

**EXTENDING THE SOUTH AFRICAN CHILD SUPPORT GRANT: A
COST-EFFECTIVENESS ANALYSIS OF IMPLEMENTING A
PREGNANCY SUPPORT GRANT**

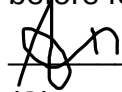
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A research report submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Public Health.

Johannesburg, October 2022.

DECLARATION

I, Aisha Moolla, declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Public Health at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



(Signature of candidate)

30th day of September 2022 in Parktown, Johannesburg

To my chosen family, without whom I could not have made it this far.

Presentations arising from this research project

The abstract of this research has been presented on 29 August 2022 at the DOHaD World Congress 2022 in Vancouver, Canada hosted on August 27-31, 2022.

Publications arising from this research project

No part of the work contained in this report was published.

ABSTRACT

Introduction: The child support grant (CSG) was introduced to reduce child poverty in South Africa. However, it fails to address the negative health consequences of maternal poverty during pregnancy. This study aims to determine whether a pregnancy support grant (PSG), through the extension of the CSG, would be cost-effective.

Methods and materials: Decision tree analytical modelling was used to determine the costs and benefits of the intervention over a 2-year time horizon. An ingredients-based approach to costing was used from a governmental perspective. Benefits were presented as disability-adjusted life years (DALYs) averted. Health states included antenatal care, stillbirth, preterm birth, low birth weight, small-for-gestational age, infant death, respiratory distress syndrome, neonatal hypoglycaemia, chronic lung disease, and motor impairment.

Results: The PSG was found to reduce costs by ZAR31,200.00 per person. An incremental cost-effectiveness ratio of -ZAR233,000.00 per DALY averted was estimated, which was below the ZAR38,500.00 threshold.

Discussion: The results are supported by current literature, which shows that income support interventions during pregnancy are cost-effective. The major limitation of this study is the use of secondary data from published literature. This may under- or overestimate parameters. However, parameters were varied in the sensitivity analysis.

Conclusion: The results indicate that the PSG is highly cost-effective.
Recommendations: The PSG should be implemented by government using an inter-governmental co-funding approach.

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LIST OF ABBREVIATIONS

AGA:	Appropriate-for-gestational age
ANC:	Antenatal care
CSG:	Child support grant
DALYs:	Disability-adjusted life years
DW:	Disability weighting
GDP:	Gross domestic product
ICER:	Incremental cost-effectiveness ratio
INMB:	Incremental net monetary benefit
LBW:	Low birth weight
LMIC:	Low- and middle-income country
NBW:	Normal birth weight
NICU:	Neonatal intensive care unit
PSG:	Pregnancy support grant
RDS:	Respiratory distress syndrome
SGA:	Small-for-gestational age
WHO:	World Health Organization
YLD:	Years lost due to disability
YLL:	Years of life lost due to premature mortality

CHAPTER ONE: INTRODUCTION

This chapter will discuss the current state of maternal and child poverty, particularly during pregnancy. It will explore the effects and cost-effectiveness of income support interventions during pregnancy. Finally, this section will present the aims and objectives of this study.

1.1 General Introduction

Despite progress since the end of the Apartheid era, South Africa has remained one of the most unequal societies globally, with a Gini coefficient of around 0.65 (1). Almost half (56%) of South African citizens live below the national upper poverty line (i.e., an income less than ZAR992 per month per person) (2). This level of poverty has affected the ability of individuals to obtain adequate nutrition leading to hunger. In 2019, approximately 11% of the population had experienced hunger and 18% had limited access to food (3). Women and children are particularly affected by poverty and hunger in South Africa, and the child support grant (CSG) aims to address these issues.

A large gender disparity exists within South Africa. Approximately 75% of female-headed households fall below the upper-bound poverty line compared to 59% of male-headed households (4). This gender discrepancy has been largely driven by the high level of female unemployment. Over the last five years, women have consistently experienced higher rates of unemployment, with 34% of women being unemployed in 2020 compared to 31% of men (1,5). Consequently, female-headed households are more likely to lack access to both sanitation and water (4). They are also more likely to have insufficient food and run out of money to purchase food (6). This has resulted in poor nutrition among women, which is made worse by the smaller food portion sizes they consume in order to feed other household members

(6). These circumstances have led women to rely on grants (27%) far more than men (15%) (6).

Similarly, South African children experience high levels of poverty, which results in poor outcomes. More than half (62%) of South African children (age 0-17 years) are multi-dimensionally poor, with more than half (51%) of children living below the lower bound poverty line (ZAR647 per month) (7). Among children under five years of age, dimensions of housing, child development, and health were most affected by poverty (8). Poverty has been found to be worst amongst children who are double orphaned (77.3%) or who are paternal orphans (75.0%), which is important when considering the large proportion of pregnancies occurring in female-headed households (8).

In an attempt to address poverty in women and children, the CSG was introduced in 1998 (9). Following the end of the apartheid era, the consequences of long-term poverty, malnutrition, and a lack of sanitation became evident among previously disadvantaged South Africa child (10). In the 1990s, approximately one-third of under five deaths were as a result of diarrhoea and lower respiratory infections, which are often linked to poverty (11). Additionally, the effects of malnutrition and stunting in the form of cognitive impairment were becoming apparent (12).

In 1997, political leaders convened experts through the Lund Committee on Child and Family Support in order to address this issue (10). This led to the rollout of the CSG in 1998, which was paid out to the poorest 30% of children at valued at ZAR100 each month until the child turned seven years of age (13). The income threshold was set at a household income of ZAR800 and ZAR1,100 in rural and urban areas, respectively (13). The eligibility criteria further included the need for child vaccinations to be up-to-date and family participation in development programs (10). Over the following two decades, the age eligibility criteria for the child has increased,

the value of the grant was increased, the income threshold has been increased, and the conditionality of the grant was removed (13).

As of April 2021, the CSG entitles families earning less than ZAR48,000 per annum per parent to ZAR460 per child per month once the child is born (14). The grant is paid out to families from birth until the age of 18 years. In 2022, it was estimated that 13 million children were enrolled, which was equivalent to 82.5% of all eligible children (13). Early initiation of the CSG reduces multidimensional poverty, resulting in improved childhood health, educational, and nutritional outcomes (9).

A basic income grant, a monthly cash transfer, has also been proposed in order to tackle high rates of poverty and unemployment (15). However, this tax-funded grant has been met with criticism as a big enough grant may be unaffordable, leading to a decline in economic growth (15). In light of this, more affordable solutions are needed.

Despite improved outcomes attributable to the CSG, poverty and hunger remain a problem for many South African women and children (6,16). Alternative interventions need to be explored to address these issues. This study aims to evaluate whether a pregnancy support grant (PSG) would be a cost-effective intervention in South Africa.

1.2 Literature Review

The United Nation's Sustainable Development Goal 3 highlights the importance of maternal and child health (17). This goal aims to reduce the maternal mortality ratio to less than 70 per 100,000 live births and the neonatal (0–1 month) and under-five mortality rates to 1,200 per 100,000 live births and 2,500 per 100,000 live births, respectively, by 2030 (17). These targets remain challenging to achieve. There are approximately 1.3 million pregnancies annually in South Africa, with a maternal mortality in facility ratio of 88 maternal deaths per 100,000 live births and a neonatal

death in facility rate of 1,200 per 100,000 live births (18). Additionally, high absolute neonatal deaths indicate the need for urgent interventions that are cost-effective (19). High rates of perinatal morbidity and mortality are largely driven by preterm birth, high blood pressure, haemorrhage, and infection (20). Preterm birth refers to neonates born before 37 weeks of gestation (21). These conditions are mediated by access to antenatal care (ANC), as adequate care results in a 16% reduction in infant mortality (0-1 year) and a 24% reduction in preterm birth (22). This highlights the need for interventions that tackle the barriers to care. One of these barriers include poverty (23). Although pregnancy contributes to societal wellbeing, in the face of vulnerability, pregnancy perpetuates the poverty experienced by South African women, affecting maternal and child outcomes.

1.2.1 Financial burden of pregnancy

Already impoverished women experience increased health and financial burdens associated with pregnancy. A high proportion of pregnancies occur in female-headed households (46%) due to the large proportion of pregnant women being single (53%) (24), leaving women with little financial support. Approximately 69% of pregnancies occur in impoverished households, with 44% of these households being eligible for a CSG (24). This highlights the financial vulnerability of these households.

Consequently, 35% and 25% of pregnant women run out of money to purchase food and experience hunger, respectively (24). These issues have even greater consequences among teenagers. Notably, 14% of pregnancies occur among women aged 10-19 years, leading to a school dropout rate of up to 74% among this group (24–26).

The economic status of pregnant women is further diminished due to a reduction in their ability to find and sustain employment opportunities. Reduced employment

occurs partly due to increased costs associated with accessing ANC such as transport costs, a lack of affordable child care that is needed when the mother is attending antenatal visits, and reduced levels of education, particularly among teenagers (8,24,27,28). Low levels of income among pregnant women have detrimental effects on both maternal and child outcomes primarily due to reduced access to ANC and a lack of adequate nutrition (8,27,29).

1.2.2 Outcomes associated with poverty during pregnancy

Following evidence linking ANC and reduced perinatal mortality, the World Health Organization (WHO) has recommended that women attend at least eight ANC visits during their pregnancy (30). In 2020, approximately 83% of South African women accessed at least one ANC visit and 91% had births performed by skilled attendants (18). This indicates that approximately 17% of women do not access any ANC and are classified as being unbooked. A lack of ANC is more prevalent among poor women, and an association exists between the likelihood and frequency of accessing ANC and earning a higher income (23,31–34). South African women who do not access ANC have highlighted the cost of transport and forgoing income-generating activities as barriers to care (35). ANC coverage is particularly low among teenagers who have reported stigma as a barrier to care (36). Further, lack of frequent ANC has been linked to both neonatal and infant mortality as well as low birth weight (LBW), which refers to a birth weight less than 2,500g (37), and stunting, defined as a height-for-age that is two standard deviations below the median (38,39). A lack of ANC has also been linked to increased rates of maternal and perinatal morbidity (40).

Maternal dietary needs increase during pregnancy to support foetal and placental growth (27,41). The earlier adequate nutrition is established during the pregnancy period, the greater the positive impact on foetal nutrition (41–43). Conversely, poor

maternal nutrition may lead to poor foetal nutrition, which increases the likelihood of negative birth outcomes, including: preterm birth; LBW; intrauterine growth restriction, defined as growth of a foetus (height or weight) below the 10th percentile for the gestational age; and impaired child development (41,43–47). These contribute to a loss of wellbeing among society. In South Africa, pregnant women often lack adequate macro- and micro-nutrient intake as a result of a lack of food variety (43). Undernutrition resulting in growth restriction accounts for 21% of disability-adjusted life years (DALYs) among children under five years (47). Maternal health is also negatively affected by undernutrition, with maternal anaemia contributing 0.4% to DALYs worldwide as a result of maternal mortality (47). Beyond the physiological consequences of a poor diet, maternal mental illness has also been linked to food insecurity (48).

1.2.3 Impact of interventions

Globally, several interventions have aimed to address the financial burden placed on pregnant women. These include PSGs, conditional and unconditional cash transfers, voucher schemes, and nutrition support focused on addressing the consequences of poverty during pregnancy. These interventions have positively affected healthcare utilisation, maternal nutrition, maternal and neonatal mortality, the preterm birth rate, birth weight, and child growth and development (49). Financial support provided to already impoverished households had a far greater effect on child outcomes compared to wealthier households, suggesting that targeting the poor may result in significant reductions in poor health outcomes later in life (50).

Antenatal care and skilled birth attendants

Several systematic reviews, cohort studies, and control trials in other low- and middle-income countries (LMICs) evaluated interventions that provide women with

financial support that have aimed to increase ANC attendance as well as delivery by a skilled birth attendant. Pregnant women were provided with the financial support to receive free ANC, obtain a cash transfer or a voucher for transport or ANC on attendance, or subsidized transport to attend antenatal visits (51–64). These incentives resulted in an up to 29% increase in ANC visits among pregnant women (54,57,59,65,66). They also resulted in a 3.6-fold increase in births assisted by skilled attendants (53–55,57,65,67–69).

Maternal nutrition

A report published by the WHO indicated that providing women with financial support has commonly resulted in the funds being used to purchase food (70). Other food-specific interventions have also been used to assist pregnant women in receiving adequate nutrition during pregnancy. These interventions improved healthy weight gain and prevented deficiencies, such as anaemia during pregnancy, in a controlled trial (71).

Preterm births and birth weight

Data on the effect of financial support on the gestational age of the infant at birth vary across control trials and cohort studies. In some studies, no significant reduction in preterm births were found (72,73), while in others, an up to 18% relative reduction in the risk of being preterm has been reported (42,74,75). Nevertheless, consistent evidence is seen for the reduction in infants who are born with LBW (72,75–77) and who are small-for-gestational age (SGA) (42,72,76,78,79). SGA refers to a birth weight less than the 10th percentile for birth weight (80).

Growth and development

Positive longer-term effects on child growth and development have been reported because of financial support during pregnancy. Children of mothers receiving

financial or nutritional support have a significantly lower rate of stunting and wasting later in life (70,71,81–85). Similarly, multiple dimensions of cognitive, language, and motor development are positively affected by this type of intervention (81).

Maternal and child mortality

The impact of pregnancy grants as well as improved maternal nutrition have been observed in relation to neonatal mortality. Rates of neonatal mortality were significantly reduced by 3.2 neonatal deaths per 1,000 live births when a maternal grant was provided (86–91).

Cost-effectiveness

Although improved maternal and child health outcomes are observed when financial support is provided to women during pregnancy, whether this form of intervention is cost-effective and feasible needs to be further evaluated. However, a paucity of literature currently exists. To date, only four studies have completed a cost-effectiveness analysis on the implementation of a financial support intervention during pregnancy in LMICs. Table 1.1 provides a summary of these economic evaluations.

Table 1.1: Summary of cost-effectiveness studies in LMICs

Intervention	Country	Perspective	Time horizon	Analysis	Threshold	Outcome	Reference
Voucher scheme	Uganda	Payer and societal	Life time	Cost-utility, decision tree	US\$1,518 per DALY averted	US\$338 (payer) and US\$302 (societal) per DALY averted	(92)
Voucher scheme	Myanmar	Societal	Not indicated	Cost-utility, decision tree	600,000 kyats per DALY averted	381,072 kyats per DALY averted	(93)

Conditional cash transfer	Nigeria	Payer	Five years	Cost-effectiveness		US\$572 per delivery and US\$11 per ANC package	(94)
Voucher scheme	Bangladesh	Payer	Ten years	Cost-effectiveness		US\$70 per delivery by a skilled birth attendant	(60)

Ugandan travel voucher scheme

Alfonso et al. have reported on the cost-effectiveness of a transport voucher scheme and quality improvement initiative in Uganda aimed at addressing barriers such as transport and service costs (92). A cost-utility analysis with a lifetime time horizon was completed from a societal perspective using decision tree modelling. The decision tree included nodes for births at a health facility, receiving private or public sector care, and being referred to higher levels of care for a caesarean section. Parameters on impact were obtained through a quasi-experimental controlled study. Women were recruited to attend ANC visits and received a transport voucher, which covered 100% of transport costs to enable them to do so. All women were considered eligible for the voucher. Service vouchers covering the consultation were also provided to women. These covered 100% of the fee in the private sector and approximately 75% in public facilities, with government and private providers subsidising personnel, drugs, and maintenance costs. The value of the transport voucher was US\$1.8–4.5, and the value of the service voucher was US\$2.87–5.75. An additional transport and service voucher valued at US\$27 and US\$59 was provided to women who were referred for a caesarean section. DALYs were calculated using fitted epidemiologic data and the rate of maternal complications. A

3% discount rate was applied. The LiST tool was used to model the deaths averted. An ingredients-based approach was used to determine costs from a payer and societal perspective. This approach to costing refers to the identification of resources and unit costs to estimate total costs (95). The perspective of the study refers to which costs are included (96). In this case, costs incurred by government (the payer) and patients (society) are included. Payer costs included the cost of the programme, excluding the pilot, voucher, and delivery costs. Private facility expenditure, user contributions, and productivity losses were added when taking a societal perspective. Costs were inflated to represent 2010 costs. From this, the cost-per-DALY averted was determined. A univariate analysis that varied parameters by 20% was done. Incremental cost-effectiveness ratios (ICERs) of US\$338 and US\$302 per DALY averted with a payer and societal perspective, respectively, was calculated. This indicated that the intervention was cost-effective using the study's reported threshold of three times the gross domestic product (GDP) per capita. The GDP per capita of Uganda was reported to be US\$506. The sensitivity analysis produced ICERs from US\$199 to US\$405 per DALY averted, which was still cost-effective when using a lower threshold of one GDP per capita.

Maternal and Child Health Voucher Scheme in Myanmar

In Myanmar, a cost-effectiveness study evaluated the introduction of the Maternal and Child Health Voucher Scheme aimed to increase ANC and births performed by a skilled birth attendant as well as reduce maternal and neonatal deaths (93). The voucher subsidised four ANC visits and made delivery and postnatal care available for free. A decision tree model was built, which included chance nodes for the level of risk in the pregnancy, ANC, delivery by a skilled birth attendant, maternal and child death, and complications including preterm birth and LBW. A societal perspective was adopted. The time horizon was not described. Base case parameters were

derived from a local survey, expert consultation, and local literature. Labour and material costs, excluding capital costs, were determined for ANC and delivery, hospitalisation, and treatment of complications. Costs were reported in kyats (2010). Discounting was not described, likely due to primary data collection in 2010. The effect of ANC on outcomes was derived from literature and consultation, while the effectiveness of the intervention was calculated using the price elasticity of demand for public health services. DALYs were also calculated using available literature. This data were used to determine the cost per DALY averted. This resulted in an ICER of 381,072 kyats per DALY averted. A threshold of 600,000 kyats, based on a GDP per capita of 591,742 kyats, was used. This suggests that the intervention was cost-effective. There was a 52% chance that it was cost-effective in the probabilistic sensitivity analysis.

Nigerian Subsidy Reinvestment and Empowerment Programme

Similarly, the Subsidy Reinvestment and Empowerment Programme (SURE-P) Maternal and Child Health (MCH) programme, which included a conditional cash transfer, was introduced in Nigeria in order to increase ANC attendance (94). A cash transfer, to the maximum total cost of 5,000 Naira, was paid out when women attended ANC visits, delivered at a public health facility, and took their infants for their vaccinations. Input data were taken from hospital records, and the cost-effectiveness study was performed from a payer perspective over a five-year time horizon. Cost data including the cost of the cash transfer and cost of running the programme, such as the cost of staff, overheads, medication, and capital, were collected using a staff survey and available literature. Costs were presented in dollars (2014). Although financial support during pregnancy improved outcomes, the cost of running the intervention strongly determined its cost-effectiveness. The intervention was found to have an incremental cost of US\$572 per delivery and US\$11 per ANC

package. These costs were largely driven by running the programme; however, if integrated into the health system, the incremental costs were expected to be US\$389 per delivery and US\$188 per ANC package.

Maternal health voucher scheme in Bangladesh

A demand-side financing pilot of a maternal health voucher scheme, which was provided to women in Bangladesh, was run. Women were given vouchers that entitled them to free maternal care services, transport subsidies, a cash transfer to the value of Taka 2,000 (US\$29) when their delivery was performed by a skilled birth attendant, and a gift box (60). In order to determine whether this intervention was cost-effective, the cost of the programme per outcome (deliveries performed by a skilled birth attendant) was calculated and compared to that in a control group that did not receive the intervention. This analysis was performed using multivariate probit regression analysis to estimate the adjusted effect of the intervention on the probability of having a delivery performed by a skilled birth attendant. From this, the incremental cost per additional birth performed by a skilled birth attendant, attributable to the intervention, was determined. Birth and demographic data were derived from household questionnaires and census data and was used to estimate the proportion of deliveries performed by a skilled birth attendant. A payer perspective was adopted to determine the costs per facility over a 10-year period. In order to determine the costs attributed to the outcome, an allocation ratio was calculated and applied to the total costs. This analysis indicated that the cost of delivery by a skilled birth attendant was approximately Taka 224.44 million (US\$3.2 million). The intervention was found to cost US\$70 for each additional delivery performed by a skilled birth attendant.

Based on these studies, the incorporation of demand-side incentives resulted in a significant change in outcomes due to improved ANC and maternal nutrition during pregnancy in LMICs. As a result, these programmes were found to be cost-effective.

Scottish Health in Pregnancy grant

In contrast to the results obtained in LMICs, high-income countries have differing results. An interrupted time series analysis of the Scottish Health in Pregnancy grant was performed over a two-year period. This intervention included an unconditional cash transfer of £190, which was administered to women when they attended ANC prior to 25 weeks gestation. The study took a payer perspective. Study outcomes included LBW, preterm birth, smoking during pregnancy, and maternal complications as a result of smoking. Hospitalisation costs for these outcomes and the grant were not discounted and were expressed in British pounds (2015). The risk ratios associated with the grant were used as the effect estimate in an Excel-based decision model. The study indicated that reductions in poor health outcomes as a result of the grant were negligible and did not diminish hospital costs sufficiently. Thus, the intervention was not cost-effective due to its large cost (£20.4 million) to the Scottish government (73). The differential in the cost-effectiveness of these interventions in LMICs and high income countries is likely due to higher benefits observed in poorer populations when provided with financial support (50).

In conclusion, although not evident in high-income countries, the implementation of pregnancy support interventions is seen to be cost-effective and sustainable to LMICs, making it potentially appropriate in the South African context. Thus, this study evaluates whether the implementation of a PSG would improve child outcomes enough to be considered cost-effective.

1.3 Statement of the problem

Poverty is associated with poor maternal and child outcomes among pregnant South African women, leading to an increase in health system costs required to treat these adverse health states (97). The implementation of a PSG may decrease the level of poverty among this population, thereby improving health outcomes (8). This will reduce the financial costs placed on the health system in the treatment of these adverse outcomes. However, it is unclear whether the cost savings will offset the investment needed to cover the cost of extending the CSG into the pregnancy period or whether these additional costs will represent good value for money.

1.4 Justification of study

Income support provided to pregnant women in LMICs has been effective at improving health outcomes associated with maternal poverty, such as preterm birth, growth restriction, and mortality (8). This type of intervention is of particular relevance to South Africa, where prematurity is the leading cause of neonatal mortality (98). It has also proven that vouchers and conditional cash transfer programmes are cost-effective in LMICs (92,93,99). However, these studies do not evaluate the implementation of a grant in LMICs, and the results are not generalizable to the South African public healthcare context due to the varying cost inputs, prevalence of disease states, and study perspectives. Therefore, a cost-effectiveness analysis of implementing a PSG grant in South Africa is required to fill this gap in literature and inform future social support policy.

1.5 Research question

Would it be cost effective to extend the CSG into the antenatal period among impoverished South African women?

1.6 Study aim

To assess the cost-effectiveness, from a governmental perspective, of extending the South African CSG into the antenatal period for impoverished women, compared to the current scenario of grant initiation during the postnatal period.

1.7 Study objectives

Objective 1: To conceptualize and build a decision analytical model comparing the costs and health benefits associated with the antenatal and postnatal initiation of the CSG among impoverished women in South Africa in 2021.

Objective 2: To calculate the costs associated with the antenatal initiation of the CSG among impoverished women in South Africa in 2021 and the cost savings to the health care system.

Objective 3: To calculate the health benefits, expressed in DALYs, associated with the antenatal initiation of the CSG among impoverished women in South Africa in 2021.

Objective 4: To estimate the ICER of the antenatal initiation of the CSG among impoverished women compared to the current scenario of grant initiation during the postnatal period in South Africa in 2021.

CHAPTER TWO: MATERIALS AND METHODS

This chapter will describe the methodology used in this study to achieve the study objectives. It will provide details related to the study design, study population, data collection, and analysis.

2.1 Study design

Using decision-analytic modelling, this study evaluated the cost-effectiveness of implementing a PSG in South Africa through the extension of the CSG into the

antenatal period. Due to the paucity of literature, modelling was used to systematically synthesise the health-outcome and cost data from varying sources, allowing for the head-to-head comparison of interventions (100,101). Modelling also allows for the extrapolation of trial data beyond the study period by projecting final health outcomes as mediated by intermediate clinical endpoints (101). This is beneficial for informing policy decision making and allowing the analysis to be generalised to different contexts (101,102).

A cost-utility analysis was performed using an Excel-based decision tree model. The incremental costs and benefits associated with the implementation of a pregnancy grant, compared to only the CSG, were calculated. Costs were expressed as South African Rands (ZAR), and benefits were expressed as DALYs. DALYs were selected as a standardised measure of benefits, rather than quality-adjusted life years, as they are more readily available in the South African context using data from the Global Burden of Disease study (103). The use of DALYs in the cost-utility analysis also allows for the comparison of this intervention with other interventions, groups, or in other LMIC settings (104,105).

The Department of Social Development will bear the cost of the proposed grant. Therefore, a governmental perspective was taken (96). This will allow the results to inform government decision-making at the national treasury level.

The intervention evaluated in this study consisted of the PSG, in addition to the CSG, using the same value and eligibility criteria as the CSG. The comparator was the existing CSG, which is only provided to families after the child is born. This entitles families earning less than ZAR48,000 per annum per parent to ZAR460 per child per month from birth to 18 years (14).

2.2 Study site

The study context was the South African public healthcare system, which provides free antenatal and postnatal care at a primary care level (106). Pregnant women receive midwife-led care supported by doctors at higher levels of care (107). Care is provided to approximately 1,100,000 women annually at more than 3,000 primary care facilities (108,109). Among these women, approximately 65% require higher levels of care (107).

2.3 Study population

The target population included South Africa women who are pregnant and eligible for a CSG in 2021. These women are eligible for the pregnancy grant and therefore earn less than ZAR48,000 (single caregiver) or ZAR96,000 (two caregivers) per annum. Non-citizens were excluded as the CSG is only provided to South African citizens (14).

An analytical time horizon of first 1,000 days of life was applied in keeping with the UNICEF First 1,000 days initiative (106). This is the period over which the costs and benefits of the intervention are calculated. The time horizon should be long enough to include all costs and benefits associated with the intervention and comparator (110). This time horizon was chosen as the costs and benefits associated with the grant largely occur during the neonatal period covered within the first 1000 days of life. Among children, the greatest risk of death occurs during the neonatal period, primarily during the first week of life (111). Further, the introduction of interventions during this period has a significant impact on reducing costs as well as morbidity and mortality, often making them cost-effective (112).

2.4 Objective 1: Conceptualizing and building the model

An Excel-based decision tree model was built to map out the sequence of health states that may occur in the intervention and comparator arms of the study. The pathways and probabilities associated with each node were derived from a review of published literature.

Databases used to identify sources for model parameters included Google Scholar, PubMed, JSTOR, Cochrane Library, the Global Health Cost-Effectiveness Analysis Registry, EBSCO, Scopus, and Psychinfo. Grey literature from internationally recognised sources such as The World Bank, WHO, and UNICEF were reviewed. The search terms in the PICO model below were used to guide the review (Table 2.1).

Table 2.1: Description of PICO phrases used in the literature search

Element	Description
Population	Pregnant women, pregnancy, infants, early childhood, young children, poor households, maternity
Intervention	Income support, pregnancy grant, cash transfers, conditional cash transfers
Comparator	Child support grant, status quo, no intervention
Outcome	Preterm birth, LBW, birthweight, SGA, stunting, underweight, wasting, nutritional outcomes, nutritional status, child health, cognitive development, neurodevelopmental outcomes, perinatal mortality, child mortality, child health, antenatal services

The health outcomes associated with the intervention and comparator were obtained from a review of the literature and through expert consultation with a paediatrician and neonatologist. This literature search strategy generated 56 studies and reports that evaluate any income support intervention provided to pregnant women. The studies were performed in sub-Saharan Africa, Latin America, Asia, and North

America. Table E1 shows the list of studies generated by the search and the outcomes measured. The selected model outcomes included those with the strongest evidence and those indicated to be of local importance to an expert in the field (113). The chosen outcomes include first ANC coverage (51–64,114,115), stillbirth (86–91), preterm birth (42,74,75), LBW (75–77,116), and SGA (42,72,78,117). The primary complications of these health states such as neonatal respiratory distress syndrome (RDS) (21), chronic lung disease (118), neonatal hypoglycaemia (80,119,120), and motor impairment (121) were included.

The effects of the PSG on child health outcomes are likely mediated through improved ANC and improved maternal nutrition among impoverished women. There is a clear association between income and the likelihood and frequency of ANC, making a lack of ANC more frequent among poor women (23,31–34). Unbooked mothers have indicated that this is due to the cost of transport and forgoing income-generating activities (35). Furthermore, lack of frequent ANC has been linked to both neonatal and infant mortality, LBW, stunting, and maternal mortality (38–40). Similarly, pregnant women frequently lack adequate macro- and micro-nutrient intake in South Africa (43) and impoverished women often feed other family members first. This has been linked to several poor child health outcomes (41,43–47). Thus, by providing additional income support, it is assumed that nutrition will be improved.

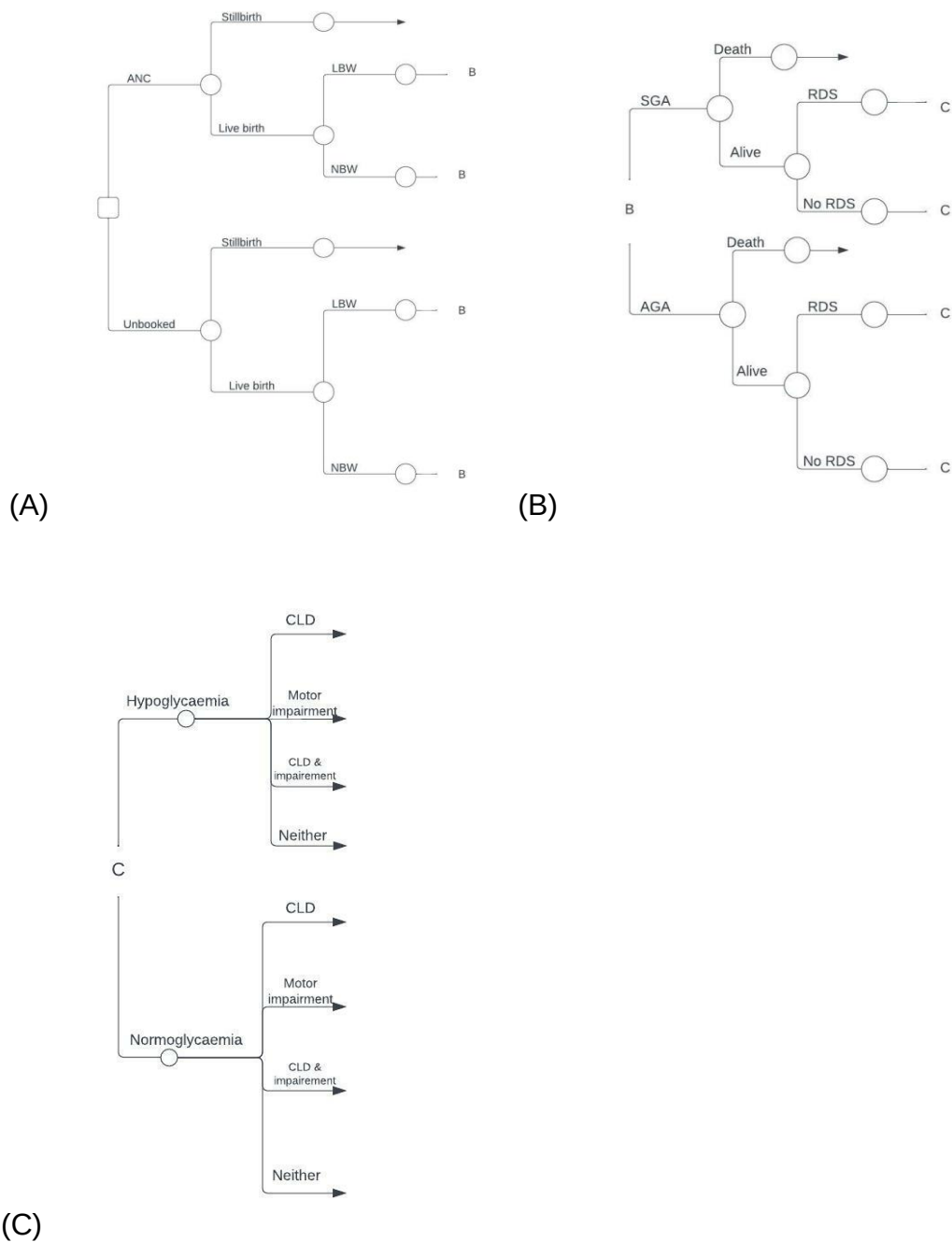


Figure 2.1: Decision tree model structure (A-C)

Abbreviations: ANC, antenatal care; LBW, low birth weight; NBW, normal birth weight; SGA, small-for-gestational age; AGA, appropriate-for-gestational age; RDS, respiratory distress syndrome; CLD, chronic lung disease.

A decision-tree model was selected for this study. This was based on previous literature evaluating the cost-effectiveness of income support interventions using

economic modelling (92,93). Figure 2.1 shows the structure of the model. The square node in the tree is termed a decision node, which indicates the beginning of the decision tree, usually representative of the intervention or comparator (122). Circle nodes are termed chance nodes, which indicate the chance of an event occurring (122). Triangle nodes are terminal nodes that indicate the end of that particular pathway (122). The first node indicates that in the intervention and comparator, women may attend at least one ANC visit or be unbooked (Figure 2.1 A). This may lead to a stillbirth (terminal node) or live birth. Among live birth infants, they may be born preterm or at term. Preterm refers to neonates born before 37 weeks of gestation (21). Once born, they may be determined to be have a LBW or normal birth weight (NBW). Infants were considered LBW if their birth weight was less than 2,500g (37). Similarly, they may be SGA or appropriate-for-gestational age (AGA) (Figure 2.1 B). SGA refers to a birth weight less than the 10th percentile for birth weight (80). This health state may lead to neonatal death or survival. Based on earlier health states in the model, complications may occur (Figure 2.1 C). Infants may develop RDS, which could later lead to chronic lung disease (terminal node). Infants may also develop neonatal hypoglycaemia, which could result in motor impairment (terminal node).

The probability associated with each branch of the decision tree was also determined based on a review of the literature. The probability of each branch derived from a single chance node should sum to one (122). The effects of the PSG were applied to the model by adjusting the probabilities in the decision tree to account for the change in probabilities of certain events occurring. Table 2.2 shows the base case population size, probabilities, effects of the grant, and assumptions included in the model.

Table 2.2: Probabilities, assumptions, and other parameter values

Parameter	Value	Source
Total pregnancies	1,337,632	(18,123)
Proportion of pregnancies among non-citizens	25%	(18,124)
Pregnancies (South African citizens)	1,003,224	Calculation
Proportion of pregnancies eligible for the CSG	44%	(97)
Number of pregnancies eligible for the CSG	441,418.48	Calculation
Antenatal first visit coverage	0.83	(18)
Live birth following ANC	0.98	(125)
Live birth in the unbooked	0.97	(125)
Preterm birth following ANC	0.17	(125)
Preterm birth in the unbooked	0.17	(125)
LBW among preterm infants	0.68	(126)
LBW among term infants	0.34	(126)
SGA among preterm LBW infants	0.44	(127)
SGA among preterm normal weight infants	0	(127)
SGA among term LBW infants	1	(127)
SGA among term normal weight infants	0.19	(127)
Death among preterm SGA infants	0.08	(127)

Death among term SGA infants	0.01	(127)
Death among preterm AGA infants	0.04	(127)
Death among term AGA infants	0.006	(127)
RDS among preterm infants	0.45	(21,128)
RDS among term infants	0	(128)
Chronic lung disease among those with RDS	0.36	(118)
Chronic lung disease among those without RDS	0	(118)
Hypoglycaemia among preterm SGA infants	0.22	(80)
Hypoglycaemia among term SGA infants	0.26	(120)
Hypoglycaemia among preterm AGA infants	0.15	(129)
Hypoglycaemia among term AGA infants	0	(119)
Motor impairment in infants with hypoglycaemia	0.051	(121)
Motor impairment in infants without hypoglycaemia	0.033	(121)
Increase in antenatal first visit coverage with a PSG (risk ratio)	0.10	(66)
Reduction in preterm birth with a PSG (risk ratio)	0.76	(130)
Reduction in LBW with a PSG (risk ratio)	0.71	(130)

Reduction in SGA with a PSG (risk ratio)	0.90	(130)
Reduction in infant death with a PSG	0.11	(131)

2.5 Objective 2: Measurement of costs

Resource utilization and costs were determined for the intervention and comparator.

The cost of the grants and direct medical costs associated with each health state were included to reflect the governmental perspective that was taken (132).

Conversely, direct non-medical costs, indirect costs, and intangible costs were excluded (132). Economic costs were presented and expressed in ZAR. Economic costs include the value of all resources used, including donations, subsidies, and volunteer time (132). They also reflect opportunity costs as individual preference is considered (132).

An ingredients-based approach was used to estimate the total costs associated with each intervention using Excel. Costs were classified by the activities required with each health state. This approach involved the identification of resources required with each health state or intervention (ingredients), measurement of the resources (quantity), and value of the resource (price) (95). Resource identification was completed by reviewing the literature on the resources required as well as through key expert consultation with the head of neonatology at Charlotte Maxeke Johannesburg Academic Hospital (113). Once the inputs were identified, they were valued using unit price data obtained from publicly available fee schedules (133) for the South African public healthcare system and the Master Procurement Catalogue (134). In cases where costs were not provided in these sources, inputs were derived from available literature.

The pregnancy grant was costed using existing literature on the CSG. The proposed intervention involves the extension of the CSG into the antenatal period using the same eligibility criteria. As infrastructure required to administer the CSG is already established, the administrative and infrastructural costs of the grant were considered negligible. The 2021 unit cost for the CSG was ZAR460 per month (14). It was assumed that the grant would be administered for five months during pregnancy. It was assumed that the grant would be collected one month after the first ANC visit, which is reported to be at four months gestation (4 months gestation) (135). The postnatal administration of the CSG for 24 months in both the intervention and comparator were included. The total cost of the grant was calculated by multiplying the unit cost of R460 by the number of months that the grant would be administered.

Cost estimates were calculated to determine the cost of routine ANC and postnatal follow-up of infants, which were considered direct medical costs. The identification of resource utilization was determined by a review of local neonatal treatment guidelines (136), and facility fees as well as consultation fees were derived from the tariffs listed in the South African uniform fee schedule for 2021 (133).

A single ANC visit was assumed in the model as literature on the effects of the pregnancy grant show an increase in antenatal first visits (66). The unit costs for an outpatient consultation with a nurse at a level 1 facility and the facility fee were used to determine the total cost. Similarly, the total cost of follow-up was calculated by multiplying the cost of consultations and facility fees by the number of follow-up visits required. Neonates who were considered preterm, LBW, or had RDS, hypoglycaemia, motor impairment, or chronic lung disease had one initial follow-up visit with a specialist at a level 3 facility followed by two level 3 facility consultations

with a medical officer (113,136). In the case of children with motor impairment, 19 additional rehabilitation consultations were included (113,136).

The direct medical costs associated with a stillborn or neonatal death were estimated based on the assumption that the body will remain in the mortuary for seven days.

The direct medical costs of treating and screening for each of the following health states were included: preterm birth, LBW, RDS, and chronic lung disease. The cost of being SGA and additional cost of motor impairment beyond rehabilitation were not included based on expert consultation (113). The resources identified were consultations, ward admissions including high care and neonatal intensive care units (NICUs) admissions; laboratory tests; imaging; and medication. These resources were identified by reviewing neonatal guidelines (136) and expert consultation (113). The unit costs were taken from the patient fee schedule 2021 (133) and the 2021 Master Procurement Catalogue (134) for medication. LBW costs were weighted according to the birth weight categories and length of stay indicated in Table 2.3.

Table 2.3 Proportion of birth weight categories

Category	Proportion	Source
NICU admission rate, <1500g	0.85	(137)
NICU admission rate, 1500-2500g	0.44	(137)
NICU admission rate, >2500g	0.03	(137)
Proportion LBW (<2500g) that are <1500g	0.17	(137)
Proportion LBW (<2500g) that are 1500-2499g	0.83	(137)
NICU days, <1500g	46 days	(138,139)
NICU days, 1500-2499g	13 days	(138,139)
NICU days, >2500g	0 days	(138,139)
High care days, <1500g	8 days	(138,139)

High care days, 1500-2499g	8 days	(138,139)
High care days, >2500g	8 days	(138,139)

In the case where cost data was reported prior to 2021, costs were adjusted for inflation using historic inflation data to annualize inflation (140). This adjustment to determine 2021 costs was done using the following equation (141):

$$\text{Cost adjusted by inflation} = \text{Cost} \times (1 + \text{inflation rate}) ^ (2021 - \text{year reported})$$

In the case where future costs were included, these were discounted to establish the present value. This is done to account for individuals' positive rate of time preference and the opportunity cost of spending money at present rather than in the future (142). Using the 5% discount rate reported in the South African Pharmaco-economic Guidelines (143), the discounted costs were calculated as follows (142):

$$\text{Discounted cost} = \text{Present value} / (1 + \text{discount rate}) ^ (\text{time})$$

Finally, once the model was built, the disaggregated costs were derived by multiplying the pathway probability with the total cost for each health state.

2.6 Objective 3: Estimating benefits

The benefits associated with the intervention and comparator were expressed using DALYs. This is a standardised metric, often used in analyses in LMICs (144). This metric is based on the methodology depicted in the Global Burden of Disease study (103), in which the DALY is calculated as the sum of the years of life lost due to premature mortality (YLL) and years lost due to disability (YLD) due to disease (145):

$$\text{DALY} = \text{YLL} + \text{YLD}$$

YLL was calculated by multiplying the number of deaths (N) by standard life expectancy at the age of death in years (L1):

$$YLL = N \times L1$$

YLD was calculated by multiplying the number of incident cases (I) by the disability weighting (DW) and the average duration of illness, in years, until remission or death (L2):

$$YLD = I \times DW \times L2$$

Thus, one DALY represents one year of life lost due to the health state (145). The input variables required to calculate the DALYs associated with each terminal health state were obtained from available literature. Terminal health states of the model include stillbirth, early neonatal death, chronic lung disease, and motor impairment. The average life expectancy for South Africa in those less than 1 year old was determined to be 65.5 years when reviewing the Global Health Observatory data repository (146). The disability weights for each health state were derived from the Global Burden of Disease Study (103). Due to a lack of specific DWs for chronic lung disease and motor impairment due to neonatal hypoglycaemia, weightings from similar disease states were used. A DW and natural history applicable to uncontrolled asthma was used for chronic lung disease due to a similar clinical presentation and treatment (113,136). Similarly, the DW for moderate motor impairment due to neonatal preterm birth complications was used for motor impairment in the model (103). Table 2.4 shows the variables used to calculate the DALYs attributed to each terminal health state. Finally, the disaggregated DALYs were ascertained from the model for each terminal health state.

Table 2.4: Parameters used to calculate the DALYs attributed to each terminal health state

Parameter	Value	Source
Age of death for stillbirths	0 years	

Chronic lung disease DW	0.133	(103)
Years lived with chronic lung disease	65.5 years	(147)
Life expectancy at age of premature death (chronic lung disease)	65.5 years	(147)
Motor impairment DW	0.061	(103)
Years lived with motor impairment	30 years	(148)
Life expectancy at age of premature death (motor impairment)	40.89 years	(148)

Similar to the cost parameters, all DALYs were discounted to account for DALYs accrued in the future. A 5% discounting rate, as stated in the South African Pharmaco-economic guidelines (143), was used.

Objective 4: Cost-effectiveness

Once the costs and DALYs for each health state in both interventions were established, the expected value of each outcome was estimated using the decision tree model. This was be done by multiplying the probability associated with each node in a pathway in the decision tree to determine the joint probability of the sequence (122). In this way, the expected costs and DALYs of each pathway was estimated using the roll-back method of multiplying the sum of the costs and DALYs in each pathway by the joint probability of that sequence.

In the case where intervention 1 represents the comparator and intervention 2 represents the intervention, the ICER was calculated using the following equation (149):

$$ICER = \frac{Costs^{intervention\ 2} - Costs^{intervention\ 1}}{Benefits^{intervention\ 2} - Benefits^{intervention\ 1}}$$

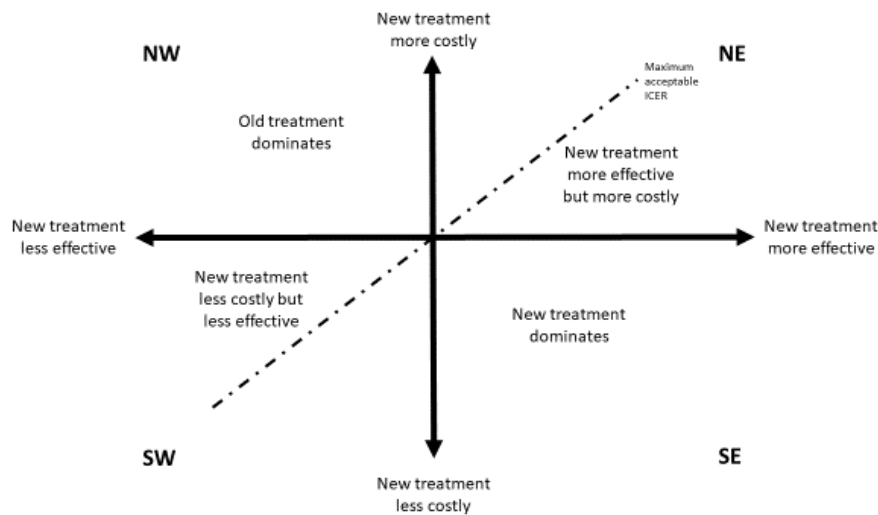


Figure 2.2: Cost-effectiveness plane structure recreated from Briggs et al. (150)

Abbreviations: NW, north-west; SW, south-west; NE, northeast; SE, southeast.

The results of this equation were presented on a cost-effectiveness plane, which indicates whether the intervention can be considered more cost effective than the comparator. Figure 2.2 illustrates the cost-effectiveness plane. The incremental benefits were plotted on the x-axis, and the incremental costs were plotted on the y-axis. Each quadrant of the plane indicates whether the intervention dominates, i.e. it is more cost-effective, or whether it is dominated, i.e. less cost-effective (150). The intervention is dominated by the comparator in the north-west (NW) quadrant, as the intervention is more expensive and averted fewer DALYs. The intervention dominates in the southeast (SE) quadrant as it is less costly and averts more DALYs. When the ICER is plotted in the northeast (NE) or south-west (SW) quadrants, the trade-offs of each need to be considered. In the SW quadrant, the intervention averts fewer DALYs but is less costly. In the NE quadrant, the intervention averts more DALYs but is also more costly. To determine whether the intervention is cost-effective when it falls into the NE quadrant, a country specific cost-effectiveness threshold (λ) is used. This is sometimes referred to as a willingness-to-pay threshold.

Implementing interventions that lie in the NE quadrant of the cost-effectiveness plane results in the displacement of spending on other interventions. To maximize health benefits within a limited healthcare budget, a cost-effectiveness threshold should be chosen which reflects the health opportunity cost of health spending (151).

According to a recent study, the optimal threshold in South Africa is ZAR38,500 per DALY averted (151). This threshold was used in the present study. If the intervention fell below the threshold, it was considered cost-effective. If it fell above the threshold, it was not considered to be cost-effective.

The cost-effectiveness of the intervention was also determined by calculating the incremental net monetary benefit (INMB). The INMB scales the costs and benefits to arrive at a comparative value when there is a known threshold (152). The INMB was calculated by multiplying the incremental benefit (ΔE), which were DALYs averted in this study, by the threshold (λ) and subtracting the incremental costs (ΔC) (152). This is represented in the following equation (152):

$$\text{INMB} = \Delta E \times \lambda - \Delta C$$

A positive INMB value represents a cost-effective intervention, while a negative result indicates that the intervention is not cost-effective (152). The INMB is preferred over the ICER when an analysis is expanded from a payer perspective to a societal perspective as it represents the value increase (152).

2.7 Sensitivity analysis

Sensitivity analyses were performed to analyse the degree to which the uncertainty of each parameter affects cost-effectiveness outcomes. A univariate analysis was performed as part of the deterministic sensitivity analysis. The base case values were varied individually by their 95% confidence intervals, where available, while keeping all other parameters constant (153). In the case where no confidence interval was

available, parameter values were varied from 50% to 150% of their base case value. Table 2.5 shows the values used in the one-way sensitivity analysis. The results of this analysis were presented using a tornado diagram. Additionally, in the case that the ICER fell below the threshold, the value of the grant was increased to establish the value at which the grant would no longer be considered cost-effective. This indicates the scope for increasing the value of the grant.

Table 2.5: Deterministic model parameters

Parameter	Base case	Low value	High value
Cost inputs (ZAR)			
Cost of the PSG	R2,300.00	R1,150.00	R3,450.00
Cost of the CSG	R11,040.00	R5,520.00	R11,040.00
Cost of ANC visit	R177.00	R88.50	R265.50
Cost of care for preterm infants	R577.90	R288.95	R866.85
Cost of care for LBW infants	R254,701.56	R99,325.88	R297,977.65
Cost of care for NBW infants	R1,255.20	R1,549.44	R4,648.32
Cost of care for stillbirth infants	R1,792.00	R896.00	R2,688.00
Cost of care for RDS infants	R30,595.61	R15,297.81	R45,893.42
Cost of care for hypoglycaemic infants	R2,936.26	R1,468.13	R4,404.39
Cost of care for chronic lung disease infants	R42,582.51	R21,291.26	R63,873.77
Cost of care for children with motor impairment	R3,819.00	R1,909.50	R5,728.50
Cost of follow-up at a hospital	R907.00	R453.50	R1,360.50

Cost of follow-up at a clinic	R3,363.00	R1,681.50	R5,044.50
Effect sizes (risk ratio)			
Increase in antenatal first visit coverage with a PSG	0.10	0.05	0.15
Reduction in preterm birth with a PSG	0.76	0.69	0.84
Reduction in LBW with a PSG	0.71	0.63	0.82
Reduction in SGA with a PSG	0.9	0.82	0.99
Reduction in infant death with a PSG	0.11	0.06	0.17
Threshold (ZAR)			
Threshold value	R38,500.00	R19,250.00	R57,750.00
DW			
Chronic lung disease DW	0.133	0.086	0.192
Motor impairment DW	0.061	0.04	0.089
Probabilities			
Antenatal first visit coverage	0.83	0.69	1
Live birth following ANC	0.98	0.49	1
Live birth in the unbooked	0.97	0.48	1
Term birth following ANC	0.83	0.41	1
Term birth in the unbooked	0.83	0.41	1
LBW among preterm infants	0.68	0.34	1
LBW among term infants	0.35	0	0.52
SGA among preterm LBW infants	0.44	0	0.67
AGA among term NBW infants	0.81	0.41	1

Death among preterm SGA infants	0.08	0	0.13
Death among term SGA infants	0.01	0	0.02
Death among preterm AGA infants	0.04	0	0.05
Death among term AGA infants	0.006	0	0.01
RDS among preterm infants	0.45	0.05	0.80
Hypoglycaemia among preterm SGA infants	0.22	0	0.32
Hypoglycaemia among term SGA infants	0.26	0.22	0.28
Hypoglycaemia among preterm AGA infants	0.15	0	0.23
Chronic lung disease among those with RDS	0.36	0	0.54
Motor impairment in infants with hypoglycaemia	0.05	0	0.08
Motor impairment in infants without hypoglycaemia	0.03	0	0.05

A probabilistic sensitivity analysis was also performed to determine the level of uncertainty that arises when varying model input parameter estimates simultaneously (154). Distributions were fitted to all input parameters. Beta distributions were used for probabilities and DWs to ensure that they are between zero and one (154). Gamma distributions were used for costs as they are always positive (154). Log-normal distributions were used to vary risk ratios (154).

Table 2.6 shows the probabilistic distributions applied in the analysis. Following this, 1000 iterations of a Monte Carlo simulation were run (154). The results of this analysis were presented in a cost-effectiveness acceptability curve.

Table 2.6: Probabilistic parameter values

Parameter	Deterministic Mean	alpha (or LN[mean])	beta	SE (or LN[SE])	Probabilistic Value	Distribution
Effect sizes						
Increase in antenatal first visit coverage with a PSG	0.101	-2.293		0.280	0.167	Log-Normal
Reduction in preterm birth with a PSG	0.760	-0.274		0.050	0.823	Log-Normal
Reduction in LBW with a PSG	0.710	-0.342		0.067	0.693	Log-Normal
Reduction in SGA with a PSG	0.900	-0.105		0.048	0.929	Log-Normal
Reduction in infant death with a PSG	0.110	-2.207		0.280	0.175	Log-Normal

DW						
Chronic lung disease DW	0.133	21.271	138.663	0.027	0.141	Beta
Motor impairment DW	0.061	22.759	350.346	0.012	0.063	Beta
Probabilities						
Antenatal first visit coverage	0.831	18.213	3.704	0.078	0.902	Beta
Live birth following ANC	0.984	229.954	3.840	0.008	0.982	Beta
Live birth in the unbooked	0.968	115.523	3.765	0.016	0.943	Beta
Term birth following ANC	0.825	14.445	3.060	0.088	0.878	Beta
Term birth in the unbooked	0.827	14.624	3.067	0.088	0.835	Beta

LBW among preterm infants	0.681	5.030	2.353	0.161	0.683	Beta
LBW among term infants	0.348	9.882	18.539	0.088	0.232	Beta
SGA among preterm LBW infants	0.444	8.273	10.356	0.112	0.333	Beta
AGA among term NBW infants	0.810	12.732	2.986	0.096	0.572	Beta
Death among preterm SGA infants	0.084	14.279	155.577	0.021	0.070	Beta
Death among term SGA infants	0.013	15.461	1,155.857	0.003	0.022	Beta
Death among preterm AGA infants	0.035	15.095	414.040	0.009	0.039	Beta

Death among term AGA infants	0.006	15.578	2,483.505	0.002	0.006	Beta
RDS among preterm infants	0.450	8.175	9.992	0.114	0.532	Beta
Hypoglycaemia among preterm SGA infants	0.216	12.087	44.000	0.054	0.178	Beta
Hypoglycaemia among term SGA infants	0.260	11.344	32.288	0.066	0.324	Beta
Hypoglycaemia among preterm AGA infants	0.150	13.179	74.683	0.038	0.147	Beta
Chronic lung disease	0.361	9.660	17.098	0.091	0.301	Beta

among those with RDS						
Motor impairment in infants with hypoglycaemia	0.051	14.825	273.979	0.013	0.060	Beta
Motor impairment in infants without hypoglycaemia	0.033	15.130	442.160	0.008	0.039	Beta
Cost inputs						
Cost of ANC visit	R177.00	R15.68	R11.29	R44.70	R151.75	Gamma
Cost of care for preterm infants	R577.90	R15.68	R36.85	R145.93	R407.25	Gamma

Cost of care for LBW infants	R254,701.56	R25.78	R9,880.14	R50,164.59	R340,505.81	Gamma
Cost of care in NBW infants	R1,255.20	R2.57	R487.87	R782.55	R935.94	Gamma
Cost of care for stillbirth infants	R1,792.00	R15.68	R114.27	R452.53	R1,587.48	Gamma
Cost of care for RDS infants	R30,595.61	R15.68	R1,951.05	R7,726.16	R31,292.17	Gamma
Cost of care for hypoglycaemic infants	R2,936.26	R15.68	R187.24	R741.48	R3,272.59	Gamma
Cost of care for chronic lung disease infants	R42,582.51	R15.68	R2,715.44	R10,753.16	R33,349.52	Gamma

Cost of care for children with motor impairment	R3,819.00	R15.68	R243.53	R964.39	R4,620.97	Gamma
Cost of follow-up at a hospital	R907.00	R15.68	R57.84	R229.04	R733.64	Gamma
Cost of follow-up at a clinic	R3,363.00	R15.68	R214.46	R849.24	R3,275.79	Gamma

2.8 Data management

The data collected for this study was stored in Excel on a password-protected computer. This file was stored in a Dropbox folder. The data will be kept for up to 5 years after the completion of the research.

2.9 Ethics

This study received an ethics waiver from the Human Ethics Committee at the University of the Witwatersrand (Appendix 2) due to the use of secondary data and the exclusion of study participants.

CHAPTER THREE: RESULTS

This chapter describes the results of the study based on the analysis. It provides the results related to costs, benefits, and the ICER or INMB.

3.1 Objective 2: Costing of the intervention and comparator

The PSG as well as the comparator were both costed using unit costs (Ps) and the quantity (Qs) for all required resources, categorised by health state activities. Table E2 details the unit prices and quantities of each resource. Table 3.1 shows the total cost of each category. The grant for an individual was costed at ZAR2,300.00. Of the health states, the management of LBW produced the largest cost due to potential admission to the neonatal ICU. The total cost for the management of LBW was approximately ZAR255,000.00.

Table 3.1: Total cost for each cost category

Cost category	Total cost
PSG	R2,300.00
CSG	R11,040.00
ANC	R177.00
Preterm birth	R577.90

LBW	R254,701.56
NBW	R1,255.20
Stillbirth	R1,792.00
RDS	R30,595.61
Hypoglycaemia	R2,936.26
Chronic lung disease	R42,582.51
Motor impairment	R3,819.00
Hospital follow-up	R907.00
Clinic follow-up	R3,363.00

The disaggregated expected costs for each health state are indicated in Table 3.2.

This indicates that LBW is a driver of costs, and the intervention is able to reduce healthcare costs substantially by preventing LBW. Other cost parameters such as the CSG and ANC are greater in the intervention due to a greater number of women accessing ANC and more children surviving.

Table 3.2: Disaggregated costs for each health state

Cost category	Intervention (costs)	Comparator (costs)	Cost difference
PSG	R2,300.00	-	-
CSG	R10,714.65	R10,650.87	-R63.78
ANC	R161.94	R147.09	-R14.86
Preterm birth	R75.37	R98.97	R23.60
LBW	R69,631.76	R101,431.64	R31,799.87
NBW	R889.82	R731.51	-R158.31
Stillbirth	R31.74	R34.01	R2.28
Infant death	R21.07	R29.15	R8.08
RDS	R1,724.28	R2,240.14	R515.86

Hypoglycaemia	R285.19	R368.48	R83.29
Chronic lung disease	R2,015.25	R3,361.77	R1,346.52
Motor impairment	R152.11	R148.17	-R3.94
Chronic lung disease and motor impairment	R80.34	R135.21	R54.87
Healthy	R2 994.11	R2 869.45	-R124.65

3.2 Objective 3: Estimating DALYs

The DALYs for four terminal health states, namely, death, healthy, motor impairment, and chronic lung disease were calculated. Table 3.3 shows the total DALYs accrued by each state. Neonatal death had the greatest DALYs accrued by it, with 19.18 DALYs accrued for this health state after discounting. This is exclusively due to the years of life lost. The healthy state did not accrue any DALYs. In the model, 0.53 and 17.27 DALYs were attributed to chronic lung disease and motor impairment, respectively. DALYs attributed to chronic lung disease are lower as no years of life were lost. Conversely, motor impairment has a significant disability burden as well as premature death, both of which increase the DALYs significantly.

Table 3.3: Total DALYs attributed to each terminal health state

Terminal health state	DALYs
Death	19.18
Healthy	0,00
Chronic lung disease	0,53
Motor impairment	17.27

Table 3.4 shows the expected DALYs derived from each terminal health state in the model. This indicates that death, in the form of a stillbirth or infant death, contributes

most significantly to the DALYs accrued. The intervention averts DALYs most significantly by averting death. In contrast, more DALYs are attributed to the intervention for motor impairment as a result of more children surviving in the intervention group, leading to a greater proportion of children with motor impairment.

Table 3.4: Disaggregated DALYs for each terminal health state

Terminal health state	Intervention (DALYs)	Comparator (DALYs)	Difference in DALYS
Death (stillbirth and infant death)	0.57	0.68	0.11
Chronic lung disease	0.02	0.04	0.02
Motor impairment	0.56	0.54	-0.01
Chronic lung disease and motor impairment	0.03	0.05	0.02
Healthy	0.00	0.00	0.00

3.3 Objective 4: Cost-Effectiveness Results

Using the joint probabilities for each pathway in the decision tree model, the expected costs and DALYs were calculated and summed to obtain the total costs and total DALYs for the intervention and comparator. Table 3.5 shows that the total costs were approximately ZAR91,000.00 and ZAR122,000.00 for the intervention and the comparator, respectively. This resulted in an incremental cost of - ZAR31,200.00. The intervention therefore resulted in a cost saving of ZAR31,200.00 per mother receiving the grant as a result of reduced neonatal complications that drive up costs. When applied to the total South African pregnant population and the population eligible for the CSG, the PSG saves approximately ZAR31,300,000,000.00 and ZAR13,800,000,000.00, respectively.

Table 3.5: Total and incremental costs

Costs	Per person (ZAR)	Pregnancies in South African citizens (ZAR)	Pregnancies in those estimated to be eligible for the CSG (ZAR)
Intervention cost	R91,077.63	R91,371,245,993.85	R40,203,348,237.29
Comparator cost	R122,246.47	R122,640,567,873.81	R53,961,849,864.48
Incremental cost	-R31,168.84	-R31,269,321,879.96	-R13,758,501,627.18

Table 3.6 shows the expected DALYs attributed to the intervention and comparator. Fewer DALYs were accrued in the intervention (1.18 per mother receiving the grant) compared to the comparator (1.31 per mother). This resulted in 0.13 DALYs averted per mother receiving the grant as a result of the intervention. This leads to 134,000 DALYs averted when applied to the total South African pregnant population and 59,000.00 DALYs averted in the population eligible for the CSG. This is due to a reduction in early neonatal complications that often result in longer-term complications and death.

Table 3.6: Total and incremental DALYs

DALYs	Per person (DALYs)	Pregnancies in South African citizens (DALYs)	Pregnancies in those estimated to be eligible for the CSG (DALYs)
PSG DALYs	1.18	1,179,932.82	519,170.44
Comparator DALYs	1.31	1,313,986.96	578,154.26
Incremental DALYs	0.13	134,054.13	58,983.818

Based on the abovementioned results, the ICER and INMB were calculated. These are presented in Table 3.7. Both results indicate that the PSG is cost-effective.

Table 3.7: ICER and INMB

Outcome	Per person	Pregnancies in South African citizens	Pregnancies in those estimated to be eligible for the CSG
INMB (ZAR)	R36,313.34	R36,430,405,934.63	R16,029,378,610.80
ICER (ZAR per DALY averted)	-R233,259.92	-R233,259.92	-R233,258.92

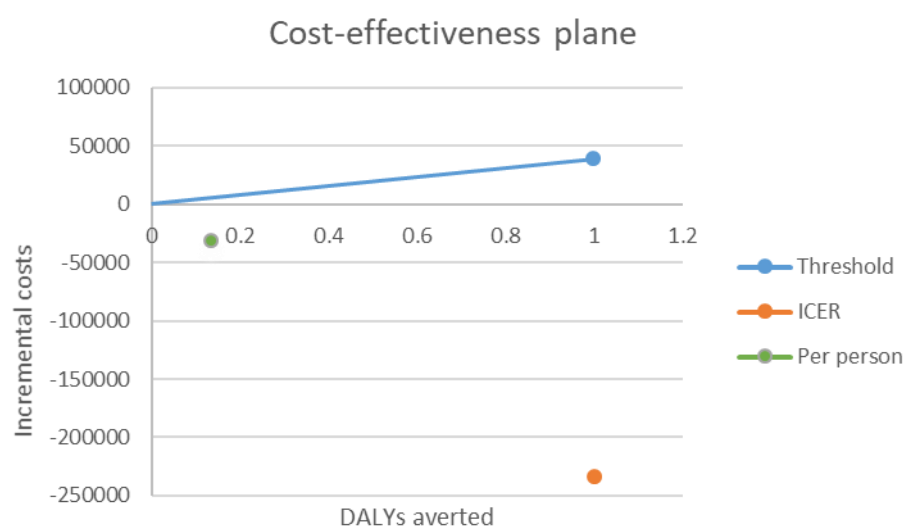


Figure 3.1: Cost-effectiveness plane

Abbreviations: DALYs, disability-adjusted life years; ICER, incremental cost-effectiveness ratio.

Figure 3.1 shows the results presented on a cost-effectiveness plane. The graph indicates both the ICER (costs per DALY averted) and the incremental costs and incremental DALYs per person receiving the grant. The ICER was approximately -ZAR233,000.00 per DALY averted in this study. The PSG was, therefore, the

dominant treatment strategy as it fell in the SE quadrant of the cost-effectiveness plane, producing cost savings and averting DALYs. Hence, the PSG should be implemented.

Sensitivity analysis

3.4.1 Deterministic sensitivity analysis

In the deterministic sensitivity analysis, various base case values were varied individually, including the effect of the grant on antenatal first visit coverage, mortality, LBW, preterm birth, and SGA as well as the cost of the pregnancy grant. Table E3 shows the high and low ICER and INMB values obtained when varying each parameter. The greatest variation in the ICER and INMB was obtained when varying the probability of a term birth with ANC. This was due to the compounded effect of the pregnancy grant and ANC on neonatal health outcomes.

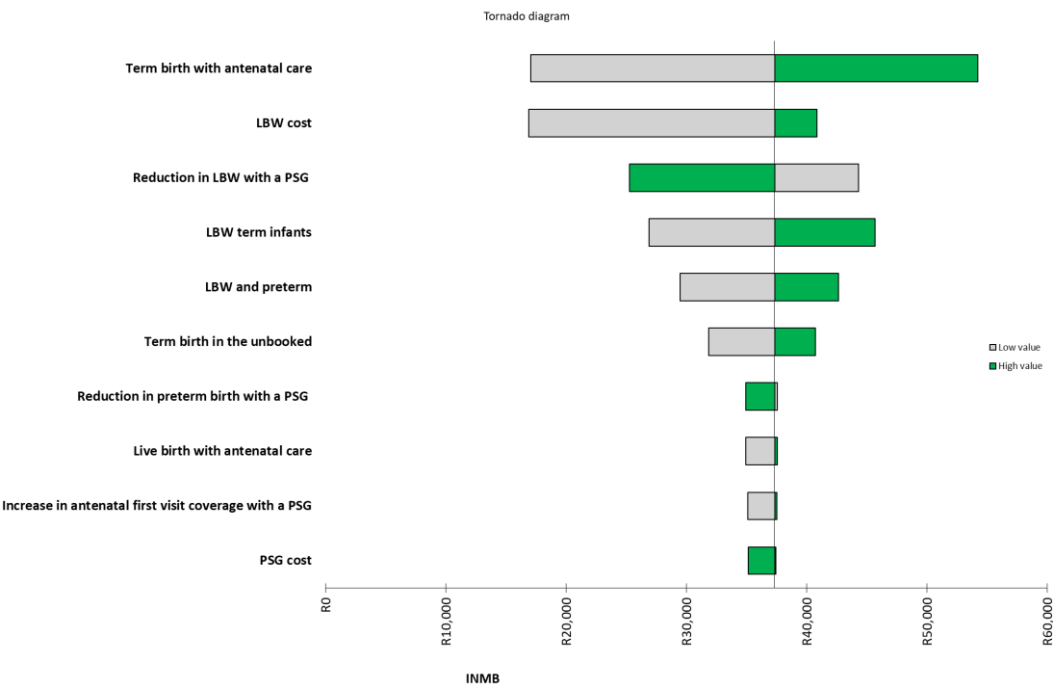


Figure 3.2: Tornado diagram for top 10 parameters

Abbreviations: LBW, low birth weight; PSG, pregnancy support grant; INMB, incremental net monetary benefit.

Figure 3.2 presents the results of the univariate sensitivity analysis in the form of a tornado diagram for the ten parameters with the greatest effect on the INMB. It indicates that varying individual parameters still resulted in a positive INMB. This shows that the intervention remains cost-effective when varying each parameter. Figure E1 represents the results of the univariate sensitivity analysis for all parameters in the form of a tornado diagram.

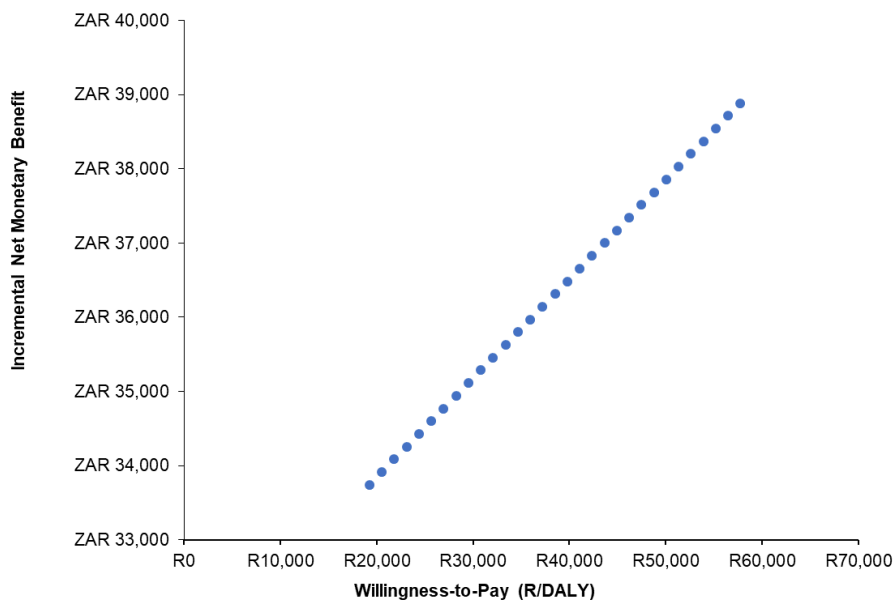


Figure 3.3: Incremental net monetary benefit vs willingness to pay threshold

The INMB accounts for the country threshold of ZAR38,500.00 (151). In order to determine how much the threshold changes the INMB, a graph plotting INMB against the threshold was produced (Figure 3.3). Regardless of the threshold, the INMB remains positive, indicating that the intervention remains cost-effective. The PSG remained cost-effective up to a value of ZAR38,613.34 per pregnancy, which is equivalent to a monthly grant of ZAR7,722.67.

3.4.2 Probabilistic sensitivity analysis

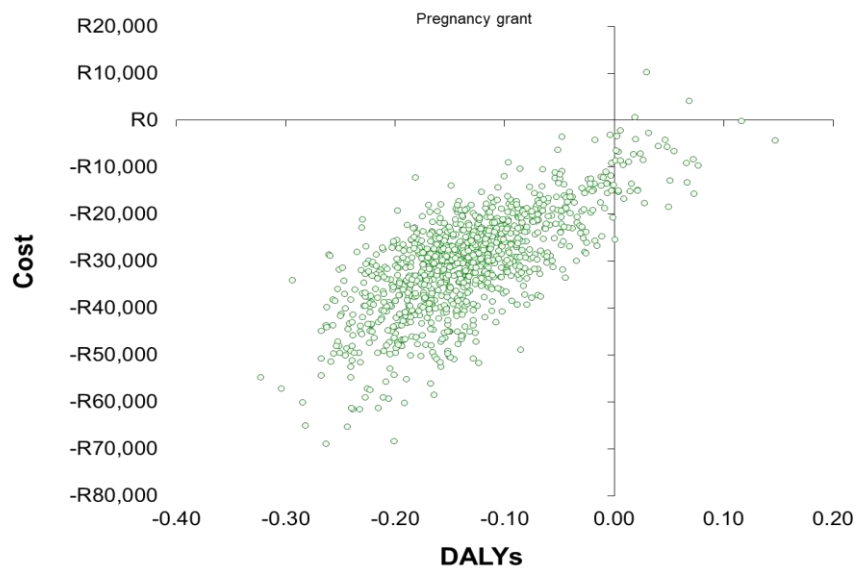


Figure 3.4: Iterations of the Monte Carlo simulation plotted on a cost-effectiveness plane

Abbreviations: DALYs, disability-adjusted life years.

After running 1,000 iterations of a Monte Carlo simulation, the total costs, incremental costs, total DALYs, and DALYs averted are averaged for the intervention and comparator in order to calculate an ICER. When running the Monte Carlo simulation, each iteration of the incremental costs and DALYs was plotted on the cost-effectiveness plane (Figure 3.4). The incremental DALYs remain negative in most cases, with 99.5% of iterations considered cost-effective. This shows that the intervention remains the dominant strategy in the probabilistic analysis, and that little uncertainty exists.

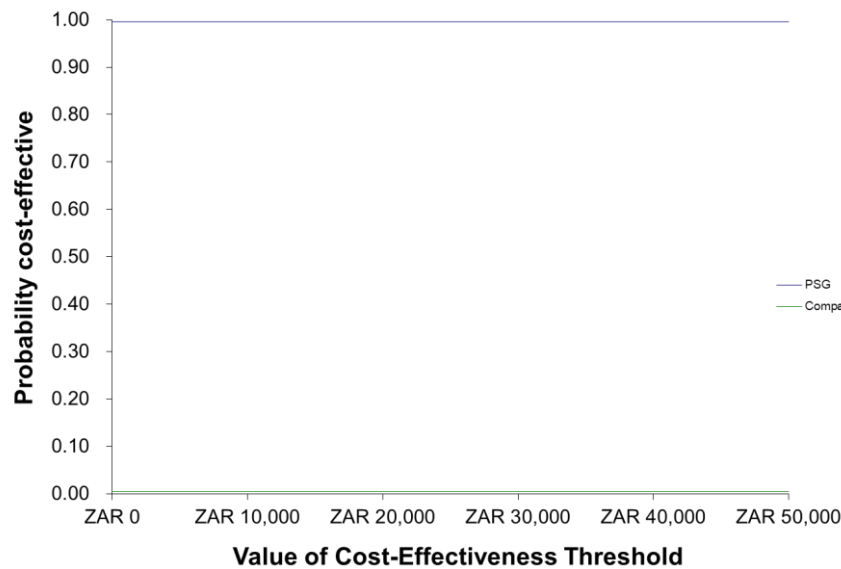


Figure 3.5: Cost-effectiveness acceptability curve

Abbreviations: PSG, pregnancy support grant.

Figure 3.5 shows the cost-effectiveness acceptability curve, which plots the cost-effective threshold against the probability of the intervention or comparator being cost-effective (154). In most iterations of the simulation, the PSA was cost saving. Hence, the value of the threshold did not change the outcome in most instances, producing the unconventional shape of the curve. The graph shows that the intervention remains cost-effective regardless of a change in threshold. There is, therefore, a low degree of uncertainty.

CHAPTER FOUR: DISCUSSION

This chapter will discuss the study results in the context of current literature. It will also present the strengths and limitations of this study. Finally, the recommendations and conclusion of the study will be discussed.

4.1 Summary of the study findings

This study aimed to determine whether extending the South African CSG into the antenatal period would be cost-effective using decision tree analytical modelling. The

total costs were ZAR91,000.00 per person and ZAR122,000.00 per person for the intervention and the comparator. These estimated costs resulted in an incremental cost of -ZAR31,200.00, indicating that the intervention would be cost saving to government. The intervention averted 0.13 DALYs per person. Overall, the model produced an ICER of -ZAR233,000.00 per DALY averted. This showed that the intervention was the dominant strategy and is cost-effective.

4.2 In context of the literature

The results of this study indicate that providing a pregnancy grant would be cost-effective. This is similar to the results of other studies in LMICs that show that conditional cash transfers and voucher schemes are cost-effective as a form of support during pregnancy (60,92,93). In contrast to the results of the present study and other LMIC studies, the effects of the grant were not sufficiently high enough to account for costs associated with the pregnancy grant in Scotland (73). Leyland et al. concluded that the benefits were negligible and programme costs were high (73). Although the study included an extensive number of health states affected by the grant, it was costed from a payer perspective (73). Therefore, productivity losses were not accounted for, which may have counteracted the costs of the programme. These results are likely to differ from this study due to higher benefits observed in poorer populations when provided with financial support (50). Although economic evaluation has been performed using quality-adjusted life years (QALYs), it is important to note how the interpretation of the results may vary. In contrast to DALYs that account for the years of life lost as a result of disease, QALYs measure the years of life lived in perfect health (155). DALYs and QALYs are only equivalent if the disability conferred by an illness is directly related to population preference for different health states (155). Therefore, the results produced in this study may vary from results represented in QALYs.

Considering the difference in results between high-income regions and those that are impoverished, it is important to determine which population sub-groups would benefit most from financial support during pregnancy. A study by Selebano et al. showed that ANC frequency was associated with wealth (156). Their study showed that impoverished women were more likely not to access care compared to wealthy women who often had more than four antenatal visits (156). This factor may be addressed by a PSG (54,57,59,65,66,157). Similarly, wealth is also strongly related to poor neonatal outcomes, including mortality (158). Neonatal mortality is also higher in rural areas, likely due to a lack of access to adequate care (158,159). These factors suggest that the PSG may be most beneficial to poor rural women as it could assist in improving ANC and prevent poor health outcomes. This study excluded non-citizens based on the eligibility criteria for the CSG. However, expert consultation and published literature indicate that immigrant mothers and children are particularly vulnerable (113,124). Approximately 25% of children accessing neonatal care are considered immigrants (124). This suggests that immigrant pregnant mothers may benefit greatly from receiving a PSG, which would ultimately reduce healthcare costs.

Despite the cost of the grant, this study still found it to be cost-effective. This was due to reductions in healthcare costs. This grant, therefore, overcomes the limitations of the basic income grant (15) by being cost saving. To illustrate, the savings of the grant offset the cost of the grant, making it affordable. It is important to note which conditions act as major cost drivers. This indicates which disease entities need to be prioritised when planning prevention strategies in order to reduce healthcare costs. Among the health states included in this study, infants who have a LBW produced the highest per capita cost at R101,431.64 in the comparator group. These findings are consistent with the available literature. LBW is often as a result of preterm birth

(21). Preterm birth and LBW contribute substantially to driving up health care costs as they often experience complications and require hospitalisation, increasing healthcare utilisation (21,160). The need for healthcare utilisation is associated with a lower gestational age and lower birth weight (160–162). Several studies indicate that moderate and late preterm infants with a LBW make up the majority of admissions (160,161). Admission into NICUs has saved the lives of many infants (163) and is considered cost-effective (161,164). However, Zainal et al. show that with NICU admission, overhead and treatments costs are the main cost drivers among hospitalised preterm and LBW infants (160). Further, healthcare costs among infants with these conditions remain high throughout the lifetime of the child (165). This points to the need for policy to shift towards the prevention of these conditions in order for both societal and governmental costs to be reduced (163). This could be achieved through the implementation of a PSG, which reduces rates of preterm birth and LBW (42,74,75).

Despite the strong evidence highlighting the benefits of financial support during pregnancy (166), it is important to explore the perverse incentives that may be derived from this when developing policies. Evidence of perverse incentives vary in the South African context. Oyenubi et al. completed a population-based study using data from the National Income Dynamic Study over a 10-year period, which showed that the CSG has led to an increase in the number of subsequent pregnancies when comparing women who do and do not receive the grant (167). This is in contrast to various cohort studies that showed no association between the CSG and subsequent pregnancy (168,169), with results indicating an inverse relationship among teenage mothers (169). Kollaparambil used data from the national income dynamics study, which is a nationally representative dataset, to evaluate the relationship between subsequent pregnancies and receiving the CSG (170). The study provided varying

results based on the population group being reviewed. Although women between 20 and 58 years were found to have a significantly greater number of children when receiving a CSG, the same effect was not observed among teenage mothers (170). These findings indicate the need to carefully consider the method used to distribute the grant.

Similarly, whether to make the grant conditional or unconditional needs to be determined. Previous economic evaluations in LMICs include interventions that involve some conditionality, generally related to attending antenatal and postnatal visits (60,92–94). However, this study evaluated a grant that does not have an associated conditionality. Conditional cash transfers have been found to be effective in improving the uptake of health services, particularly preventative care (171). In a Cochrane review, utilisation of preventative care among children and pregnant women was significantly increased (171). Similarly, unconditional cash transfers have shown to improve health outcomes by allowing individuals to spend the additional monetary support on healthcare, increasing healthcare utilisation (172). In a Cochrane review, unconditional cash transfers also had a positive effect on nutrition by improving food security and allowing recipients to have a more diverse diet (172). This was the assumption included in the current study. Given that unconditional cash transfers increase healthcare utilisation and nutrition, adding a conditionality to the PSG may not be necessary. Additionally, making the grant conditional may not be feasible in areas that have inadequate access to healthcare facilities for antenatal and postnatal care or in countries without adequate systems to ensure that conditions are met (172), such as in South Africa.

Another important consideration for the PSG would be the funding of the grant. Implementing upstream policies and programs outside the health sector is crucial to addressing the social determinants of health. However, investment into these

interventions may not be undertaken by the health sector due to an underestimation of benefits when non-health benefits are accrued (173). Similarly, other sectors may underestimate the health benefits of the intervention given the focus on their own departmental objectives (173). At present, the Department of Social Development is assumed to bear the cost of the grant as this department is responsible for paying the CSG (14). However, unlike the Department of Health, the Department of Social Development has no explicit mandate to consider DALYs. Additionally, the cost savings produced by the PSG will only be accrued by the Department of Health. This highlights the need for inter-sectoral collaboration in order to improve overall health, particularly when interventions outside of the health sector achieve health gains more efficiently than the marginal productivity of the health sector (173,174). This issue may be dealt with using an inter-governmental co-funding approach (173,174). This approach would involve the redistribution of relevant health sector funds to the Department of Social Development (174). The Department of Social Development is then able to determine how much to contribute to the PSG based on the marginal productivity of their budgets (174). By pooling funds in this way, it may be possible to more effectively achieve common objectives and capture the full multi-sectoral value of these investments (173).

The abovementioned considerations are critical to explore during the decision-making process. Policy development and implementation in South Africa is detailed in the National Policy Development Framework and consists of four steps (175). These steps include the following: 1. Formulation of policy in a green paper based on a root-cause analysis, evidence generation, and stakeholder engagement; 2. Adoption of policy following extensive consultation and approval of the policy; 3. Implementation of the policy once an implementation plan has been drafted; and 4. Monitoring and evaluation of the policy (175). The evidence produced by this study

forms a fundamental part of the first step in this process as it provides the evidence required to motivate for the introduction of the PSG. In addition to ensuring that policy is evidence-based, policy is also aimed at addressing issues of unemployment, poverty, and inequality (175). As stated in section 1.2, women are particularly vulnerable to all of these factors (4,5), and this vulnerability is heightened among pregnant women (24). Hence, the implementation of the PSG manages to address several key steps in the initial stages of policy development, indicating a need for further discussion on the topic of the PSG.

4.3 Strengths

The results of this study produced a similar outcome to other LMIC studies, which show that financial pregnancy support is cost-effective. Both voucher schemes (54,92,93) and conditional cash transfers (60,94) improved maternal nutrition and increased ANC through financial support. However, there are significant differences between previous studies and this study.

First, no previous economic evaluation analysed the effect of a grant in Sub-Saharan Africa. While incentives, such as vouchers, provide support to pregnant women, they may not cover items that address the recipients priority needs. Therefore, this study fills a gap in the literature.

Second, the study inputs, particularly the effects of the intervention, which were used in previous studies, were not generalizable to the South African context. Due to the free ANC provided in the South African public sector (106), any form of financial support would not assist in reducing fees related to care. Many studies are based in settings in which care is not provided free of charge (60,93,176). The impact of the financial support was therefore directed at addressing this cost burden. This could not be included in our model, which may have reduced the impact of the grant in this

study. However, the impact of the grant on ANC coverage was included in order to account for the cost barriers to accessing transportation (177) and adequate nutrition (27). Study inputs were primarily taken from South African sources. This study was costed using South African 2021 data and used a country specific threshold, making it relevant to the South African context.

Finally, this study used decision tree modelling to evaluate the cost effectiveness of the PSG, similar to the methodology used in previous studies (93,176). Changes in ANC (176) and health states such as infant death, preterm birth and LBW (93) were included in the model based on previous studies. The model built in this study was, however, far more extensive and included additional health states, such as SGA and stillbirth, which are affected by the proposed PSG as well as complications such as hypoglycaemia, RDS, chronic lung disease, and motor impairment. This may have more accurately accounted for benefits and reductions in costs.

4.4 Limitations

When engaging with the results of this study, various methodological and data limitations should be considered. Methodological limitations discussed in this section include the perspective taken, the time horizon, and model assumptions. Data limitations are largely related to a lack of country specific data. These limitations relate to the costing of the grant and the use of global disability weights.

The WHO suggests a willingness-to-pay threshold of three times the country's annual per capita GDP per DALY averted (178). In 2020, the reported GDP per capita value was US\$5,655.90, equating to a threshold of US\$16,967.70 per DALY averted (179). However, a country specific threshold of US\$3,015 (ZAR38,500.00) per DALY was estimated (151), which is far lower than the proposed WHO threshold. This threshold reflects health-related opportunity costs (151). However, due to the governmental

perspective taken in this study, the threshold may not capture all opportunity costs. Despite this, the ICER was well below the threshold even when varying parameters in the sensitivity analysis. In order to address this issue, decision-making needs to take place at a National Treasury level or the health sector should fund the PSG using cost savings.

Various studies have taken a societal perspective, accounting for productivity losses (93,176). This was not included in the current study. However, this may suggest that the cost savings are greater than reported as mothers often experience productivity losses when their infant is hospitalised. Kingkaew et al. reported an average loss of income for the accompanying relatives between 535-15,689 kyats (93). Similarly, Alfonso et al. included a US\$1.33 cost attributed to productivity losses (176). Reducing the need for hospitalisation with the intervention may therefore reduce productivity losses, mitigating the effects of programme costs.

This study had a time horizon of two years after birth to represent the first thousand days of life. However, a longer time horizon is recommended to capture all relevant costs and consequences (180). Therefore, this model may not capture all costs and consequences. However, most health consequences, such as preterm birth, LBW, and SGA, occur during the neonatal period. Consequences are also likely to be accounted for in the model as 47% of all deaths under five years of age take place during the neonatal period (22). Further cost savings are also expected to accrue due to future health and developmental benefits associated with the grant (50). Therefore, this study provides a conservative estimate of the potential cost savings.

The model assumes that 100% of those eligible for the PSG will enrol in the programme in order to include the greatest possible benefits. However, this is unlikely to be the case. Up to 95% of poor children have been reported not to receive

the grant, despite being eligible, as families in rural areas often lack access to application sites or are unaware of their eligibility (9). If there is a significant variation in the benefits produced by the PSG between those who would have access to the grant and those who do not, the results of this model would be biased. For instance, benefits would be underestimated if those who are poor and from rural areas do not access the grant despite experiencing the most benefit. The model was, however, constructed to represent a per capita ICER, which could be used to determine the cohort value based on coverage.

Although this study reflected cost savings as a result of reductions in poor neonatal health outcomes, several studies have indicated that costs are increased by introducing demand-side incentives (60,94). The cost of the intervention was based on the cost of the CSG. However, other costs such as administrative, human resource, and supply-chain costs were not included. This may result in an underestimation of the costs associated with the grant. However, infrastructure required to administer the pregnancy grant already exists due to the implementation of the CSG (170). It was assumed that additional costs would remain low as the administrative system already exists. Hatt et al. and Onwujekwe et al. have emphasized the need for programme integration in order to reduce programme costs that may otherwise show an over-inflated increase in facility costs (60,94). Additionally, when varying the cost of the grant in the sensitivity analysis, the pregnancy grant remains cost-effective. The grant could be increased to approximately ZAR38,600.00 per pregnancy, equivalent to ZAR7,720.00 per month, before it crosses the threshold. Based on the assumption that the value of the grant may be associated with the effect size (81), the grant is likely to remain cost-effective, even with high grant costs.

Another methodological limitation is the lack of country specific disability weights used in the study (103). Therefore, the DALYs accrued with each health state may not represent the South African experience.

Finally, it is important to consider the generalisability of the results. Data on the effect of the grant were largely derived from studies conducted in other countries. This may reduce the generalisability of the results. In order to address this, input parameters were largely taken from studies in LMICs. A sensitivity analysis was also performed, where these parameters were varied across the range of results presented in all available studies.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Recommendations

Due to the use of decision analytical modelling, assumptions and value judgements were made during the conceptualisation of the model. Therefore, further research is required in order to validate the findings of this model to strengthen the body of literature evaluating the cost-effectiveness of a PSG and close the large gap in the literature. A cost-effectiveness study using primary data to establish more precise costs and impact data is recommended. The analysis should also be conducted from a societal perspective to account for additional costs, such as productivity losses, and the additional benefits experienced by impoverished families. Further, non-health outcomes that are affected by the PSG, such as human capital and domestic violence experienced by women, need to be included (49). Stratifying the model across different population groups is recommended in order to determine which groups, including immigrants and varying socio-economic groups, would benefit most from the PSG in order to ensure that policy is equitable and that the appropriate income threshold is used. As non-citizens contribute substantially to healthcare costs,

it may be necessary to include them in the PSG. A budget impact analysis would also assist in highlighting the impact of implementing this intervention on overall government financing. Using this, further discussion on the financing of the PSG is required. Additionally, research into the effect of different grant values on health outcomes is required. From this, a scenario analysis can be performed to determine the impact of varying grant values on the ICER in order to determine the grant value at which the greatest cost saving is achieved. This data could be used to inform evidence-based policy decision-making, while addressing priority social issues (175).

5.2 Conclusion

This study shows that a PSG would be cost-effective in South Africa, producing cost savings and a reduction in DALYs. The model provides a starting point for the evaluation of the cost-effectiveness of a PSG and closes the gap in literature in LMICs. In addition to further literature and stakeholder consultation as part of the National Policy Development Framework, policy change in favour of the PSG should be considered.

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7. APPENDICES

APPENDIX 1: PLAGIARISM DECLARATION



PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I, Aisha Moolla (Student number: 707427) am a student registered for the degree of Master of Public Health in the academic year 3 (2022).

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

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TO WHOM IT MAY CONCERN

Waiver: This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical)

Investigator: Dr A Moolla
Student No. (if appropriate):
707427 Staff No. (if appropriate):

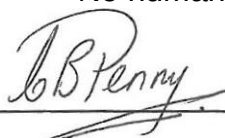
Supervisor: Dr C Kohli-Lynch

School: School of Public Health

Department: Medical School
University

Project title: Extending the South African child support grant: a cost-effectiveness analysis of implementing a pregnancy support grant

Reason: Review of information in the public domain
No human participants will be involved in the study



Dr CB Penny

Chairperson: Human Research Ethics Committee (Medical)

Research Office Secretariat:

Third Floor, Phillip Tobias Building, corner of St Andrews and York Roads, Parktown, Johannesburg 2193

Postal address: Private Bag 3, Wits 2050

Tel Nos: +27 (0)11 717 1234/1252/2656/2700

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APPENDIX 4: LITERATURE REVIEW RESULTS

Table E1: List of studies generated by the literature review

Source	Programme and country	Type of transfer	Impact of income support on health states
(181)	Progresa (Mexico)	Conditional cash transfer	Newborns receiving the intervention were 25.3% less likely to have been ill over the prior month. The intervention had no impact on stunting.
(51)	Demand-side incentives in LMICs		The incentive led to an increase in ANC.
(54)	Pilot voucher program (Bangladesh)	Cash incentives and free access to ANC, delivery, and postnatal care.	Those who received the intervention had a 46.4% higher chance of receiving care from a qualified provider and 13.6% higher chance having a delivery performed by a skilled birth attendant.
(83)	Bolsa Familia programme (Brazil)	Conditional cash transfer	Children in the intervention group were 26% more likely to have a normal height-for-age compared to the control group.
(87)	Literature review of cash transfer programmes		Cash transfer programmes may reduce child mortality. This is mediated through improved healthcare and reduced malnutrition.
(86)	Janani Suraksha Yojana (India)	Conditional cash transfer	The intervention increases ANC and births at a facility. The intervention group also had a reduction of 4.1 (2.5–5.7) perinatal deaths per

Source	Programme and country	Type of transfer	Impact of income support on health states
			1000 pregnancies and 2.4 (0.7–4.1) neonatal deaths per 1000 livebirths.
(59)	The Maternity Allowance Program (MAP) (Bangladesh)	Conditional cash transfer	Diet diversity food scores increased by 0.24 points. Antenatal and postnatal care access increased by 16% and 7%, respectively.
(75)	Metis families (Canada)	Unconditional cash transfer	The intervention group had a reduced risk of LBW (relative risk: 0.74; 95% CI: 0.59, 0.94) and preterm birth (relative risk: 0.78; 95% CI 0.65, 0.94).
(81)	Mexican programme Oportunidades/Progreso (Mexico)	Unconditional cash transfer	The height-for-age Z score was higher in those with a higher cash transfer (β 0.20, 95% CI 0.09–0.30; $p < 0.0001$). This group also had a lower rate of stunting (–0.10, –0.16 to –0.05; $p < 0.0001$), a lower body mass index (–2.85, –5.54 to –0.15; $p = 0.04$), and a reduction in overweight (–0.08, –0.13 to –0.03; $p = 0.001$). Higher cash transfers were also associated with improved motor, language and cognitive development.
(73)	Health in Pregnancy (HiP) grant (Scotland)	Grant	There was no statistically significant effect on birthweight.
(71)	Progreso (Mexico)	Fortified nutrition supplements, nutrition	Average haemoglobin levels were higher in the intervention group (11.12 g/dL; 95% CI 10.9–11.3 g/dL) than in the comparison group (10.75 g/dL; 95% CI, 10.5–11.0 g/dL).

Source	Programme and country	Type of transfer	Impact of income support on health states
		education, health care, and cash transfers	
(52)	Programa de asignación familiar (family allowance programme) (Honduras)	Conditional cash transfer	The intervention led to an 18% and 20% increase in ANC and postnatal child follow-ups, respectively.
(182)	Bolsa Familia (Brazil)	Conditional cash transfer	There was no impact on child immunisation.
(76)	Progresa (Mexico)	Conditional cash transfer	The birthweight of the intervention group was 127.3g higher.
(183)	Red de Protección Social (Nicaragua)	Conditional cash transfer	The intervention led to an increase in cognitive outcomes of boys (by 0.15 SD). There was no impact on anthropometrics.
(131)	Progresa (Mexico)	Conditional cash transfer	The intervention resulted in a 17% reduction in the infant mortality. There was no impact on neonatal mortality.

Source	Programme and country	Type of transfer	Impact of income support on health states
(89)	Bolsa Familia (Brazil)	Conditional cash transfer	The intervention led to a 9.3% and 24.3% reduction in infant mortality and post neonatal mortality rates, respectively.
(90)	Bolsa Familia (Brazil)	Conditional cash transfer	Increased intervention coverage was associated with a reduction in under-five mortality.
(91)	Bolsa Familia (Brazil)	Conditional cash transfer	Post-neonatal infant mortality decreased from 5.24 to 1.38 per 1000 live births when the coverage of the Bolsa Familia went from 25% to 60% and the family health programme coverage increased from 0% to 100%.
(58)	Progresa (Mexico)	Conditional cash transfer	A longer exposure to the Oportunidades resulted in increase of 2.1% ANC compare to a shorter exposure time.
(184)	Juntos (Peru)	Conditional cash transfer	The risk of underweight (prevalence ratios 0.39 (p=0.018)) and overweight were reduced (0.94 (P<0.001)). Anaemia among children also decreased on an individual (prevalence ratios 0.93, p=0.04) and district levels (1.09, p=0.035).
(116)	Plan de Atención Nacional a la Emergencia Social (PANES) (Uruguay)	Conditional cash transfer	LBW was reduced by 19-25%.

Source	Programme and country	Type of transfer	Impact of income support on health states
(185)	Familias en Acción (Colombia)	Conditional cash transfer	Child visits were increased by the intervention.
(186)	Comunidades Solidarias Rurales (El Salvador)	Conditional cash transfer	The intervention had no effect on health seeking behaviour.
(187)	Progresa (Mexico)	Conditional cash transfer	Birth by a skilled birth attendant only increased amongst women who had a subsequent pregnancy and a previous delivery without the intervention.
(188)	Study intervention (Kenya)	Conditional and unconditional cash transfer	Among those who received an unconditional cash transfer, a conditional cash transfer, or no cash transfer, 62.7%, 58.2%, and 48.2% delivered at a facility, respectively.
(189)	Study intervention (Kenya)	Conditional and unconditional cash transfer & maternal voucher	The voucher and cash transfer increased antenatal and postnatal care by 9.6%. The cash transfer alone had no effect on utilisation.
(190)	Kakamega country cash transfer (Kenya)	Conditional cash transfer	The rate of care utilisation (four antenatal visits) increased from 47.4% in 2014 to 63.9% in 2016 in the intervention group. The national increase was 9%.
(61)	Subsidy Reinvestment and	Conditional cash transfer	The intervention increased monthly antenatal visit averages by 15.11 visits per 100,000

Source	Programme and country	Type of transfer	Impact of income support on health states
	Empowerment Programme (Nigeria)		population per month. First visit timing was not affected.
(115)	Randomised control trial (Democratic Republic of Congo)	Conditional cash transfer	Retention in care was 9% greater in the intervention group than the control.
(191)	Randomised control trial (Nigeria)	Conditional cash transfer	The intervention group received 12.8-18.9% more treatment compared to the control group.
(192)	Child Grant Program (Zambia)	Unconditional cash transfer	The intervention had no effect on ANC.
(84)	Samurdhi National Poverty Alleviation Scheme (Sri Lanka)	Conditional cash transfer	The intervention increased the height-for-age z-score by 0.40 standard deviations. It also increased weight-for-height z-scores by 0.45 standard deviations.
(99)	Demand-side financing (DSF) pilot maternal health voucher	Vouchers for maternal health services, transport, conditional cash transfer	The intervention group was more likely to attend at least 3 antenatal visits (55%) and postnatal visits (36%) than the control group.

Source	Programme and country	Type of transfer	Impact of income support on health states
	scheme (Bangladesh)		
(86)	Janani Suraksha Yojana (JSY, India)	Conditional cash transfer	The intervention resulted in a decrease of between 3.7 and 4.1 perinatal deaths per 1000 pregnancies and 2.3 and 2.4 neonatal deaths per 1000 livebirths.
(193)	Janani Suraksha Yojana (JSY, West Bengal, India)	Conditional cash transfer	There was no change in the maternal mortality rate.
(53)	Maternal health voucher scheme (Bangladesh)	Vouchers for maternal health services and transport	The intervention group was 2.8 times more likely to access postnatal care, 2.0 times more likely to access ANC, and 1.5 times more likely to get treatment for complications.
(62)	Saving Children and Improving Lives (India)	Conditional cash transfer	The intervention group had 29.2% more antenatal visits.
(194)	Janani Suraksha Yojana (JSY, India)	Cash transfer (linked to institutional delivery)	The intervention group was more likely to receive postpartum contraceptive counselling (odds ratio 1.66; 95% confidence interval, 1.38–2.00) and to have obtained contraception (OR, 1.31; 95% CI, 1.02–1.68).

Source	Programme and country	Type of transfer	Impact of income support on health states
(195)	Janani Suraksha Yojana (JSY, India)	Conditional cash transfer	The intervention group had a vaccine coverage rate of 9.1% greater than the control group.
(196)	Janani Suraksha Yojana (JSY, India)	Conditional cash transfer	There was no effect on ANC
(197)	Janani Suraksha Yojana (JSY, India)	Conditional cash transfer	The intervention reduced the maternal mortality ratio particularly in richer quintiles.
(198)	Janani Suraksha Yojana (JSY, India)	Conditional cash transfer	The intervention had no effect on ANC or neonatal mortality.
(199)	Household cash transfers (PKH) and community cash transfers (Generasi, Indonesia)	Conditional cash transfer	Both interventions increased antenatal and postnatal care.

Source	Programme and country	Type of transfer	Impact of income support on health states
(200)	Janani Suraksha Yojana (JSY, India)	Conditional cash transfer	The intervention reduced maternal depression by 36%.
(201)	Pilot CCT (Afghanistan)	Conditional cash transfer	The intervention group, consisting of the whole family, had a higher rate of service utilisation.
(202)	Household cash transfers (PKH) and community cash transfers (Generasi, Indonesia)	Conditional cash transfer	The intervention reduced the likelihood of wasting and severe wasting by 33% and 41% respectively. Generasi reduced the likelihood of severely underweight by 47%.
(203)	Household cash transfers (PKH, Indonesia)	Cash transfer	The intervention increased the vaccination rate by 30% compared to the control group.
(63)	Mamata scheme (India)	Conditional cash transfer	The intervention led to a 5% increase in the likelihood of accessing ANC, a 10% increase in the likelihood of receiving supplements, and a decline of 0.84 on the Household Food Insecurity Access Scale.
(64)	Household cash transfers	Conditional cash transfer	The intervention increase ANC utilisation by 0.07 standard deviations.

Source	Programme and country	Type of transfer	Impact of income support on health states
	(PKH, Indonesia)		
(204)	Participatory Learning and Action (PLA) women's groups + fortified flour or cash transfers (Nepal)	Monthly fortified flour transfer or unconditional cash transfers	The cash transfer improved dietary diversity.
(66)	Janani Suraksha Yojana (JSY, India)	Conditional cash transfer	The intervention group was 10.1%-point more likely to access ANC, 12.2%-points more likely access maternal postnatal care and 8.6%-points more likely to access newborn care.
(77)	Participatory Learning and Action (PLA) women's groups + fortified flour or cash transfers (Nepal)	Monthly fortified flour transfer or unconditional cash transfers	Birthweight was 78.0 g (95% CI 13.9, 142.0) higher in the group that received food compared to the control. There was no difference in the group that received cash.

Source	Programme and country	Type of transfer	Impact of income support on health states
(78)	Newfoundland and Labrador Mother-Baby Nutrition Supplement (Canada)	Unconditional cash transfer	Those who received the intervention early during pregnancy had similar rates of LBW when compared to the rest of the country (risk ratio: 1.19, 95% CI = 0.68–2.08).
(130)	Happy Baby Prenatal Benefit (Canada)	Unconditional cash transfer	The intervention was associated with an increase in ANC (odds ratio 1.27 (95% CI: 0.94, 1.71)) and a reduction in LBW (odds ratio: 0.63 (95% CI: 0.43-0.93) and preterm birth (odds ratio: 0.82 (95% CI: 0.57, 1.16)).
(79)	Happy Baby Prenatal Benefit (Canada)	Unconditional cash transfer	Those who received the intervention had a 29% lower chance of having a LBW baby and a 15% lower chance of having a preterm birth compared to the control group.

APPENDIX 5: PS AND QS TABLE

Table E2: Unit costs (Ps) and Quantities (Qs) table

	Cost per unit (including facility fee)	Number of units	Total
Grant costs			
Grant cost (months)	R460.00	5	R2,300.00
CSG	R460.00	24	R11,040.00
ANC			
ANC visit	R177.00	1	R177.00
Stillbirth			
Stillbirth costs	R1,792.00	1	R1,792.00
Preterm			
Facility fee	R444.00	1	R444.00
Dispensing fee	R48.00	2	R96.00
Tocolysis (nifedipine 20mg)	R1.55	6	R9.31
Steroids (betamethasone 4 mg dose)	R4.77	6	R28.59
NICU costs			
NICU days, <1500g	R20,594.00	46	R947,324.00
NICU days, 1500-2499g	R20,594.00	13	R267,722.00
NICU days, >2500g	R20,594.00	0	R0.00
High care days, <1500g	R5,230.00	8	R41,840.00
High care days, 1500-2499g	R5,230.00	8	R41,840.00
High care days, >2500g	R5,230.00	8	R41,840.00
NICU admission rate, <1500g	n/a	0.85	
NICU admission rate, 1500-2500g	n/a	0.44	
NICU admission rate, >2500g	n/a	0.03	
Proportion LBW (<2500g) that are <1500g	n/a	0.17	
Proportion LBW (<2500g) that are 1500-2499g	n/a	0.83	
RDS			
Pharmacy fees	R48.00	1	R48.00

Surfactant (doses)	R1,976.91	2	R3,953.82
CPAP (days)	R8,379.79	1	R8,379.79
Nasal prong oxygen (days)	R1,301.00	14	R18,214.00
Hypoglycaemia			
Practitioner fees	R850.00	2	R1,700.00
3hrly HGTs (per blood draw)	R43.00	8	R344.00
10% dextrose (ml)	R63.43	10	R634.26
1hrly HGTs (per blood draw)	R43.00	6	R258.00
Screening			
Cranial ultrasound	R720.00	3	R2,160.00
ROP	R407.00	1	R407.00
Chronic lung disease			
Consultation and facility fee	R1,237.00	2	R2,474.00
Ventilation (days)	R1,301.00	28	R36,428.00
Lasix 0.5-1mg/kg/dose 12 hourly	R299.63	9	R2,696.71
Spironolactone 1mg/kg/dose 12hourly	R48.09	9	R432.80
Salbutamol – 0.1-0.5 mg/kg 2-6 hourly	R223.65	1	R223.65
Dexamethasone 0.05 mg/kg/dose daily X 3 days, 0.025mg/kg/dose daily X 3 days	R54.56	6	R327.35
Developmental impairment			
Allied health follow-up	R201.00	19	R3,819.00
Follow-up			
Initial specialist follow-up	R407.00	1	R407.00
Doctor 6 monthly until 18 months (consultations)	R250.00	2	R500.00
Clinic follow up (consultations)	R177.00	19	R3,363.00

APPENDIX 6: SENSITIVITY ANALYSIS OUTPUTS

Table E3: High and low ICER (ZAR/DALY averted) and INMB (ZAR) values when varying individual parameters

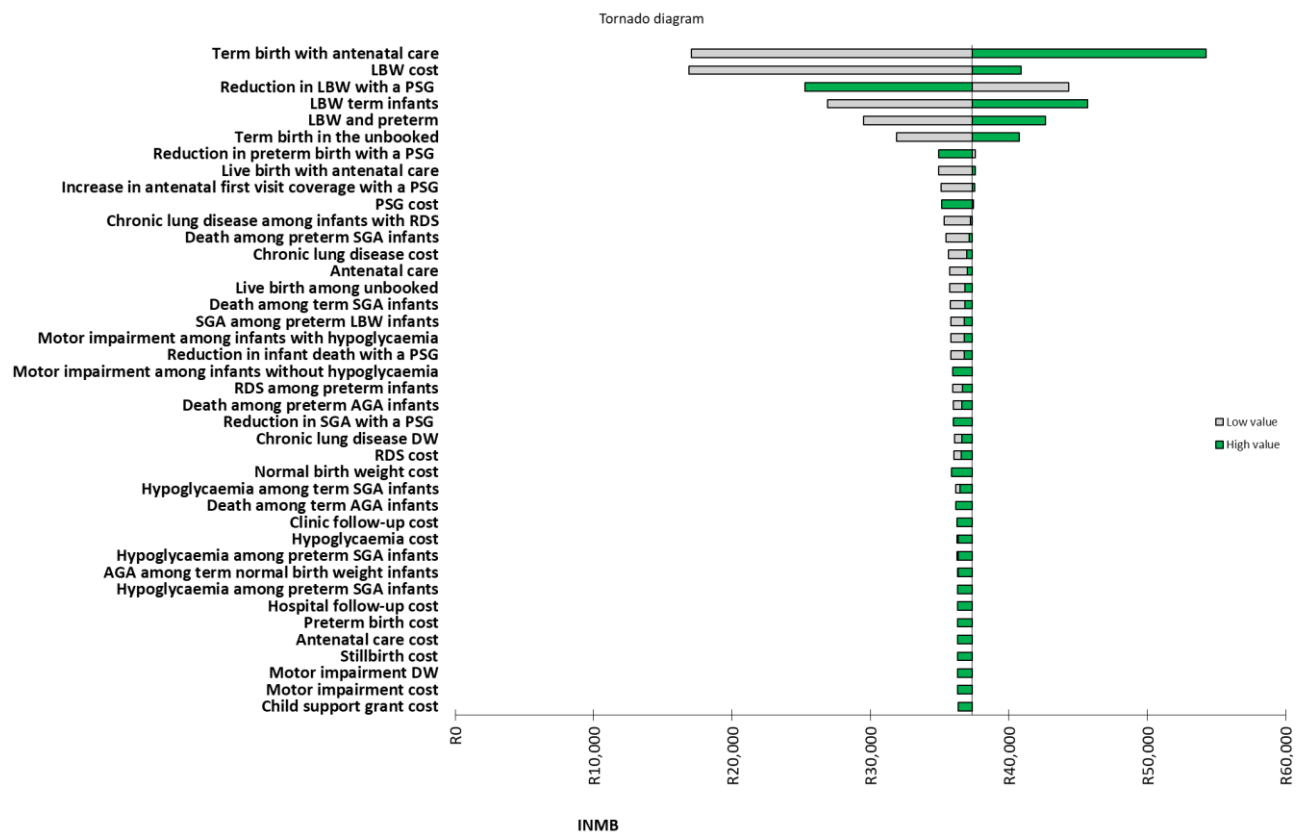
Parameter	Low ICER	High ICER	Low INMB	High INMB
Costs				
PSG cost	-R249,714.95	-R232,502.39	R38,512.25	R36,212.25
CSG cost	-R241,347.31	-R241,347.31	R37,394.14	R37,394.14
ANC cost	-R241,164.26	-R241,056.79	R37,369.68	R37,355.31
Preterm birth cost	-R241,020.34	-R241,191.11	R37,350.45	R37,373.26
LBW cost	-R88,083.05	-R267,507.07	R16,914.45	R40,889.69
NBW cost	-R232,981.20	-R230,056.28	R36,276.23	R35,885.39
Stillbirth cost	-R241,069.93	-R241,147.40	R37,357.07	R37,367.42
RDS cost	-R239,178.39	-R242,910.26	R37,104.32	R37,602.98
Hypoglycaemia cost	-R240,797.01	-R241,420.33	R37,320.60	R37,403.89
Chronic lung disease cost	-R235,990.45	-R245,885.67	R36,678.33	R38,000.57
Motor impairment cost	-R241,104.00	-R241,113.02	R37,361.62	R37,362.83
Hospital follow-up cost	-R241,002.48	-R241,207.78	R37,348.06	R37,375.49
Clinic follow-up cost	-R241,575.09	-R240,673.34	R37,424.57	R37,304.08
Effects				
Increase in antenatal first visit coverage with a PSG	-R276,699.82	-R214,349.80	R36,151.76	R38,572.74
Reduction in preterm birth with a PSG	-R233,870.11	-R249,935.12	R38,659.28	R35,972.57
Reduction in LBW with a PSG	-R289,136.13	-R167,926.76	R45,656.50	R25,957.66
Reduction in SGA with a PSG	-R229,116.75	-R255,202.95	R37,649.06	R37,059.90

Reduction in infant death with a PSG	-R268,237.13	-R220,293.46	R36,861.09	R37,829.99
DW				
Chronic lung disease DW	-R252,580.73	-R228,103.18	R37,128.59	R37,655.57
Motor impairment DW	-R241,308.52	-R240,858.21	R37,357.99	R37,367.60
Probabilities				
ANC	-R252,697.04	-R228,778.67	R36,793.89	R38,043.47
Live birth with ANC	-R297,894.37	-R205,327.50	R35,991.97	R38,641.14
Live birth among unbooked	-R243,550.92	-R238,932.14	R36,788.83	R37,897.43
Term birth with ANC	-R801,067.27	-R194,623.86	R17,812.65	R55,608.54
Term birth in the unbooked	-R271,940.46	-R220,880.00	R32,868.00	R41,856.50
LBW and preterm	-R212,203.95	-R263,556.87	R30,334.02	R43,921.93
LBW term infants	-R183,387.97	-R291,594.68	R27,667.06	R47,057.44
SGA among preterm LBW infants	-R268,399.28	-R218,826.82	R36,865.40	R37,859.09
AGA among term NBW infants	-R241,821.24	-R240,447.71	R37,337.47	R37,385.38
Death among preterm SGA infants	-R291,004.36	-R205,737.02	R36,529.70	R38,194.80
Death among term SGA infants	-R269,693.65	-R217,984.00	R36,833.25	R37,891.25
Death among preterm AGA infants	-R257,345.43	-R226,785.09	R37,057.03	R37,667.46
Death among term AGA infants	-R234,529.55	-R248,067.04	R37,505.20	R37,219.29

RDS among preterm infants	-R240,301.54	-R241,852.15	R37,000.93	R37,699.47
Hypoglycaemia among preterm SGA infants	-R242,538.46	-R239,696.31	R37,322.97	R37,401.53
Hypoglycaemia among term SGA infants	-R247,039.29	-R235,466.87	R37,202.43	R37,522.06
Hypoglycaemia among preterm SGA infants	-R241,656.30	-R240,599.87	R37,347.14	R37,376.35
Chronic lung disease among infants with RDS	-R252,501.65	-R231,721.59	R36,385.75	R38,273.64
Motor impairment among infants with hypoglycaemia	-R266,142.77	-R220,380.77	R36,876.82	R37,847.67
Motor impairment among infants without hypoglycaemia	-R224,702.67	-R258,740.06	R37,737.48	R37,012.03

APPENDIX 7: EXTENDED TORNADO DIAGRAM

Figure E1: Tornado diagram including all parameters



Abbreviations: LBW, low birth weight; PSG, pregnancy support grant; SGA, small-for-gestational age; RDS, respiratory distress syndrome; AGA, appropriate-for-gestational age; DW, disability weight.