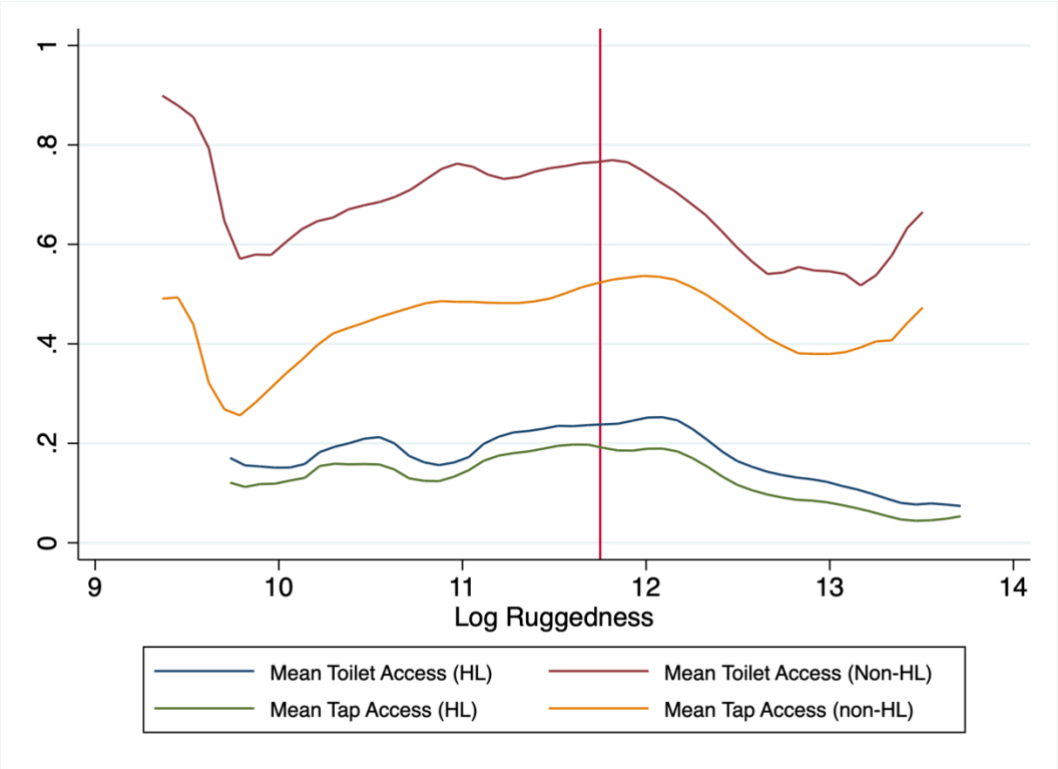


Figure 3-C2: Terrain ruggedness and average access to tap water and sanitation



Appendix 3-D:

This analysis is included due to the importance of the mechanism of formal housing in the supply of WASH infrastructure. Since terrain ruggedness and homeland boundaries are likely to impact formal housing. This model is given by equation 3 below.

Equation 3:

$$Prop\ Formal_w = \beta_0 + \beta_1 HL_w \times Year_t + \beta_2 Rugged_w \times Year_t + \boldsymbol{\delta_1 X} + e_w$$

In each census, households were asked whether their housing was formal, informal, or traditional housing. The proportion of households in each ward with formal housing is the dependent variable of interest here. The Homeland and Rugged dummy variables, and time interactions are the same as in equation 2. The vector of controls, $\boldsymbol{X}$, is also the same. The difference in the final regression is that the Mundlak control for the dependent variable is included, which implies that the covariates must be interpreted as effects on the deviation from the mean of the proportion of formal housing in each ward. This specification approximates a panel model with fixed effects (Wooldridge, 2019, 2021). This changes the specification, where the coefficients should now be interpreted as showing the relationship between the control (right hand side) and the deviation from the mean of the dependent variable (left hand side).

Table 3-D4 shows the impact of ward characteristics on the proportion of formal housing in a ward. These are also estimated as panel models with random effects. The baseline specification on column 2.1 shows the same significant negative relationship between ruggedness and formal housing as well as homelands and formal housing. Time controls are added in column 2.2, which show that formal housing increased in 2001 and 2011 in non-rugged, non-homeland wards relative to these wards in 1996.

Table 3-D4: Regression on formal housing

	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)
	Proportion Formal Housing				
Homeland	-0.1190***	-0.1464***	-0.1464***	-0.1317***	-0.0367***
	(0.0083)	(0.0091)	(0.0091)	(0.0095)	(0.0038)
Rugged	-0.0898***	-0.0696***	-0.0696***	-0.0689***	0.0175***
	(0.0085)	(0.0093)	(0.0093)	(0.0092)	(0.0038)
2001		0.0746***	0.0746***	0.0555***	0.0533***
		(0.0057)	(0.0057)	(0.0056)	(0.0046)
2011		0.1697***	0.1697***	0.1437***	0.1406***
		(0.0057)	(0.0057)	(0.0056)	(0.0046)
Homeland x 2001		0.0242***	0.0242***	0.0348***	0.0360***
		(0.0065)	(0.0065)	(0.0063)	(0.0052)
Homeland x 2011		0.0581***	0.0581***	0.0740***	0.0758***
		(0.0065)	(0.0065)	(0.0063)	(0.0052)
Rugged x 2001		-0.0255***	-0.0255***	-0.0216***	-0.0211***
		(0.0066)	(0.0066)	(0.0064)	(0.0053)
Rugged x 2011		-0.0351***	-0.0351***	-0.0310***	-0.0305***
		(0.0066)	(0.0066)	(0.0064)	(0.0053)
Log Population Density				0.0347***	0.0387***
				(0.0015)	(0.0011)
Mean Population Density				-0.0237***	-0.0388***
				(0.0026)	(0.0012)
Metro				0.0500***	0.0017
				(0.0120)	(0.0031)
Mean Proportion Formal Housing					0.9962***
					(0.0042)
Constant	0.7761***	0.6946***	0.6946***	0.6263***	-0.0631***
	(0.0073)	(0.0080)	(0.0080)	(0.0154)	(0.0055)
Adjusted R-squared	0.082	0.152	0.152	0.182	0.864
N	11085	11085	11085	11085	11085

NOTE: * p<0.1, ** p<0.05, *** p<0.01

Homeland areas saw a relative increase in formal housing in 2001 and 2011 in comparison to non-rugged, non-homeland wards in 1996. Moreover, the positive time interaction terms show that the time trend in homelands was steeper than in non-homeland wards. This is likely linked to the rollout of RDP housing, mentioned in the policy review in section 2. Rugged wards saw a significantly slower increase in formal housing relative to non-rugged, non-homeland wards, however, shown by the negative time interaction terms. This result remains stable when all other controls area added, and indicates that ruggedness poses a significant disincentive to formal housing. That is to say, people who live in rugged areas may either choose to move to a less rugged area to build a formal house, or they may choose to build a traditional or informal house in the rugged area due to the increased cost of building.

Controls for metro areas and population density are added in column 2.4, showing that more densely populated areas saw a relative increase in formal housing, but areas with high average population density between 1996-2011 tend to have lower proportions formal housing in these years on average. This is likely to overlap with the high population density in the former homelands (von Fintel and Fourie, 2019).

The Mundlak control for formal housing included in column 2.5 has a coefficient that is essentially one[62]. The size of the coefficients is reduced, but the signs and levels of significance do not change, except for the coefficient on ruggedness and metro wards. This implies that the interpretation above regarding all unchanged coefficients is robust. The final regression implies a more nuanced relationship between ruggedness and formal housing, where adding the Mundlak device changes the sign of the coefficient on ruggedness, implying that given the average level of formal housing between 1996 and 2011, more rugged areas saw an increase in formal housing relative to non-rugged wards.

Table 3-D4 shows a clear relationship between formal housing, ruggedness and institutional (homeland) boundaries. What remains to be seen, however, is whether there is a separate channel through which ruggedness and institutions impact WASH infrastructure. That is, if formal housing is universally rolled out, would this lead to near universal access to WASH infrastructure? Or does ruggedness and institutions impact WASH infrastructure roll-out over and above the relationship with formal housing?

[62] The null hypothesis that this coefficient is equal to 1 cannot be rejected (P= 0.3681).

Appendix 3-E: additional tables and figures

Table 3-E1: Spatial Durban Model of ward characteristics on sanitation access

	(SDM1.1)	(SDM1.2)	(SDM1.3)	(SDM1.4)	(SDM1.5)
	Proportion of households with Flush/Chemical toilets				
Homeland	-0.4248***	-0.4085***	-0.3542***	-0.3476***	-0.3994***
	(0.0107)	(0.0115)	(0.0099)	(0.0099)	(0.0107)
Rugged	-0.0207**	-0.0164	-0.0054	-0.0008	-0.0132
	(0.0101)	(0.0109)	(0.0094)	(0.0094)	(0.0086)
2001		0.0380***	0.0158***	0.0193***	0.0112**
		(0.0056)	(0.0051)	(0.0051)	(0.0051)
2011		0.1310***	0.0788***	0.0865***	0.0781***
		(0.0059)	(0.0057)	(0.0058)	(0.0058)
Homeland x 2001		-0.0017	-0.0113**	-0.0104*	-0.0063
		(0.0063)	(0.0056)	(0.0056)	(0.0056)
Homeland x 2011		-0.0618***	-0.0805***	-0.0780***	-0.0759***
		(0.0063)	(0.0057)	(0.0057)	(0.0057)
Rugged x 2001		-0.0013	0.0084	0.0073	0.0094
		(0.0065)	(0.0058)	(0.0058)	(0.0057)
Rugged x 2011		-0.0094	0.0049	0.0035	0.0050
		(0.0065)	(0.0058)	(0.0058)	(0.0057)
Proportion Formal Housing			0.4926***	0.4602***	0.4283***
			(0.0088)	(0.0102)	(0.0105)
Mean Proportion Formal Housing				0.1114***	0.2440***
				(0.0183)	(0.0185)
Metro					0.0420**
					(0.0171)
Log Population Density					0.0138***
					(0.0014)
Mean Population Density					0.0162***
					(0.0022)
Constant	0.4507***	0.5127***	0.2812***	0.2224***	-0.0527***
	(0.0128)	(0.0136)	(0.0152)	(0.0180)	(0.0196)
R-squared	0.443	0.461	0.580	0.582	0.642
N	11085	11085	11085	11085	11085

NOTE: * p<0.1, ** p<0.05, *** p<0.01

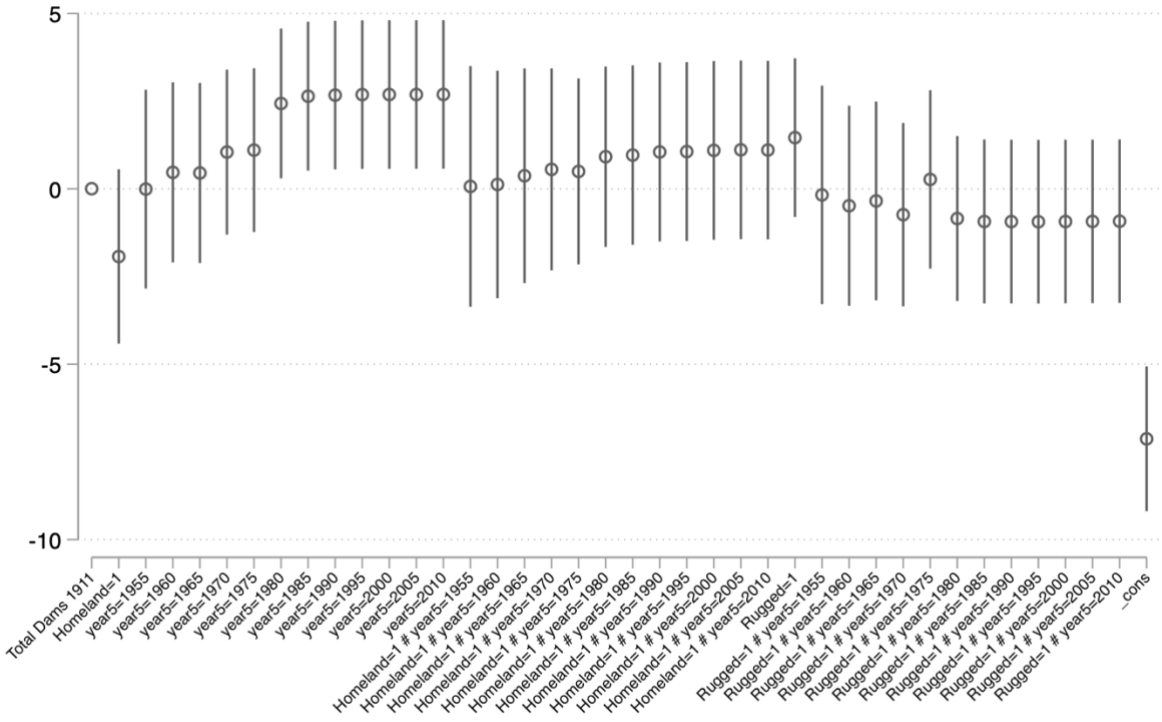
Table 3-E2: Spatial Durban Model of ward characteristics on tap water access

	SDM1.6	SDM1.7	SDM1.8	SDM1.9	SDM1.10
	Proportion HH with tap access inside				
Homeland	-0.3045***	-0.3027***	-0.2511***	-0.2355***	-0.2660***
	(0.0100)	(0.0104)	(0.0083)	(0.0081)	(0.0092)
Rugged	-0.0057	-0.0071	0.0035	0.0159**	0.0054
	(0.0094)	(0.0098)	(0.0078)	(0.0076)	(0.0073)
2011		0.0137***	-0.0279***	-0.0020	-0.0173***
		(0.0047)	(0.0050)	(0.0050)	(0.0050)
Homeland x 2011		-0.0042	-0.0224***	-0.0144***	-0.0114**
		(0.0053)	(0.0049)	(0.0048)	(0.0049)
Rugged x 2011		0.0029	0.0157***	0.0110**	0.0127***
		(0.0055)	(0.0050)	(0.0049)	(0.0049)
Proportion Formal Housing			0.4604***	0.3421***	0.3085***
			(0.0091)	(0.0103)	(0.0106)
Mean Proportion Formal Housing				0.3205***	0.4397***
				(0.0159)	(0.0166)
Metro					0.0637***
					(0.0148)
Log Population Density					0.0108***
					(0.0013)
Mean Population Density					-0.0011
					(0.0020)
Constant	0.4343***	0.4328***	0.2202***	0.0710***	-0.0787***
	(0.0128)	(0.0130)	(0.0138)	(0.0151)	(0.0171)
R-squared	0.351	0.352	0.565	0.583	0.625
N	7390	7390	7390	7390	7390

NOTE: * p<0.1, ** p<0.05, *** p<0.01. Sample size is reduced due to the exclusion of 2001 data.

Figure 3-E3: ZIP regression coefficients

Dependent variable is the cumulative full service capacity of all dams in the ward.



Appendix 3-F: the impact of WASH infrastructure on the health of children

Table 3-F1: impact of ruggedness and homelands on regional stunting prevalence

	Stunting Prevalence				
Homeland	0.0409***	0.0282***	0.0023	0.0011	0.0010
	(0.0009)	(0.0014)	(0.0015)	(0.0016)	(0.0015)
Rugged	0.0089***	-0.0018	-0.0027**	-0.0027**	-0.0054***
	(0.0009)	(0.0012)	(0.0012)	(0.0012)	(0.0011)
Homeland x Rugged		0.0209***	0.0202***	0.0213***	0.0235***
		(0.0017)	(0.0017)	(0.0017)	(0.0016)
Proportion flush toilets			-0.0254***	-0.0254***	-0.0080***
			(0.0021)	(0.0021)	(0.0022)
Proportion tap inside			-0.0314***	-0.0339***	-0.0412***
			(0.0024)	(0.0025)	(0.0033)
Proportion formal housing				0.0059***	0.0082***
				(0.0019)	(0.0020)
Log population density					-0.0058***
					(0.0002)
Household asset index					0.0053
					(0.0042)
Constant	0.2636***	0.2687***	0.3065***	0.3032***	0.3270***
	(0.0008)	(0.0009)	(0.0014)	(0.0018)	(0.0019)
R-squared	0.205	0.216	0.295	0.296	0.374
N	3695	3695	3695	3695	3695

* p<0.1, ** p<0.05, *** p<0.01

Table 3-F1 shows the association between former homelands, high ruggedness and the under 5 child stunting prevalence. This table shows that stunting is higher in former homeland regions relative to non-homeland regions but is not significantly higher in rugged regions relative to non-rugged regions. Access to flush toilets and tap water significantly reduces this stunting penalty in the homelands. Once controls for formal housing, household assets and population density are included in the final column, there is no significant association between former homeland wards and stunting. However, *rugged homeland* wards still experience a stunting penalty.

These results are directly comparable to those discussed at length in Bridgman and von Fintel (2022). Since ruggedness is found to reduce the effectiveness of national policy implementation, the stunting penalty in rugged homelands is important to consider. Special attention to augmenting the local state capacity in rugged former homeland regions is imperative to improving the stunting prevalence in these areas.

APPENDICES FOR CHAPTER FOUR:

Appendix 4-A: two sources of the South African 2011 Census

There are two primary means by which the data from the 2011 South African Community census can be accessed. The first is through a website called SuperWeb, which gives the user access to multiple relational databases by which she can pull out tables, and build a dataset with geographic units as the level of observation. For example, the user can download a table with the number of households who have access to flush toilets, or the number of children who have living mothers at the level of the electoral ward in South Africa. The second means by which the data from the 2011 South African Community census can be accessed is the 10% sample of the data. This dataset is at the level of the individual, and has over 4 million observations. The 10% sample data takes a random sample of individuals, with the Census Enumeration Area as the primary sampling unit, and then includes a weighting variable which can be used as a frequency weight to calculate nationally accurate statistics.

The original OVCSA data accesses the 201 South African census via Superweb, which has information at the level of electoral wards in South Africa, but does not distinguish between parental absence and parental death. This data was fit for the purpose of the analysis in Bridgman and von Fintel (2022), which analyses the regional differences in the stunting rate for the most vulnerable children in the country, including double orphans and children with both parents absent. However, for the current analysis, distinguishing between parental absence and death is material, and the 10% sample is therefore used.

The 10% sample of the data is available only at the level of the local municipality (N=234), and not the electoral ward (N=4267). However, this geographic level still provides sufficiently small polygons to perform a meaningful analysis of the spatial variation in child health measures.

Appendix 4-B: Individual GHS tables

Table 4-B1: Full GHS 2010 table

	Child Hunger (child is hungry sometimes, often or always)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mom absent	0.1000***	0.0928**	0.0611	0.0608	0.1073***	0.0942	0.0678
	(0.0376)	(0.0375)	(0.0577)	(0.0576)	(0.0379)	(0.0583)	(0.0604)
Dad absent	0.0941***	0.0666***	0.0390**	0.0390**	0.1045***	0.0562***	0.0531***
	(0.0113)	(0.0120)	(0.0167)	(0.0167)	(0.0120)	(0.0173)	(0.0168)
Both absent	0.0706***	0.0438***	0.0074	0.0067	0.0850***	0.0307	0.0196
	(0.0161)	(0.0163)	(0.0210)	(0.0210)	(0.0168)	(0.0222)	(0.0216)
Maternal orphan	0.1776***	0.1499***	0.1722***	0.1676***	0.1871***	0.1878***	0.1531***
	(0.0458)	(0.0471)	(0.0595)	(0.0600)	(0.0458)	(0.0611)	(0.0570)
Paternal orphan	0.1243***	0.0867***	0.0738**	0.0738**	0.1315***	0.0757**	0.0703**
	(0.0252)	(0.0263)	(0.0310)	(0.0310)	(0.0251)	(0.0320)	(0.0325)
Double orphan	0.0712	0.0449	0.0648	0.0466	0.0728	0.0554	0.0636
	(0.0449)	(0.0445)	(0.0668)	(0.0657)	(0.0449)	(0.0671)	(0.0594)
Log HH Income		-0.0503***				-0.0548***	-0.0585***
		(0.0055)				(0.0085)	(0.0083)
CSG receipt			0.0553			0.0937	0.0911
			(0.0534)			(0.0664)	(0.0661)
FCG receipt				-0.0077		0.1042	0.1118
				(0.0762)		(0.0993)	(0.0942)
Remittance receipt					-0.0498***	-0.0900***	-0.0898***
					(0.0156)	(0.0189)	(0.0192)
Urban control						Yes	Yes
Flush Toilet							-0.0320
							(0.0247)
Tap water							-0.0722***
							(0.0185)
Provincial fixed effect							Yes
Constant	0.1149***	0.5336***	0.1346**	0.1896***	0.1171***	0.5119***	0.7130***
	(0.0075)	(0.0477)	(0.0547)	(0.0134)	(0.0076)	(0.0959)	(0.1036)
R-squared	0.016	0.042	0.005	0.005	0.019	0.027	0.0262
N	11477	11254	7477	7479	11477	7477	7477

* p<0.1, ** p<0.05, *** p<0.01

Table 4-B2: Full GHS 2011 table

	Child Hunger (child is hungry sometimes, often or always)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mom absent	0.0625**	0.0561*	0.0428	0.0431	0.0645**	0.0656	0.0516
	(0.0302)	(0.0307)	(0.0422)	(0.0422)	(0.0303)	(0.0420)	(0.0415)
Dad absent	0.0528***	0.0272**	0.0031	0.0032	0.0557***	0.0147	0.0144
	(0.0107)	(0.0112)	(0.0157)	(0.0157)	(0.0113)	(0.0163)	(0.0158)
Both absent	0.0410***	0.0135	-0.0007	-0.0012	0.0449***	0.0199	0.0101
	(0.0144)	(0.0143)	(0.0196)	(0.0196)	(0.0154)	(0.0207)	(0.0204)
Maternal orphan	0.0751**	0.0591	0.0556	0.0496	0.0774**	0.0712	0.0455
	(0.0375)	(0.0380)	(0.0496)	(0.0479)	(0.0376)	(0.0472)	(0.0465)
Paternal orphan	0.1124***	0.0697***	0.0525*	0.0526*	0.1142***	0.0543**	0.0443*
	(0.0248)	(0.0236)	(0.0272)	(0.0272)	(0.0250)	(0.0269)	(0.0267)
Double orphan	0.0823	0.0356	0.0621	0.0343	0.0845	0.0470	0.0304
	(0.0536)	(0.0604)	(0.0652)	(0.0694)	(0.0536)	(0.0701)	(0.0711)
Log HH Income		-0.0462***				-0.0537***	-0.0545***
		(0.0054)				(0.0075)	(0.0074)
CSG receipt			0.0175			0.1002*	0.0936
			(0.0679)			(0.0590)	(0.0604)
FCG receipt				0.0851		0.1858	0.1787
				(0.1093)		(0.1209)	(0.1212)
Remittance receipt					-0.0146	-0.0472***	-0.0404**
					(0.0146)	(0.0164)	(0.0160)
Urban control						Yes	Yes
Flush Toilet							-0.0111
							(0.0259)
Tap water							-0.0552***
							(0.0184)
Provincial fixed effect							Yes
Constant	0.1013***	0.4887***	0.1420**	0.1592***	0.1020***	0.4697***	0.6177***
	(0.0076)	(0.0471)	(0.0687)	(0.0132)	(0.0076)	(0.0870)	(0.0954)
R-squared	0.0078	0.0373	0.0017	0.0019	0.0080	0.0212	0.0262
N	10828	10574	7052	7053	10828	7052	7052

* p<0.1, ** p<0.05, *** p<0.01

Table 4-B3: Full GHS 2014 table

	Child Hunger (child is hungry sometimes, often or always)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mom absent	0.0720**	0.0634**	0.0633	0.0650	0.0732**	0.0738*	0.0570
	(0.0314)	(0.0304)	(0.0468)	(0.0468)	(0.0313)	(0.0447)	(0.0442)
Dad absent	0.0832***	0.0552***	0.0480***	0.0497***	0.0850***	0.0503***	0.0487***
	(0.0103)	(0.0105)	(0.0151)	(0.0151)	(0.0109)	(0.0153)	(0.0152)
Both absent	0.0533***	0.0217	0.0159	0.0175	0.0561***	0.0212	0.0172
	(0.0132)	(0.0134)	(0.0175)	(0.0174)	(0.0135)	(0.0174)	(0.0176)
Maternal orphan	0.0933**	0.0645	0.0948*	0.1101*	0.0942**	0.1027*	0.1110**
	(0.0415)	(0.0418)	(0.0560)	(0.0571)	(0.0416)	(0.0573)	(0.0540)
Paternal orphan	0.1215***	0.0818***	0.0839***	0.0855***	0.1227***	0.0716**	0.0663**
	(0.0268)	(0.0261)	(0.0316)	(0.0315)	(0.0269)	(0.0309)	(0.0304)
Double orphan	-0.0221	-0.0406	-0.0597	-0.0327	-0.0218	-0.0279	-0.0112
	(0.0295)	(0.0295)	(0.0369)	(0.0390)	(0.0295)	(0.0398)	(0.0397)
Log HH Income		-0.0491***				-0.0609***	-0.0617***
		(0.0046)				(0.0078)	(0.0081)
CSG receipt			0.0546			0.0069	0.0281
			(0.0429)			(0.0562)	(0.0541)
FCG receipt				-0.1614***		-0.1275**	-0.1305**
				(0.0323)		(0.0631)	(0.0616)
Remittance receipt					-0.0100	-0.0341**	-0.0276*
					(0.0147)	(0.0170)	(0.0166)
Urban control						Yes	Yes
Flush Toilet							-0.0354
							(0.0257)
Tap water							-0.0142
							(0.0187)
Provincial fixed effect							Yes
Constant	0.0758***	0.5074***	0.0701	0.1230***	0.0762***	0.6359***	0.7569***
	(0.0062)	(0.0426)	(0.0436)	(0.0119)	(0.0063)	(0.0885)	(0.0958)
R-squared	0.0078	0.0373	0.0017	0.0019	0.0080	0.0212	0.0262
N	10828	10574	7052	7053	10828	7052	7184

* p<0.1, ** p<0.05, *** p<0.01

Table 4-B4: Full GHS 2015 table

	Child Hunger (child is hungry sometimes, often or always)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mom absent	0.0792**	0.0676**	0.0772*	0.0758*	0.0827***	0.0821*	0.0836**
	(0.0321)	(0.0330)	(0.0425)	(0.0425)	(0.0321)	(0.0429)	(0.0423)
Dad absent	0.0762***	0.0562***	0.0437***	0.0435***	0.0834***	0.0536***	0.0467***
	(0.0106)	(0.0114)	(0.0139)	(0.0139)	(0.0112)	(0.0148)	(0.0144)
Both absent	0.0502***	0.0299**	0.0208	0.0197	0.0603***	0.0391**	0.0396**
	(0.0139)	(0.0146)	(0.0176)	(0.0176)	(0.0147)	(0.0186)	(0.0183)
Maternal orphan	0.0476	0.0314	0.0180	0.0161	0.0509	0.0292	0.0260
	(0.0408)	(0.0433)	(0.0492)	(0.0493)	(0.0407)	(0.0491)	(0.0469)
Paternal orphan	0.1212***	0.0950***	0.0749***	0.0740***	0.1241***	0.0779***	0.0759***
	(0.0244)	(0.0246)	(0.0276)	(0.0276)	(0.0245)	(0.0274)	(0.0270)
Double orphan	0.0835	0.0676	0.0582	0.0533	0.0888	0.0518	0.0280
	(0.0594)	(0.0583)	(0.0769)	(0.0784)	(0.0598)	(0.0847)	(0.0868)
Log HH Income		-0.0314***				-0.0379***	-0.0391***
		(0.0045)				(0.0071)	(0.0072)
CSG receipt			0.0769**			0.0867**	0.0859**
			(0.0369)			(0.0371)	(0.0336)
FCG receipt				-0.0260		0.0676	0.0873
				(0.0965)		(0.1011)	(0.0893)
Remittance receipt					-0.0370***	-0.0458***	-0.0423***
					(0.0134)	(0.0158)	(0.0156)
Urban control						Yes	Yes
Flush Toilet							-0.0808***
							(0.0219)
Tap water							-0.0650***
							(0.0173)
Provincial fixed effect							Yes
Constant	0.0823***	0.3557***	0.0469	0.1236***	0.0853***	0.3501***	0.6028***
	(0.0063)	(0.0409)	(0.0376)	(0.0104)	(0.0064)	(0.0705)	(0.0771)
R-squared	0.0078	0.0373	0.0017	0.0019	0.0080	0.0212	0.0262
N	10828	10574	7052	7053	10828	7052	6122

* p<0.1, ** p<0.05, *** p<0.01

Table 4-B5: Full GHS 2018 table

	Child Hunger (child is hungry sometimes, often or always)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mom absent	0.0567*	0.0512	0.0236	0.0229	0.0623**	0.0310	0.0186
	(0.0316)	(0.0331)	(0.0392)	(0.0392)	(0.0317)	(0.0398)	(0.0414)
Dad absent	0.0759***	0.0541***	0.0485***	0.0476***	0.0859***	0.0526***	0.0451***
	(0.0095)	(0.0101)	(0.0132)	(0.0132)	(0.0104)	(0.0140)	(0.0137)
Both absent	0.0456***	0.0211	0.0244	0.0250	0.0574***	0.0294	0.0292
	(0.0138)	(0.0149)	(0.0179)	(0.0180)	(0.0146)	(0.0191)	(0.0183)
Maternal orphan	0.0898	0.0751	0.0997	0.0925	0.0943*	0.0927	0.0780
	(0.0562)	(0.0574)	(0.0711)	(0.0694)	(0.0559)	(0.0696)	(0.0676)
Paternal orphan	0.0676**	0.0412	0.0209	0.0189	0.0735***	0.0156	0.0036
	(0.0283)	(0.0285)	(0.0276)	(0.0275)	(0.0285)	(0.0274)	(0.0262)
Double orphan	0.1840	0.1528	0.1735	0.1626	0.1926	0.1547	0.1830
	(0.1250)	(0.1254)	(0.1343)	(0.1298)	(0.1241)	(0.1298)	(0.1250)
Log HH Income		-0.0321***				-0.0355***	-0.0357***
		(0.0041)				(0.0057)	(0.0057)
CSG receipt			0.0143			0.0212	-0.0036
			(0.0499)			(0.0529)	(0.0491)
FCG receipt				0.0438		0.0772	0.0979
				(0.1165)		(0.1271)	(0.1209)
Remittance receipt					-0.0421***	-0.0688***	-0.0676***
					(0.0128)	(0.0161)	(0.0155)
Urban control						Yes	Yes
Flush Toilet							-0.0584***
							(0.0217)
Tap water							-0.0474***
							(0.0172)
Provincial fixed effect							Yes
Constant	0.0577***	0.3478***	0.0765	0.0915***	0.0590***	0.3781***	0.5492***
	(0.0057)	(0.0392)	(0.0505)	(0.0103)	(0.0058)	(0.0779)	(0.0803)
R-squared	0.0078	0.0373	0.0017	0.0019	0.0080	0.0212	0.0262
N	10828	10574	7052	7053	10828	7052	5498

* p<0.1, ** p<0.05, *** p<0.01

Table 4-B6: Full GHS 2019 table

	Child Hunger (child is hungry sometimes, often or always)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mom absent	0.0887***	0.0890***	0.0959**	0.0962**	0.0886***	0.1115***	0.1055***
	(0.0315)	(0.0315)	(0.0387)	(0.0387)	(0.0314)	(0.0383)	(0.0377)
Dad absent	0.0665***	0.0667***	0.0582***	0.0582***	0.0663***	0.0645***	0.0645***
	(0.0102)	(0.0103)	(0.0133)	(0.0133)	(0.0111)	(0.0143)	(0.0140)
Both absent	0.0516***	0.0518***	0.0414**	0.0416**	0.0513***	0.0586***	0.0627***
	(0.0132)	(0.0133)	(0.0164)	(0.0164)	(0.0137)	(0.0176)	(0.0180)
Maternal orphan	-0.0248	-0.0246	-0.0308	-0.0304	-0.0249	-0.0158	-0.0194
	(0.0243)	(0.0243)	(0.0301)	(0.0303)	(0.0243)	(0.0315)	(0.0301)
Paternal orphan	0.0958***	0.0960***	0.0690**	0.0691**	0.0957***	0.0749**	0.0801***
	(0.0265)	(0.0265)	(0.0306)	(0.0306)	(0.0268)	(0.0311)	(0.0304)
Double orphan	0.0318	0.0322	0.0509	0.0529	0.0316	0.0770	0.0923
	(0.0543)	(0.0543)	(0.0725)	(0.0729)	(0.0545)	(0.0717)	(0.0726)
Log HH Income		-0.0001				-0.0357***	-0.0370***
		(0.0006)				(0.0056)	(0.0057)
CSG receipt			0.0609			0.0319	0.0384
			(0.0432)			(0.0582)	(0.0580)
FCG receipt				-0.0932***		-0.0749	-0.0832
				(0.0227)		(0.0607)	(0.0667)
Remittance receipt					0.0010	-0.0078	-0.0047
					(0.0162)	(0.0179)	(0.0177)
Urban control						Yes	Yes
Flush Toilet							0.0327
							(0.0218)
Tap water							-0.0409**
							(0.0167)
Provincial fixed effect							Yes
Constant	0.0644***	0.0652***	0.0232	0.0837***	0.0643***	0.3656***	0.4220***
	(0.0060)	(0.0069)	(0.0437)	(0.0091)	(0.0059)	(0.0765)	(0.0866)
R-squared	0.0078	0.0373	0.0017	0.0019	0.0080	0.0212	0.0262
N	10828	10574	7052	7053	10828	7052	5399

* p<0.1, ** p<0.05, *** p<0.01

Table 4-B7: Full GHS 2021 table

	Child Hunger (child is hungry sometimes, often or always)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mom absent	0.0714	0.0713	0.0420	0.0385	0.0762	0.0692	0.0463
	(0.0560)	(0.0560)	(0.0638)	(0.0640)	(0.0564)	(0.0627)	(0.0631)
Dad absent	0.0620***	0.0538***	0.0363	0.0364	0.0738***	0.0557**	0.0479*
	(0.0181)	(0.0184)	(0.0243)	(0.0242)	(0.0188)	(0.0250)	(0.0247)
Both absent	0.0503*	0.0436*	0.0307	0.0290	0.0648**	0.0513	0.0380
	(0.0258)	(0.0259)	(0.0333)	(0.0335)	(0.0274)	(0.0354)	(0.0345)
Maternal orphan	-0.0206	-0.0300	-0.1012***	-0.1085***	-0.0092	-0.0905***	-0.0835***
	(0.0500)	(0.0505)	(0.0197)	(0.0214)	(0.0502)	(0.0238)	(0.0272)
Paternal orphan	0.2134***	0.1983***	0.1905**	0.1887**	0.2195***	0.1831**	0.1827**
	(0.0657)	(0.0659)	(0.0740)	(0.0742)	(0.0661)	(0.0750)	(0.0724)
Double orphan	-0.0608***	-0.0737***	-0.0785***	-0.1038***	-0.0437**	-0.0800**	-0.0509
	(0.0155)	(0.0177)	(0.0254)	(0.0346)	(0.0193)	(0.0367)	(0.0504)
Log HH Income		-0.0215***				-0.0494***	-0.0515***
		(0.0069)				(0.0143)	(0.0144)
CSG receipt			0.1178***			0.6326**	0.6541**
			(0.0310)			(0.2790)	(0.3143)
FCG receipt				0.0585		0.5970**	0.5480*
				(0.1633)		(0.2665)	(0.2991)
Remittance receipt					-0.0606**	-0.0751***	-0.0608**
					(0.0271)	(0.0271)	(0.0256)
Urban control						Yes	Yes
Flush Toilet							0.0010
							(0.0407)
Tap water							0.0037
							(0.0274)
Provincial fixed effect							Yes
Constant	0.0706***	0.2617***	-0.0117	0.1060***	0.0722***	-0.1076	0.0254
	(0.0116)	(0.0647)	(0.0365)	(0.0191)	(0.0116)	(0.3127)	(0.3531)
R-squared	0.0078	0.0373	0.0017	0.0019	0.0080	0.0212	0.034
N	10828	10574	7052	7053	10828	7052	2207

* p<0.1, ** p<0.05, *** p<0.01

Table 4-B9: GHS Parental share sample sizes

	2010	2011	2014	2015	2018	2019	2021
Lives with mother and father	37,5%	35,9%	36,7%	37,7%	38,1%	35,8%	37,1%
Lives with dad, mom absent	2,1%	2,2%	2,4%	2,1%	2,1%	2,4%	1,9%
Lives with mom, dad absent	41,4%	43,8%	45,3%	44,2%	45,5%	44,7%	47%
Both parents absent	10,9%	11,1%	11,3%	10,7%	10,9%	11,6%	10,1%
Maternal orphan	1,6%	1,5%	0,9%	0,8%	0,5%	1,06%	0,8%
Paternal orphan	5,6%	4,6%	3,03%	3,6%	2,7%	3,9%	2,6%
Double orphan	0,93%	0,9%	0,4%	0,7%	0,14%	0,4%	0,4%

Appendix 4-C: Robustness test – results from NIDS wave 1 to 3

Tables 4-B1 to 4-B3 show the results of the robustness test which analyses the effect of parental status on child health outcomes using the National Income Dynamics Study (NIDS) wave 1 to 3 data. The data in waves 1 to 3 of NIDS was collected in 2008, 2010 and 2012 respectively, and these waves are used to allow for more comparability between this analysis and the primary results, which are for 2011 to 2013.The sample is limited to children who are 0 to 5 years old. This sample limitations allows for these results to be directly comparable to the primary results presented in section 6. Limiting the sample to children in this age group is also advisable given the different factors which cause stunting in younger children relative to older children (Wayan Dewi Tarini *et al.*, 2020).

Unfortunately, the smaller sample size reduces the statistical significance of the results in all waves except for wave 2. The data in wave 2 was collected in 2010, which is the year in which the 2008 Global Financial Crisis most affected the South African economy (Maisonnave *et al.*, 2015). The results in wave 2, therefore, represent the effects of a negative economic shock on child nutrition where no policy response was taken to mitigate the shock. Table B2 indicates that in 2010, there was a significant stunting penalty for paternal orphans and children with living but absent fathers as well as children with both parents living but absent. The 2010 coefficients for these groups of children are likely significant because of the increased risk of adverse health shocks in times of economic crises.

This result suggests that paternal orphans are not the only vulnerable group of children in terms of nutrition, but that children with absent fathers are also at risk of adverse health shocks in times of economic crises. Active father presence is linked with better health outcomes for their children. Male involvement and active partner support while the mother is pregnant is associated with fewer maternal health problems (Stapleton *et al.*, 2012; Walsh *et al.*, 2017). Better maternal health is a strong predictor of infant health, which could also act as a mechanism whereby paternal presence influences healthy growth for young children over and above their potential financial support. Further studies have found that a father's nutritional status is a strong predictor of child stunting status (Gertler *et al.*, 2003), although this effect is likely to be tied to socioeconomic status and food availability.

A significant result is seen in comparison of the 2010 crisis year with the results from the individual analysis of the GHS data in 2021, which is also considered a crisis year due to the

COVID-19 pandemic. These results are similar, and show that there is a stunting and hunger penalty associated with paternal orphanhood in 2010 and 2021, respectively.

Table 4-C1: NIDS Wave 1 results

	Wave 1 (2008) Stunting in Children under 5 years old							
Mom Absent	-0.0334	-0.0340	-0.0345	-0.0341	0.1510	-0.0583	0.2346*	0.2261*
	(0.0482)	(0.0483)	(0.0477)	(0.0482)	(0.1504)	(0.0563)	(0.1329)	(0.1294)
Dad Absent	0.0383*	0.0379*	0.0346*	0.0367*	0.0262	0.0308	0.0146	-0.0098
	(0.0208)	(0.0209)	(0.0209)	(0.0212)	(0.0584)	(0.0213)	(0.0621)	(0.0596)
Both Absent	0.0112	0.0110	0.0108	0.0083	-0.0222	0.0035	-0.0616	-0.0841
	(0.0272)	(0.0272)	(0.0271)	(0.0269)	(0.0677)	(0.0278)	(0.0665)	(0.0663)
Maternal Orphan	0.0308	0.0285	0.0284	0.0297	-0.1683***	0.0228	-0.1485***	-0.1572***
	(0.0835)	(0.0844)	(0.0838)	(0.0838)	(0.0494)	(0.0834)	(0.0561)	(0.0566)
Paternal Orphan	0.0532	0.0527	0.0489	0.0507	-0.0153	0.0465	-0.0485	-0.0809
	(0.0401)	(0.0402)	(0.0396)	(0.0394)	(0.0901)	(0.0403)	(0.0813)	(0.0836)
Double Orphan	0.0006	-0.0012	-0.0004	-0.0027	-0.1126	-0.0090	-0.1758*	-0.2223**
	(0.0653)	(0.0645)	(0.0643)	(0.0667)	(0.0758)	(0.0659)	(0.0915)	(0.0982)
FCG received		0.0000					-0.0001	-0.0001
		(0.0001)					(0.0001)	(0.0001)
CSG Received			0.0000				-0.0001*	-0.0001**
			(0.0000)				(0.0000)	(0.0000)
OAG Received				0.0000			0.0001*	0.0001
				(0.0000)			(0.0000)	(0.0001)
Remittance Received					-0.0000		-0.0000	-0.0000
					(0.0000)		(0.0000)	(0.0000)
Log HH Income						-0.0124	0.0005	0.0159
						(0.0077)	(0.0278)	(0.0276)
Flush Toilet								-0.0590
								(0.0638)
Constant	0.1303***	0.1301***	0.1262***	0.1298***	0.1713***	0.2317***	0.1910	0.1729
	(0.0160)	(0.0160)	(0.0174)	(0.0162)	(0.0498)	(0.0660)	(0.2249)	(0.2150)
R-squared	0.003	0.003	0.004	0.003	0.011	0.006	0.035	0.043
N	3130	3732	3732	3732	752	3732	752	751

* p<0.1, ** p<0.05, *** p<0.01

Table 4-C2: NIDS Wave 2 results

	Wave 2 (2010) Stunting in Children under 5 years old							
Mom Absent	0.0807	0.0821	0.0789	0.0809	0.0202	0.0432	-0.0196	0.0261
	(0.1034)	(0.1035)	(0.1062)	(0.1035)	(0.1593)	(0.1092)	(0.1673)	(0.2526)
Dad Absent	0.0618***	0.0621***	0.0465**	0.0622***	0.0106	0.0316	-0.0271	-0.2320
	(0.0220)	(0.0220)	(0.0219)	(0.0226)	(0.0914)	(0.0216)	(0.0923)	(0.1816)
Both Absent	0.0858**	0.0867**	0.0855**	0.0866**	-0.0631	0.0504	-0.0966	-0.3066
	(0.0381)	(0.0381)	(0.0383)	(0.0390)	(0.0980)	(0.0375)	(0.1002)	(0.1864)
Maternal Orphan	0.0304	0.0338	0.0257	0.0309	-0.1401	0.0131	-0.2476***	-0.4192**
	(0.0589)	(0.0589)	(0.0576)	(0.0594)	(0.0870)	(0.0570)	(0.0936)	(0.1917)
Paternal Orphan	0.0756**	0.0762**	0.0608	0.0760*	0.3062	0.0317	0.2595	0.0941
	(0.0383)	(0.0383)	(0.0391)	(0.0388)	(0.1857)	(0.0382)	(0.1798)	(0.2533)
Double Orphan	0.0799	0.0830	0.0749	0.0807	0.2198	0.0396	0.0573	0.3917
	(0.0893)	(0.0890)	(0.0841)	(0.0897)	(0.3023)	(0.0948)	(0.2757)	(0.3159)
FCG received		-0.0000					0.0001	0.0001
		(0.0000)					(0.0002)	(0.0002)
CSG Received			0.0001**				0.0001	0.0001
			(0.0000)				(0.0001)	(0.0001)
OAG Received				-0.0000			0.0000	-0.0000
				(0.0000)			(0.0000)	(0.0001)
Remittance Received					-0.0000***		0.0000	-0.0000
					(0.0000)		(0.0000)	(0.0000)
Log HH Income						-0.0507***	-0.0685**	-0.0691
						(0.0095)	(0.0291)	(0.0496)
Flush Toilet								0.0176
								(0.1389)
Constant	0.1104***	0.1107***	0.0956***	0.1106***	0.1449*	0.5405***	0.6810***	0.9561**
	(0.0160)	(0.0161)	(0.0169)	(0.0161)	(0.0871)	(0.0831)	(0.2526)	(0.4670)
R-squared	0.003	0.003	0.004	0.003	0.011	0.006	0.035	0.043
N	3156	3156	3156	3156	303	3156	303	108

* p<0.1, ** p<0.05, *** p<0.01

Table 4-C3: NIDS Wave 3 results

	Wave 3 (2012) Stunting in Children under 5 years old							
Mom Absent	-0.0425	-0.0421	-0.0415	-0.0433	0.1469	-0.0574	0.1418	0.1358
	(0.0350)	(0.0351)	(0.0350)	(0.0348)	(0.1007)	(0.0352)	(0.0980)	(0.1329)
Dad Absent	0.0247	0.0255	0.0240	0.0242	0.1236***	0.0057	0.1122***	0.1024**
	(0.0178)	(0.0178)	(0.0181)	(0.0178)	(0.0316)	(0.0172)	(0.0375)	(0.0495)
Both Absent	0.0036	0.0055	0.0041	0.0022	0.1411***	-0.0178	0.1227**	0.0964
	(0.0203)	(0.0203)	(0.0203)	(0.0209)	(0.0421)	(0.0201)	(0.0512)	(0.0713)
Maternal Orphan	0.0470	0.0533	0.0463	0.0464	0.1659	0.0291	0.1498	0.2719
	(0.0386)	(0.0386)	(0.0388)	(0.0387)	(0.1133)	(0.0382)	(0.1251)	(0.1726)
Paternal Orphan	0.0213	0.0223	0.0210	0.0206	0.1172***	-0.0023	0.0976*	0.0838
	(0.0212)	(0.0212)	(0.0213)	(0.0213)	(0.0449)	(0.0213)	(0.0576)	(0.0866)
Double Orphan	0.0136	0.0254	0.0137	0.0123	0.0034	-0.0064	-0.0037	0.0354
	(0.0280)	(0.0285)	(0.0280)	(0.0283)	(0.0402)	(0.0275)	(0.0469)	(0.0656)
FCG received		-0.0000**					-0.0000	-0.0000
		(0.0000)					(0.0000)	(0.0000)
CSG Received			0.0000				0.0000	-0.0000*
			(0.0000)				(0.0000)	(0.0000)
OAG Received				0.0000			-0.0000	0.0000
				(0.0000)			(0.0000)	(0.0000)
Remittance Received					-0.0000		-0.0000	0.0000
					(0.0000)		(0.0000)	(0.0000)
Log HH Income						-0.0284***	-0.0215	-0.0247
						(0.0066)	(0.0186)	(0.0227)
Flush Toilet								0.0327
								(0.0480)
Constant	0.1710***	0.1714***	0.1683***	0.1708***	0.0687***	0.4211***	0.2587	0.3187
	(0.0149)	(0.0149)	(0.0156)	(0.0150)	(0.0230)	(0.0577)	(0.1674)	(0.2074)
R-squared	0.003	0.003	0.004	0.003	0.011	0.006	0.035	0.043
N	11172	11172	11172	11172	1785	11172	1785	833

* p<0.1, ** p<0.05, *** p<0.01

Table 4-C4: cell sizes in NIDS data

	Wave 1 (2008)		Wave 2 (2010/11)		Wave 3 (2012/13)	
	Freq,	Percent	Freq,	Percent	Freq,	Percent
Lives with mother and father	894	28,6%	784	24,8%	800	21,8%
Lives with dad, mom absent	43	1,4%	55	1,7%	55	1,5%
Lives with mom, dad absent	1,51	48,3%	1,693	53,6%	2,046	55,8%
Both parents absent	435	13,9%	314	9,9%	500	13,63
Maternal orphan	56	1,8%	55	1,7%	48	1,3%
Paternal orphan	160	5,1%	222	7%	191	5,2%
Double orphan	28	1%	34	1%	28	0,8%

Table 4-C4: Robustness check with pooled NIDS data

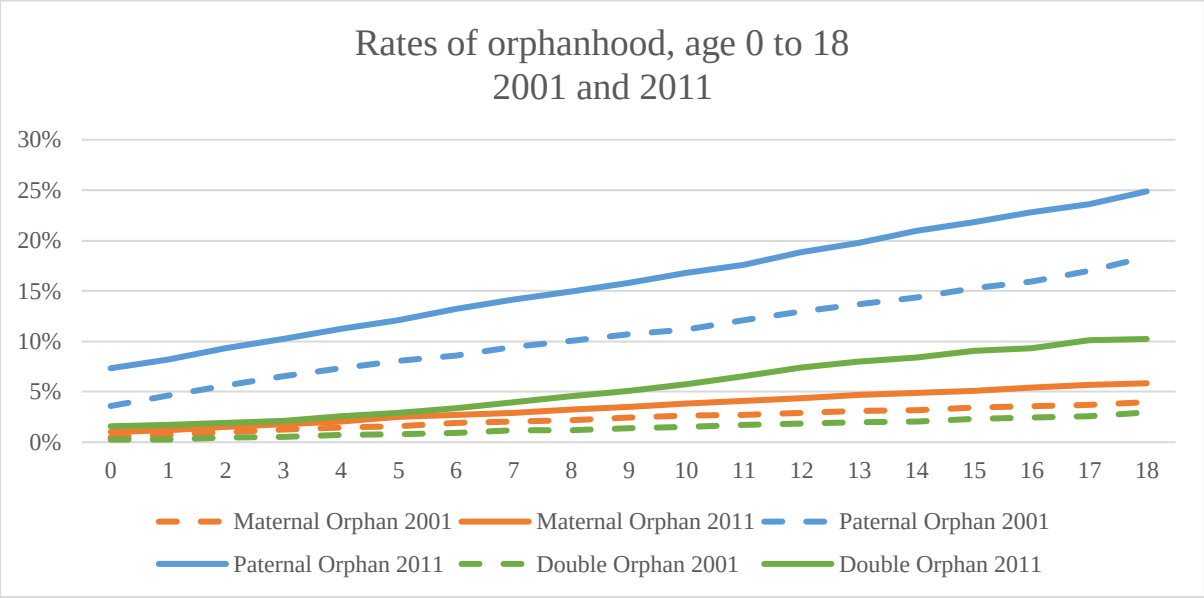
	Pooled sample							
	Stunting in Children under 5 years old							
Mom Absent	-0.0266	-0.0266	-0.0248	-0.0261	-0.0217	-0.0378	-0.0217	-0.0045
	(0.0357)	(0.0357)	(0.0358)	(0.0357)	(0.1088)	(0.0351)	(0.1095)	(0.1101)
Dad Absent	0.0121	0.0121	0.0075	0.0129	-0.0423	0.0021	-0.0618	-0.0668
	(0.0114)	(0.0114)	(0.0115)	(0.0115)	(0.0479)	(0.0117)	(0.0481)	(0.0477)
Both Absent	0.0321*	0.0321*	0.0333*	0.0333*	-0.0855	0.0187	-0.1152**	-0.1244**
	(0.0174)	(0.0174)	(0.0174)	(0.0176)	(0.0524)	(0.0177)	(0.0531)	(0.0528)
Maternal Orphan	0.0657**	0.0656**	0.0592**	0.0669**	-0.1090*	0.0621**	-0.1296*	-0.1377**
	(0.0289)	(0.0290)	(0.0289)	(0.0290)	(0.0639)	(0.0289)	(0.0668)	(0.0649)
Paternal Orphan	0.0818***	0.0818***	0.0739***	0.0833***	0.0388	0.0778***	0.0190	0.0098
	(0.0173)	(0.0173)	(0.0176)	(0.0175)	(0.0577)	(0.0173)	(0.0577)	(0.0580)
Double Orphan	0.0683*	0.0680*	0.0635	0.0704*	0.0286	0.0652*	0.0000	-0.0003
	(0.0396)	(0.0398)	(0.0393)	(0.0397)	(0.1173)	(0.0394)	(0.1170)	(0.1168)
FCG received		0.0000					0.0000	0.0000
		(0.0000)					(0.0001)	(0.0001)
CSG Received			0.0000**				0.0000	-0.0000
			(0.0000)				(0.0000)	(0.0000)
OAG Received				-0.0000			0.0000*	0.0000
				(0.0000)			(0.0000)	(0.0000)
Remittance Received					-0.0000		0.0000	0.0000
					(0.0000)		(0.0000)	(0.0000)
Log HH Income						-0.0272***	-0.0400**	-0.0275*
						(0.0053)	(0.0160)	(0.0165)
Flush Toilet								-0.0158
								(0.0328)
Constant	0.1466***	0.1466***	0.1376***	0.1472***	0.2251***	0.3671***	0.5400***	0.5001***
	(0.0091)	(0.0091)	(0.0096)	(0.0092)	(0.0451)	(0.0448)	(0.1367)	(0.1372)
R-squared	0.003	0.003	0.004	0.003	0.011	0.006	0.035	0.043
N	6926	6926	6926	6926	1071	6926	1071	1070

NOTE: * p<0.1, ** p<0.05, *** p<0.01. Standard errors are double clustered at the household and individual level.

The NIDS regressions were run using a pooled dataset of children under 5 years in waves 1 to 5 of the NIDS data. The models were clustered at the individual level to account for the same individual child appearing in the dataset up to 3 times. The results are shown in the table below. This table suggests that paternal orphans experience a stunting penalty, and that maternal orphans experience are less likely to be stunted. These results should be investigated further.

Appendix 4-D: A discussion of South African orphanhood between 2001 and 2011

Figure 4-D1: Rates of orphanhood in 2001 and 2011



The share of children who are orphans is far higher in 2011 relative to 2001. This is especially the case for paternal and double orphanhood. Paternal orphanhood increased from 7% to 11% of four-year-old children between 2001 and 2011. While the rate of orphanhood is higher at each age in 2011 relative to 2001, there is no change in the probability of orphanhood at any age.

As mentioned in section 4.2.1, orphanhood in South Africa increased dramatically between the mid-1990s and 2010 due to the HIV pandemic in South Africa at that time. The halt in the increase in orphanhood is attributed to the successful rollout of Antiretroviral treatment in 2004, which started to have a meaningful effect in 2010 (De Paoli, Mills and Grønningsæter, 2012).

Appendix 4-E: Robustness check of the assocciation between individual parental status and stunting prevalence

Table 4-E1: Regressions of each of the types of parental status on child stunting

	Child Stunting Prevalence						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Share double orphan	0.0005						
	(0.0016)						
Share paternal orphan		0.0065***					
		(0.0021)					
Share maternal orphan			-0.0005				
			(0.0014)				
Share both parents absent				-0.0009			
				(0.0022)			
Share dad absent					-0.0024		
					(0.0015)		
Share mom absent						-0.0015	
						(0.0017)	
Share lives with both parents							0.0006
							(0.0026)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.2663***	0.2596***	0.2661***	0.2666***	0.2841***	0.2691***	0.2640***
	(0.0204)	(0.0201)	(0.0208)	(0.0205)	(0.0229)	(0.0209)	(0.0225)
	(0.0334)	(0.0348)	(0.0364)	(0.0341)	(0.0326)	(0.0356)	(0.0331)
N	222	222	222	222	222	222	222

NOTE: * p<0.1, ** p<0.05, *** p<0.01. Controls include Municipality OAG, CSG, FCG and remittance receipt, Sanitation, Piped water, HH Asset index, and indicator variables for former homelands and metropolitan municipalities.

The reference category for comparison is “all other parental status shares” including the share that lives with both parents. The table suggests that in places where there are higher shares of paternal orphans relative to all other parental status shares, there is a significantly higher stunting prevalence. This confirms the results and the interpretation presented in table 4.2.

The second purpose of this robustness check is to estimate the change in stunting prevalence that is associate with a 1-standard-deviation change in paternal orphanhood. Column (2) shows that a 1-standard-deviation change in the share of children who are paternal orphans is associated with a 0,65% increase in stunting in an area.