INVESTIGATING THE INEQUALITIES IN LOW BIRTH WEIGHT FOR UNDER-FIVE CHILDREN IN LESOTHO

By

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DECLARATION

I, **Topollo Eric Motlamelle (201600927)**, hereby declare that except where otherwise indicated and acknowledged in the text, footnotes, tables, figures and appendices, the thesis is based on my original work. I also acknowledge that it has not been previously or concurrently submitted for any other degree at the National University of Lesotho (NUL) or other institutions.

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DEDICATION

I would like to dedicate this study to my late mother, Khahliso Moahloli; my late uncle, Tšitso Moahloli; sister; niece; father; and the rest of my family and friends who have played a pivotal role in supporting my academic drive. Likewise, I dedicate this to my pastors whose prayers have acted as a shield throughout this journey of the mastery of the science of this noble profession, economics.

ABSTRACT

Underweight children, especially those with low birth weight (LBW), tend to face several health challenges as they grow such as chronic illnesses; school dropouts; or even death. It may not be shocking that Lesotho as one of the most unequal societies in Sub-Saharan Africa (SSA) experiences inequality in health outcomes like LBW. Prior to this study, studies in Lesotho only focused on the drivers of LBW. This study, therefore, contributes by investigating the socio-economic inequalities in LBW for under-five children in Lesotho. It goes further to determine which population sub-group is the most affected by the inequality in LBW. The study used the Erreygers Index to measure the inequality, and then estimated the Recentered Influence Function (RIF-OB) approach to decompose the LBW inequality by areas of residence. It found that inequality in LBW does exist amongst under-five children in Lesotho and it appears to be more focused towards the rural areas. It also found that antenatal care visits and wealth status have been key drivers of LBW inequality in Lesotho. The study concludes by recommending possible remedies to help mitigate the incidence of LBW and its associated consequences.

Keywords: decomposition, inequality, Journal of Economic Literature (JEL) classification codes, Lesotho, low birth weight, socio-economic status,

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Background

Governments around the world are mandated to strive for the provision of good quality health care to encourage good health care outcomes. In particular, the government of Lesotho (GoL) has directed many funds to both primary and secondary levels of health care provision, which saw substantial increases in nominal expenditure of over 100% for district health management teams, laboratories, and pharmaceuticals.

In addition, the government has also partnered with organisations, like Partners in Health (PIH)[1] and Christian Health Association of Lesotho (CHAL), towards improved health care service provision. For instance, the CHAL co-ordinated the management of Lesotho's tertiary hospital (Queen Mamohato Memorial Hospital (QMMH)) by Tšepong's private consortium along with its associated entry-way clinic and three filter clinics (United Nations International Children's Emergency Fund [UNICEF], 2017). Also, up to 86% of total expenditure from the CHAL had been channelled to health care facilities in Maseru, Berea, Leribe and Thaba-Tseka by 2017 (UNICEF, 2017). UNICEF further states that the investment in the health care facilities has since broadened maternal and child health coverage in Lesotho, as well as improving within facility deliveries, antenatal care from skilled personnel, child immunisation and closing the gap in unmet need for family planning commodities.

Lesotho, like most lower-middle income countries, has a user fee policy[2], subsidised health care and average out-of-pocket payments at both its primary and tertiary health care facilities including its tertiary hospital, QMMH, which have made services affordable for all the Basotho. However, underutilisation of healthcare services still looms. As such, there has been several health threatening conditions for which the abovementioned policies were introduced for the majority of the population of Lesotho like that of HIV/AIDS- and tuberculosis-prevalence, together with the most recent pandemic, COVID-19. These have all received attention from the Ministry of Health (MoH) and relevant stakeholders. However, some health issues have attracted relatively lower attention on the national level.

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[1] See the PIH website at https://www.pih.org/country/lesotho to view the country profile.
[2] Such policies have been cited to ease financial barriers, which may hinder people from accessing healthcare services (World Health Organisation [WHO], 2017).

Additionally, proportionate betterments in some health outcomes – LBW, in particular, lag behind these vast enhancements in health financing as reported by UNICEF (2017). As such, some fall-backs tend to arise on the national level. Thus, this study seeks to pay attention here because if not prioritised, LBW may result in dire consequences.

LBW is the public health issue that the entire globe is grappling with. In 2015 alone, some 20.5 million new-borns suffered from LBW world-wide (UNICEF, 2019). LBW has been defined as an infant's weight at birth less than 2500 grams (5.5 pounds) (World Health Organisation [WHO], 2022). In the SSA region, the LBW cases ranged at 13% between 2000 and 2015, but Lesotho's annual prevalence hovered around 15% during the same period (UNICEF & WHO, 2019). This is a slight deviation from the study of (Nwako *et al*., 2020), which reported that the prevalence was much higher at about 25% in 2020.

It has been noted in the literature that most of the contributing factors to the birth weight of a new-born may be grouped into both maternal and socio-economic factors. These include the mother's age, body mass index (BMI), nutrition, antenatal care visits, gestational age, employment status, marital status, residence, educational level, economic status, and other behavioural attitudes, like smoking and alcohol intake (Abeywickrama & Anuranga, 2020).

According to the World Health Organisation (WHO), LBW is a significant world-wide public health issue, which is associated with short- and long-term consequences that persist throughout infancy and adulthood (Sathi *et al*., 2022; WHO, 2014). Khan *et al*. (2018) noted that these consequences persist through acute and chronic deficiencies during the upbringing of a child. It is, therefore, indisputable that LBW accounts for up to 30-fold increased risk towards infant mortality as opposed to standard birth weights (Tessema *et al*., 2021). For instance, the infants with LBW were more likely to die (Vilanova *et al*., 2019), have educational disadvantages (Hack *et al*., 2002), have stunted growth (Christian *et al.*, 2013), have inhibited cognitive development like having lower IQ levels (Gu *et al*., 2017; WHO, 2022), and have adult onset-chronic states, such as diabetes and obesity (Jornayvaz *et al.*, 2016).

The WHO postulates that the above-mentioned effects are more common in developing countries (WHO, 2022). That calls for efforts to identify strategies which can mitigate for the incidence of LBW. Once identified, the efforts may be extended further to reach the required average annual reduction rate of three percent necessary to attain the 2012 – 2025 global target of reducing the number of infants born with LBW from the 20.5 million cases down to a significant 14 million cases of infants born with LBW by 2025[3].

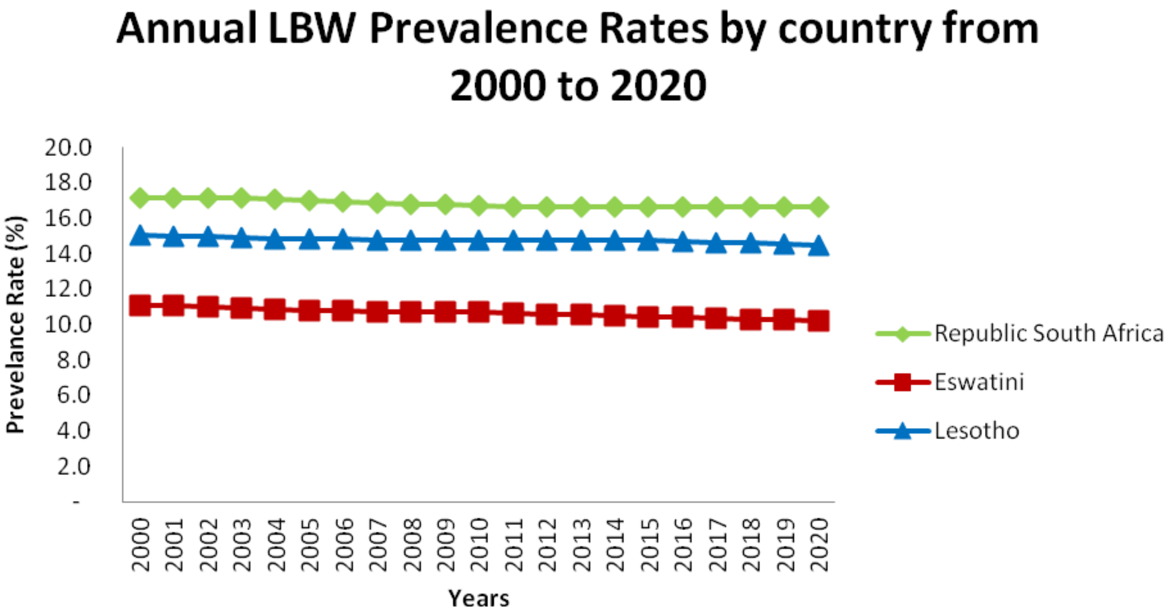
As mentioned, Lesotho is plagued with high levels of inequality in several areas like income, opportunities, and health outcomes. If health is an important input in the development of human capital, it should be that by reducing the gap in LBW inequality and narrowing the gap in the income inequality should also narrow.

In order to achieve this reduction, the existent literature of LBW in Lesotho has exposed the factors that are responsible for driving LBW (Nwako *et al*. 2020). However, what remains unknown is whether there is inequality in the distribution of LBW or not, and what might be explaining this inequality in Lesotho. Since LBW is a serious public health concern around the globe due to its detrimental effects on societies and governments at large, LBW is likely to perpetuate infant mortality, school failure rates and blow-up public health expenditure if it is not dealt with urgently. For this reason, the purpose of this study is not to only comprehend the socio-economic inequalities in LBW for under-five children in Lesotho, but to also find the possible drivers of such inequalities in Lesotho.

It may even be seen that Lesotho fares high on the LBW prevalence cases amongst its two closest neighbouring countries: the Republic of South Africa (RSA) and Eswatini as seen in Figure 1 below, and this is a call for concern. This is a concern because given the size of Lesotho relative to that of RSA, it would have been better for Lesotho to fare much closer to Eswatini.

[3] This pivots directly from the World Health Assembly's (WHA) nutrition target of reducing LBW by 30% between 2012 and 2025.

Figure 1: How Lesotho compares with RSA and Eswatini in Annual LBW Prevalence



Notes: Lesotho might still be faring higher than RSA and Eswatini despite the estimates depicted in Figure 1. This may be due to the possible lack of adjustments for heaping in this UNICEF/WHO LBW estimates (2023 edition) relative to the UNICEF/WHO LBW estimates (2019 edition) depicted in Annex 2. Additionally, the 2023 edition estimates were derived through a standard methodology applied across countries to ensure comparability while the 2019 edition involved household surveys which were adjusted for missing birth weights and heaping using the Blencowe *et al.*, 2019 methodology. Furthermore, the 2019 dataset applied the b-spline and hierarchical regression methodologies.

Source: UNICEF/WHO Low Birth Weight Estimates data (UNICEF & WHO, 2023)

Despite the effects being ambiguous across studies, it has been pointed out that some of the contributing factors to LBW, include, income, mother's income; the number of antenatal visits and the mode of birth, amongst others (Mishra *et al.*, 2021; Sathi *et al.*, 2022). This may, as well, justify the need to separately determine the most pertinent factors for Lesotho based on its different environment without running the risk of misdiagnosing LBW in Lesotho due to non-generalisable results from the previous studies.

The Multiple Indicator Cluster Survey (MICS)/2018 datasets are constructed from carefully selected representative, probabilistic and random samples. Thus, the design of the MICS allows it to be statistically sound, internationally comparable and to be a potent source of data on 33 Sustainable Development Goals indicators. But MICS/2018 does not capture income as a stand-alone. However, it may be proposed that to determine the relationship between most forms of inequalities, income effects may be captured in the wealth index present in the dataset. Thus, to avoid any measurement error, the wealth index has been used to capture these effects to aid inference. Therefore, this may inform a policy on how women in their communities at large may be empowered financially to allow them to curb the prevalence of LBW[4].

1.2 Research Question

To the above regard, this study is interested in investigating the inequalities in low birth weight of under-five children in Lesotho. This is in response to this question: "Do inequalities in low birth weight in Lesotho exist, if so, where?"

1.3 Objectives of the Study

To fill the knowledge gap, this study seeks to answer to the abovementioned research question, and therefore, aims:

1. To measure the socio-economic inequality in LBW of under-five children in Lesotho.
2. To decompose the inequality in LBW by area of residence (locality) using the maternal and social characteristics of women in Lesotho.

1.4 Contribution

This study is anticipated to append the existing body of literature on LBW and its associated inequalities in Lesotho by going beyond the determined factors driving LBW through measuring the inequality in LBW and decomposing that inequality by the mother's locality.

In the previous studies that have been conducted in different countries such as South Asia, Sri-Lanka and India, wealth was found as the relatively consistent contributor to LBW. In additional to wealth, the antenatal care (ANC) visits and maternal BMI are the main drivers of LBW (Mishra *et al*., 2021; Sathi, et al., 2022) while Abeywickrama (2020) and Ngo *et al*. (2022) add the area of residence to the lot. However, the literature remains divided on the additional contributors to LBW in different countries due the contextual nature of the results of each study. For instance, maternal education has been found to determine LBW in South Asia (Sathi *et al*., 2022) for both lower- and middle-income countries of South Asia (Ngo *et al*., 2022).

[4] The relative inference to income is crucial because most of the Health Inequality literature seems to be adopted from the income inequality literature (Heckley *et al*., 2016) as a better standard of life is linked to income.

In contrast, Abeywickrama (2020) has found that maternal height, gestational age, sex of child, ethnicity and province were significant determinants while maternal education played no role in influencing LBW. As for Mishra *et al*. (2021), maternal education jointly influenced LBW in India, together with maternal BMI, ANC visits and residence. Nevertheless, amid all these discrepancies, rural residents were more likely to bear children with LBW (Abeywickrama & Anuranga, 2020; Ngo *et al*., 2022; Sathi *et al*., 2022). Thus, what remains worth determining is the inequality in LBW and the drivers of this inequality in LBW, and to what degree these very factors influence this inequality in Lesotho.

Although there is a minimal literature in Lesotho, it is to this regard that I have singled out Nwako *et al*.'s (2020) study. Nwako *et al*. conducted a study to determine the prevalence of LBW and the influencing factors associated with LBW using a tertiary hospital - QMMH, in Maseru. Nwako *et al*. (2020) have noted that their study used a sample of 412 new-borns born to 402 mothers who resided in Maseru and were delivered at QMMH. In their research, data were collected using questionnaire as a research instrument. This study has found that the prevalence of LBW stood at an alarming 24.75%. According to Nwako *et al*. (2020), the logistic regression analysis results revealed that maternal height and education, energy source, residential area, ANC visits and gestational age have been found to be the significant determinants of LBW in Lesotho. However, other maternal characteristics have also been found to be insignificant. These included the maternal BMI, weight, age and income, and marital- and employment statuses, along with the new-born's gender and the mother's working hours. Additionally, the gestational age less than 37 weeks and HIV status were strongly associated with LBW in Lesotho. Nwako *et al*. further acknowledges the differences in LBW and the prevalence of LBW in Maseru. However, their study does not measure the possible inequalities in the distribution of LBW in Lesotho, nor go as far as informing as to how far they extend. Moreover, the sample using purely residents of Maseru raises a dispute over the external validity of the results therein. For instance, the LBW prevalence estimate of the study (24.75%) is 10 percentage points higher than that of a more reliable data body, the WHO, of 15%.

Moreover, Nwako *et al*. (2020) attested that LBW exists and is prevalent. Nonetheless, they did not go as far as to assess if inequalities exist, and if they exist, they did not state area where those inequalities are most pronounced. It may be put forth that a further analysis is vital to investigate the extent to which inequalities lay and possibly to reveal, which sub-groups are most affected to provide knowledge about where the most intervention should be focused without negligence of ethical issues. This study is of paramount significance as LBW has been cited as a serious public health concern around the globe as seen in the empirics and in the earlier mentioned consequences, which have detrimental effects on families, societies[5] and governments at large.

Many studies, which have been conducted in their respective countries, have shown that if not dealt with, LBW will perpetuate infant mortality, school failure rates and blow-up public health expenditure, as well as educational expenditure due to the close relationship shared by education and health. In this regard, Lesotho is not an exception from suffering these catastrophic issues due to the relatively high prevalence that it experiences as depicted in Figure 1 above. In particular, the overblown public health expenditure may not only result in other vital aspects of the economy suffering under-investment, but also in state resources being focused in the least required groups of the society. For this reason, most of those that are in dire conditions are not even getting the relevant assistance needed. Thus, it may be presented that it would be better if for different sub-groups, subsides would be targeted to the most significant areas for that specific group, instead of the widespread subsidies for the least demanding aspects due to obsolescence.

Therefore, this study seeks to significantly add to the body of knowledge through the assessment of the inequalities, and where they are located as Lesotho has not experienced an extensive investigation to this regard. Additionally, this study will contribute by its method of analysis as it will consider more potent, MICS/2018, Round 6 dataset, which is much broader in terms of its larger size, more reliable information gathered from over 200 variables on socio-economic, demographic, household, and parental characteristics. This is likely to consider more child delivery healthcare facilities from multiple districts of Lesotho, thus ensuring externally valid results as opposed to the data Nwako *et al*. (2020) used. Lastly, policy modification and/or targeted intervention will be informed for enhanced effectiveness and efficiency of the public health sector of Lesotho.

Having been able to achieve the objectives, the findings of this study have also identified the socio-economic factors, which exacerbate LBW on a national level. Specifically, this study finds that inequality in the distribution of LBW between the rural and urban areas of Lesotho does exist amongst under-five children in Lesotho. Also, from the results, this inequality in LBW appears more focused towards the rural areas of Lesotho. It also found that wealth

[5] It has been noted that LBW is one of the essential indicators of measuring a society's socio-economic development (Mishra *et al*., 2021).

status and antenatal care visits are core factors influencing the inequality in LBW for under-five children in Lesotho.

Thus, this study has extended the literature by going beyond the findings from a logit regression due to the binary nature of the dependent variable by measuring the inequalities in the distribution of LBW and by employing decomposition techniques Thus, this will help relevant authorities by aiding policy direction and policy intervention in multiple areas, like the achievement of the SDG goals and Lesotho health sector goals. The goals include the Sustainable Development Goals (SDGs) numbers 2 and 3, which are of Zero Hunger, and Good Health and Well-being, respectively (United Nations, 2022). It has predominantly revealed the areas to focus public health interventions in Lesotho to curb the high incidence of LBW as seen in Figure 1, especially because the data in Figure 1 above is suggestive that Lesotho needs rigorous efforts to achieve reduced LBW cases.

1.5 Organisation of the Study

To achieve the set objectives, this study is structured as follows: chapter 2 explores the various views from the previous studies on LBW in other nations. Essentially, this chapter unveils what is known about LBW and the existent inequalities thereof. Chapter 3 presents the methods of analysis. It will cite the data to be used and the sources of data from which they stem. Additionally, it further exposes the estimation models to measure the inequalities in LBW, well as the decomposition used to achieve the embedded objectives. Chapter 4 reports the key findings as well as the supporting findings while chapter 5 concludes by giving a summary of all the findings in relation to the research question, and then gives some recommendations.

CHAPTER 2

LITERATURE REVIEW

This section explores the literature on LBW in various settings by considering both the theoretical and empirical aspects.

2.1 Theoretical Literature

Several studies have documented LBW and its behaviour in numerous settings. To single out a few, Sathi *et al*. (2022) studied LBW in South Asia. Sathi and colleagues discovered that most research unveiled that maternal-infant behaviours and lifestyle-related indicators were substantial in affecting the rate of children affected by LBW. However, at the time of their study, no study had investigated the socio-economic status (SES) inequalities in LBW in South Asia as lump amidst present disparities on the continent. Abeywickrama *et al*. (2020) and Mishra *et al*. (2021) had only provided a summative outlook of SES for the whole of South Asia using their separate studies on India and Sri Lanka, respectively. This prompted Sathi *et al*. (2022) to measure SES inequalities and to determine the prevalence and factors influencing LBW amongst under-five children in South Asia. This was done in the face of these inconsistencies in the findings from other South Asian regions to append the literature with a comprehensive estimation over the South Asian setting. Specifically, Sathi *et al*. (2022) discovered that most LBW cases were concentrated and more extensive amongst the children from low-income households and mothers with minimal education. They also revealed that wealth-related inequalities in LBW were higher than those related to education. In essence, maternal age and education, wealth status, sex of child, birth status, ANC visits, iron supplement intake, mode of birth and residential status were significant indicators of LBW in South Asia; and children from India had the greatest SES inequalities followed by Nepal, Bangladesh, Afghanistan, and Pakistan.

Before Sathi *et al*. (2022)'s study, Mishra *et al*. (2021) had conducted a study to understand the socio-economic status-related inequality for LBW amongst children in India. They argued that that the SES had no affiliation with a newborn's LBW in India. According to Mishra *et al*., this study was in response to the then dearth literature on comprehending the various determinants LBW, which are insidious to India. Their study concurred that LBW was concentrated amongst Indian children from lower SES, and wealth quintile was exacerbated much of the inequality. Additionally, Mishra *et al*. reported that, of the included factors, maternal education, and body mass index (BMI), ANC and residential status were the significant drivers of LBW in India whilst the birth order and interval, tribe and religion, amongst others, had no part in determining LBW.

Prior to Mishra *et al*. (2021), Abeywickrama and Anuranga (2020) had focused in Sri Lanka. They highlighted that LBW is the indication of inequalities in specific population sub-groups. Studies prior to this one thusly focused on either the rural or hospital-based settings in Sri Lanka using small and homogeneous samples. As such, the national level determinants of LBW could not be teased out. Hence, in an effort to widen the understudied socio-economic inequality determinants and the subsequent decomposition of such inequalities, Abeywickrama and Anuranga (2021) sought to identify the socio-economic determinants, and to decompose those determinants to find out their contribution to such inequalities in LBW. Following the relevant estimation procedures, Abeywickrama and Anuranga (2021) disclosed that the socio-economic inequality of LBW was doubled in the rural sector relative to estate areas. Moreover, maternal height and BMI, gestational age, birth interval, ANC visits, sex of child, wealth, ethnicity and the province were all statistically significant drivers, but maternal education was statistically insignificant in Sri Lanka.

Several other studies have been conducted in the context of Africa. Oladeinde *et al*. (2015) noted that the key to birth/child delivery was carried out at a traditional birth home (TBH) by a traditional birth attendant in Benin City, Nigeria. This then prompted Oladeinde *et al*. (2015) to conduct a study to determine the prevalence and related risk factors for the delivery of LBW neonates in a TBH in Benin City. They found that the following significantly led to LBW neonates being born in this City: maternal age, height, anaemia, gestational age, marital status, time of registration (into the TBH) and being in a polygamous union.

Finally, following the vast literature on estimating the prevalence of LBW in Ethiopia, Alemu and Aynalem (2022) sought to contribute to scanty literature on nation-wide studies in which different geographical areas were not considered. As such, Alemu and Aynalem aimed to estimate the mean prevalence of LBW and its associated contributors in Ethiopia using full and comprehensive data. Multiple pregnancies, maternal higher and primary education, residence in Afar and Amhara were found to be influencing LBW in Ethiopia.

It is worth remarking that this literature, including that of Nwako (2020), jointly concurs that LBW inequalities are more marked in poorer households both in low- and middle-income countries, and Lesotho forms part of them. Even though these studies followed somewhat similar approaches, there is some non-linearity in the results; as such, it may not be a surprise to find the contrasting results in the case of Lesotho. Furthermore, it is evident that most of this inequality in LBW is made apparent by the wealth that a household is endowed with. As a result, wealth quintile has been involved in the analysis, including the blend of covariates, as this literature dictates.

2.2 Review of Related Empirical Literature

In determining the socio-economic inequalities in South Asia, Sathi *et al*. (2022) considered a merged nationally representative dataset on mothers and children's health indicators composed of demographic health surveys from Afghanistan, Bangladesh, India, Maldives, Pakistan, and Nepal. This merger produced a 170,547 sample of under-five children from these countries. These authors used a mixed effect logistic regression, Wagstaff- and Erreygers Concentration Indices and Concentration Curves (CC) to assess socio-economic based on wealth and education levels. According to Sathi *et al*., 17% of the children had LBW in South Asia, most of which were from Pakistan because they postulated that Pakistan had ranked the highest on the LBW prevalence scale at 19.18% while India, Afghanistan, Bangladesh, Maldives, and Nepal stood at 16.84%, 15.13%, 14.93%, 13.12% and 11.73% respectively. Sathi *et al*. (2022) found that greater than four ANC visits reduced the odds of having babies with LBW significantly by 0.83 folds. Moreover, women from the poorest wealth quintile were 1.53 times more likely to deliver LBW babies than those from the wealthier quintile, and uneducated women has a 39% likelihood of having babies with LBW than their counterparts.

In Mishra *et al*.'s (2021) paper, it was also argued that regional variations in LBW are often found uneven. As such, they used 2015/16 National Family Health Survey data for their analysis, which came to a sample of 127,141. Like Sathi *et al*. (2022), Mishra *et al*. (2021) estimated logistic regressions to determine the significant factors of LBW in India, followed by estimating the standard concentration index (CI) by wealth scores and further decomposing the results using the Wagstaff decomposition methodology. Of these, they found that the LBW was more prevalent in women aged 19 years and below. About 18.2% of Indian children had LBW, and a CI value of -0.05 revealed that LBW was concentrated amongst the children from lower SES (Mishra *et al*., 2021). Moreover, Mishra *et al*. noted that about 73.6% of the socio-economic status (SES) inequality was explained by wealth quintile. Educational status explained SES related inequality in these Indian children, therefore, was about 43.4% for LBW while maternal BMI, ANC and residential status defined 28.4%, 20.8% and -15.7% respectively.

In 2020, Abeywickrama and Anuranga conducted their study using 2016/17 Sri Lankan Demographic and Health Survey gathered from 27,210 households from all of the 25 districts of Sri Lanka. For their analysis, Abeywickrama and Anuranga (2020) used a stepwise multivariate linear regression to determine the effect of each factor on birth weight, and CI and CC to estimate the extent of wealth-related inequality in LBW, followed by the decomposition of the CI using the O'Donnell *et al*. (2006) methodology. According to Abeywickrama and Anuranga (2020), male children were about 68 grams lighter than females. The children from higher wealth quintiles were 113 heavier than their counterparts while the children born from the Indian Tamil ethnicity were about 147 grams lighter than those from other ethnicities. The CI of -0.13 revealed that LBW was concentrated amongst the poorest households. Last of all, decomposition results reported that maternal BMI, ethnicity, and maternal education explained 23.8%, 12% and 27.3% of the inequality in LBW in Sri Lanka. However, it became evident that gestational age, birth interval, sex of child and provinces had little to no contribution at all to the inequality in LBW in Sri Lanka.

Now closer to home, in Nigeria and Ethiopia, Alemu and Aynalem (2022) recently estimated a multilevel logistic regression using the Ethiopian Demographic and Health Survey data of 1,259 women to identify those factors leading to LBW in their earlier noted study. It was reported that the women with secondary/higher educational attainment were about 44% less probable to experience LBW births in Nigeria. Also, the women with multiple births were 5 times more likely to get LBW new-borns while the women from Afar and Amhara regions were 3 times more likely to bear children with LBW compared to the Tigray region. Moreover, here in Africa, the prevalence of LBW is 6.3% in Nigeria; in Lesotho, it is about 25% while in Ethiopia, it is 12.3% as discovered by Alemu and Aynalem (2022), Nwako *et al*. (2020) and Oladeinde *et al*. (2015) respectively. They cement firmly that LBW is indeed prevalent in developing countries.

In conclusion, it is quite lucid that there are contrasting magnitudes, and that the results differ by region. That is, where some covariates are significant, others may not be and vice versa. As suggested by these aforementioned empirics, the present studies have also estimated the logistic regression just to expose the determinants of LBW in Lesotho, concentration index and concentration curves to explore the degree of inequality in Lesotho. Nevertheless, when it comes to the decomposition approach, it has differed from the above mentioned by using the Heckley *et al*.'s (2016) adaptation of the Oaxaca-Blinder decomposition. It is to this regard that this study rather unfolds in a clearer manner focusing on Lesotho.

CHAPTER 3

METHODOLOGY

This section describes the data used for this study. Thereafter, it considers the estimation strategies used to attend to each of the objectives of this study in order to respond to the question of this study.

3.1 Data and Description of Variables

Subsections 3.1.1 and 3.1.2 outline the sources of the data used in this study and the description of the variables utilised in this study, respectively.

3.1.1 Sources of Data

This study used secondary microeconomic data contained in the 2018 Multiple Indicator Cluster Survey (MICS), round 6 dataset. These are reliable data collected meticulously and are nationally representative as they cover a wide range of indicators, demographic, household, gender specific and socio-economic. The dataset was compiled by the Bureau of Statistics (BoS) under the Ministry of Development Planning. It was supported mainly by the United Nations (through UNICEF, United Nations Development Programme [UNDP] & the World Food Programme [WFP]), the Global Alliance for Vaccines and Immunisation (GAVI) and the World Bank in partnership with the MoH.

This potent dataset boasts, amongst others, 10,413 households, 6,453 interviewed eligible women aged between 15 and 49; 3,569 eligible children aged 0 – 5 years, hailing from both the rural (42.7%) and urban (57.3 percent) areas of the Mountain Kingdom of Lesotho. From these aggregate samples of women and households, only about 30.34% (1,083) of the children born to these mothers were weighed at birth, and their weights were recalled from their clinical cards or memory for recording. However, the sample of 717 women was eligible in the MICS6/2018 dataset for analysis as they had all the relevant information for this study. Despite the possible concerns over the characteristics of the sample, it was found that this sample of 717 possesses all the characteristics of the nationally representative sample of 6,453 women. As such, the sample guarantees compelling inferences due to its external validity.

3.1.2 Outcome and Explanatory Variables

In Table 1 below, the variables, which are considered for this study, are listed along with their respective descriptions.

Table 1: Variables and their descriptions

Variables	**Description**
Outcome Variable:	
• Child's Birth Weight	Child's birth weight is used to define LBW by WHO standards, such that Y=1 if the birth weight is < 2,500g, and Y=0 is >/= 2,500g. This was modelled using the continuous weight of the child measured at birth.
Explanatory Variables:	
(A) Maternal Characteristics	
• Maternal Functional Disability	These maternal characteristics include mother's mobility functions, auditory and perceptive functions. It was my belief that if a woman has some difficulty here there, may be some negative effects, such as breathing, could inhibit adequate oxygen from reaching the unborn child.
• Wealth index	This is the wealth index quintile; a respondent was classified based on their economic status: poorest, poorer, middle, rich and/or richest.
• Locality	Locality is the type of settlement of the respondent: rural or urban.
• Gender of the child	This was historically done considering the gender of the child at their birth. A confirmation question had asked whether the child at hand a boy (male) or a girl (female) was.
• Antenatal Care (ANC) visits	This is the number of times a mother visited a healthcare facility for antenatal care during the period of her pregnancy. For estimates, the

	lower bound of the interval was taken[6].
• Maternal Age	Maternal age is the woman's age in full years a woman has by the time of birth of the child. Accuracy was insured by the preceding questions in the questionnaire. For instance, the date of birth (month and day) was used to validate the years that a person had completed at the time of the interview.
• Maternal Educational level	Maternal educational level is the highest level, grade, form or year of school that the woman attended school: it was either primary/none, secondary, higher level.
• Maternal Marital Status	This is the woman's current marital status at the time of the interview. It was categorised into five levels ranging from married to never married
• Tetanus Toxoid Injection Doses	This is the number of times that the pregnant mother had received tetanus toxoid injection doses per child.
(B) Household Characteristics	
• Household Size	This is the number of people living with the mother during pregnancy and/or at the time of the interview
• Access to Internet	This was taken to make inferences about the availability of information or access to information.
• Type of Toilet Facility	This gives the type of toilet facility at the woman's place of residence. Given its nature, the issues of hygiene may step in. It has three levels: flush, pit and none/bush/field.
• Type of Water Source	This is the main source of water used by the

[6] This was in an effort to avoid over estimation. That is, if a mother responded that they had been to the health care facility about four to six times, 'four (4)' was assumed to be the number of times that she had antenatal care visits.

	household. It may, as well affect the woman's health as clean water is preferable for a healthy woman. It is divided into 5 levels: piped, spring, well, tanked and surface.
• Type of Energy Source	This is the main mode of energy. Some effects like that of paraffin with its fumes may be harmful to the pregnant mother if inhaled over the long periods of time. It is classified as paraffin, electricity and other (such as Biomass).

3.2 Theoretical Framework

This study pivoted on the utility maximisation microeconomic theory. Specifically, the theory is outlined by Michael Grossman in 1972. According to Laporte (2020), the Grossman model is apt for explaining the linkage between health-related decisions, health outcomes and aging at both the individual and aggregate levels. This further provides the guidance about the most probable implications of such decisions at the level of health systems and overall healthcare expenditure over time. Holistically, an individual's health behaves rather dynamically because it may suffer the effects of unpredictable shocks, individual decisions and more importantly, an individual's context. Some of these effects may be cumulative through an individual's lifetime as extensively introduced earlier in this study. In Grossman's pure consumption model, health was not an inferior commodity; an increase in complete real wealth would increase demand for healthcare (Grossman, 1972).

The Grossman model admits that individuals often maximise their lifetime utility subject to the constraints that they face (Laporte, 2020; Wagstaff, 1986). More vividly, health can be viewed as a durable stock that produces healthy occasions. Specifically, it could be inferred that through this investment, mothers could blend work and leisure, such that they enjoy healthy life outcomes, which may then extend to the developing child during pregnancy. Additionally, this inference may be extended by assuming that women maximise their unborn child's health outcome, birth weight, a subject to the constraints that they face. However, once optimised, the child will consume healthier states of life from birth onwards, thus taking advantage of both the investment and consumption motives (Grossman, 1972).

3.3 Measurement of Inequality

To meet the first objective of this study, the inequalities in LBW was measured using the standard concentration index (CI), together with the Erreygers Index (EI) as the main index and the Wagstaff Index (WI).

Lesotho is one of the most unequal societies in the SSA with the GINI coefficient of 44.9% in 2017 (World Bank, 2022), with the women as the most affected, particularly in areas of income and opportunities. As such, it may not be a far reach to assess those inequalities in health outcomes to attract immediate attention to reduce them. This will also spill over into reducing gaps in other unequal areas. This further poses this question: To what extent do these inequalities exist? It may be argued that these creep into public health issues, like the low birth weight. As suggested, income tends to be the propellant of the great deal of issues due to its ability to afford even the basic necessities. If income is inequitably distributed, how then is low birth weight distributed along with it?

This study used a similar approach to that one used by Cai *et al*. (2017) henceforth. Nonetheless, unlike their focus in health score inequalities between the rural and urban residents of China, this study has focused on the context of Lesotho. Additionally, this study used the Recentred Influence Function Oaxaca-Blinder (RIF-OB) type of the RIF methodology whose foundation was proposed by *Firpo et al*., 2009. Thus, to respond to this question of the purported inequalities, they need to first be measured to confirm their existence and to discern where they are focused.

In this regard, the standard concentration index (CI) and the concentration curves (CC) are utilised to meticulously address the first objective at hand. The former is a relative measure of inequality that describes how concentrated LBW is on the distribution of the wealth index (ranking variable). This is due to the nature of the CI to lean predominantly on the relationship between the health variable and the individual's rank in the living standards variable, but not in the variation of the living standards itself (O'Donnell *et al*, 2008). The latter (CCs) visually depicted the extent of wealth-related inequalities in the distribution of LBW.

Thus, the standard concentration index (CI) was estimated as follows:

$$CI = \frac{2}{n^2 \mu_h} \sum_{i=1}^{n} h_i R_i \qquad (1)$$

while the Wagstaff Index is:

$$WI = \frac{\frac{2}{n^2\mu_h}\sum_{i=1}^{n} h_i R_i}{1-\mu_h} \qquad (2)$$

and

$$EI = 4\mu_h \left(\frac{2}{n^2\mu}\sum_{i=1}^{n} h_i R_i\right) \qquad (3)$$

where in all indices h_i is the LBW indicator for infant i. μ is the mean of this health outcome (h) - birth weight. R_i is the corresponding rank of the individual on the wealth distribution (using the wealth index). N is the sample size of eligible units; -1 < (·)I < 1 with the upper-bound (lower-bound) shows that LBW may be pro-rich (pro-poor) health inequality. Additionally, (·)I = 0 means that there is no inequality. The standard CI considers weighting by the average birth weight and considers the covariance between the health outcome and an individual's rank on the income distribution: wealth index in this case.

The EI was used as the main index due to its favourable advantages that it posses over the CI and the WI that was used for robustness checks, which are the transfer, mirror, cardinal invariance[7] and level independence. The latter and key assumption crucial for this study is that of the level of independence, which posits that the proportional increment of health across all units of analysis does not affect the index; thus, this makes the index invariant to scalar addition even when the bounds of the variable are fixed (Erreygers, 2009a; Kjellsson & Gerdtham, 2013).

3.4 Decomposition Method of Analysis

To conclude, if inequalities do exist, a further decomposition of those inequalities in LBW by the socio-economic characteristics of women in Lesotho would be done. As such, this decomposition of the estimates of the socio-economic determinants to the overall inequality was done to bring out the elasticity of birth weight to comprehend the extent of the inequality in each variable. According to Cai *et al*. (2017), decomposing socio-economic health inequalities unveil specific factors that may be potentially altered by policy decision makers

[7] See Kjellsson and Gerdtham (2013) for a detailed discussion of these first three properties of these indices. The standard CI assumes the only transfer property while the WI builds on the CI by adding the mirror and cardinal invariance properties.

because health inequalities are not only unfair, but may also be avoided (Marmot, 2007). As this aligns with the desired contributions of this study, similar to Cai *et al*. (2017), I have distinctively used the most recent Heckley et *al.*'s (2016) methodology, the Recentered Influence Function (RIF), which is known to decompose the potential inequalities by health-related factors and has proven efficient due to its favourable attributes (Cai *et al*., 2017).

The RIF regression decomposition approach is said to better explain the causes of socio-economic-related health inequalities by directly decomposing the weighted variance of health and socio-economic rank. It can decompose all forms of inequality measures like the Erreygers, Wagstaff and, of interest, the standard Concentration Indices. Furthermore, the RIF has less restrictive assumptions, including, the rank and weighting function ignorability assumptions. Therefore, its simplicity in estimation and the ease of interpreting the results makes more favourable over the commonly used, Wagstaff Index. This makes this approach much more robust in estimation. It has a broader coverage of the independent variables on the distribution of the dependent variable (LBW). With improved accuracy, this then allows us to position the observational point on the distribution of LBW having controlled for its rank on the income distribution. Thus, the effect is more targeted, hence permitting policy intervention to be focused in the right and specific place. The practical implementation of the RIF Concentration Index regression decomposition is clear-cut, and it is embedded in STATA. It follows a mathematical process as developed by Heckley et *al.* (2017), which is be available in Annex .

3.5 Limitations of the Study

Although this study attempts to study the inequalities in health outcome and birth weight, it is worth acknowledging that hereditary influences may be of delimitation. Other significant factors, like mother's nutritional status during pregnancy and the intake of nutritional supplements (for example, iron, calcium, vitamins, and minerals), have been excluded based on the absence of such data and the absence of relevant proxies that includes the mother's body mass index. As for habitual characteristics, such as smoking and taking alcohol, I did not identify the variation to be specifically connected to the mother during her pregnancy. As such, these have been left out. For instance, the data available for the abovementioned habitual characteristics did not specifically map to the pregnancy interval, so it could be that the mother only started smoking and/or drinking post her pregnancy. Another issue to consider is that, given that from most of the development of the child during pregnancy, it would rather be a cumbersome task to carefully identify the paternal factors influencing the birth weight of the child in question. This may be embedded in the culture of men in Lesotho to be absent during this gestational period even to the extremes that connecting a father to a child may be a tedious process where even a birth certificate may prove futile.

Therefore, to avoid biases, like the selection bias, it is worth leaving aside until such data surfaces. The study does not also track the changes in these determinants with time to understand the longevity with which the consequences of LBW may endure. Further research may be conducted to assess how long the consequences brought by these determinants may last using a cohort with LBW through time. In the face of the relatively small sample for this analysis, the results need not be discarded nor considered irrelevant, because despite being small, it surpasses the benchmark for the sample to bear efficient estimates. As a result, due to its randomness and being nationally representative, the external validity suffices.

CHAPTER 4

FINDINGS AND DISCUSSIONS

This section summarises and describes the data used for this study before estimating the specified empirical models cited in chapter 3. Subsection 4.3 reports the results which were obtained to respond to the objectives of this study.

4.1 Summary Statistics

Below is a table of the summarised statistics of all the variables of interest computed using the MICS6/2018 dataset. Several observations have been made from these recorded figures in Table 2. For instance, the sampled children weighed from 600 grams and 5.6 kilograms (kg) at birth. The 600 grams children could have been born prematurely, and this is significantly below the average weight of 3.02 kg in the sample at hand.

The transformed weight of these children at birth showed that about 21% of the children in Lesotho were diagnosed with LBW at the period of the data collection. Again, most women were found to be 26 years old on average, and the majority of these women had visited a healthcare facility for antenatal care during pregnancy about five times. It could be inferred that these women were in the prime of their childbearing age and fertility and were more likely to be at their healthiest livelihoods. Additionally, about six percent of mothers in Lesotho had no functional disabilities; meaning that most women experienced some form of challenges in areas like sight, hearing, and mobility. This may result in a woman not having access to essential tools that include information and properly prepared meals, thus threatening the mother's health, and later, the weight of the child at birth.

The residential dynamics could suggest from the average household size of five people that overcrowding could challenge the health of a pregnant mother if the house is a two-roomed house or less. This could be common in the rural poor areas of Lesotho.

Moreover, about 48% of the children in Lesotho were females who were born to approximately 69% of women hailing from the rural areas of Lesotho. About 37% of these women were likely exposed to a broader spectrum of informational power afforded by internet access while the remainder, 63%, could have relied on more traditional forms of information, such as newspaper and/or radio, which might have been less helpful concerning antenatal information. Finally, the characteristics of households revealed that about 29%, 76% and 62% of sampled households were in the poorest wealth quintile, relied on piped water as a primary source of water, used a pit toilet and used paraffin as the main source of energy respectively. This dominant source of energy is relatively common in the rural areas of Lesotho due to the less popular and expensive alternative that is electricity. However, the smoke from these paraffin stoves/lamps could restrict adequate oxygen intake if inhaled over longer time frames, thus inhibiting sufficient oxygen from reaching the child's brain for the maximised development of the child during the mother's gestational period.

Table 2: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Outcome Variable (s):					
Child's Birth Weight	717	3.023	0.590	0.600	5.600
LBW (=1 if Child's Birth Weight ≤ 2.5 kg, 0 Otherwise)	717	0.213	0.410	0	1
Explanatory Variables by category:					
(A) Maternal Characteristics					
Maternal Age	717	26.156	6.249	16	46
Antenatal Care Visits	717	5.219	2.205	1	20
Tetanus Toxoid Injection Doses	717	2.188	1.047	1	6
Maternal Functional Disabilities (1=None, 0=Present)	717	0.063	0.243	0	1
Locality (1=Rural, 0=Urban)	717	0.693	0.462	0	1
Child gender (1=Female, 0=Male)	717	0.484	0.500	0	1
Maternal Education Level:					
• 1=Primary/None	717	0.357	0.479	0	1
• 2=Secondary	717	0.555	0.497	0	1
• 3=Tertiary	717	0.088	0.283	0	1
Maternal Marital Status:					
• 1=Married	717	0.798	0.402	0	1
• 2=Widowed	717	0.028	0.165	0	1
• 3=Divorced	717	0.011	0.105	0	1
• 4=Separated	717	0.021	0.143	0	1
• 5=Never Married	717	0.142	0.350	0	1
(B) Household Characteristics					
Household Size	717	5.146	2.261	1	14
Internet Access (1=Yes, 0=No)	717	0.374	0.484	0	1
Wealth Index:					
• 1=Poorest	717	0.287	0.453	0	1
• 2=Second (Poor)	717	0.212	0.409	0	1
• 3=Middle	717	0.184	0.388	0	1
• 4=Fourth (Rich)	717	0.194	0.396	0	1
• 5=Richest	717	0.123	0.328	0	1
Type of Water Source:					
• 1=Piped	717	0.756	0.430	0	1
• 2=Well	717	0.071	0.257	0	1
• 3=Spring	717	0.162	0.369	0	1
• 4=Tanked	717	0.003	0.053	0	1
	717	0.008	0.091	0	1

• 5=Surface					
Type of Toilet Facility:					
• 1=Flush	717	0.015	0.123	0	1
• 2=Pit	717	0.715	0.451	0	1
• 3=None/Bush/Field	717	0.269	0.444	0	1
Type of Energy Source:					
• 1=Paraffin	717	0.623	0.485	0	1
• 2=Electricity	717	0.363	0.481	0	1
• 3=Other (for example, Biomass)	717	0.014	0.117	0	1

Notes: The above table displays the variables used, and their respective number of observations (Obs), means, standard deviations (std. dev), minimum values (min) and maximum values (max), respectively. The children's birth weight is in kilograms (kg) in the Household Characteristics sub-section. It is worth noting that the use of Internet Access made inferences on the effect of having access to information that may be available to mothers. It may be disputed, but it carries much relevant analytical power given that due to technological advancement, more people, women alike, spend much more time-consuming information on their hand-held as opposed to the more traditional medium of information like newspapers.

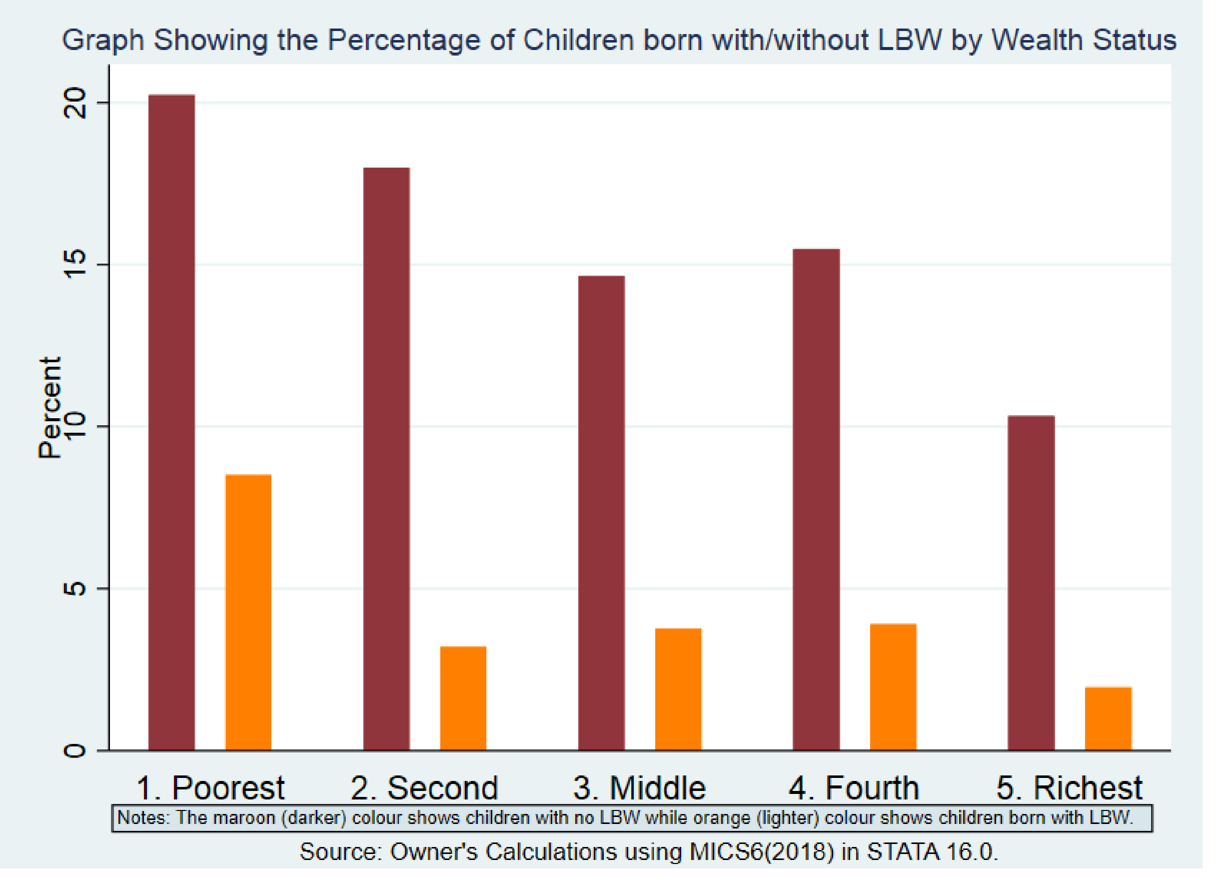
Source: Own Calculations using the MICS6/2018 dataset in STATA 16.0.

4.2 Descriptive Statistics

The descriptive statistics was computed by tabulating the household wealth index, number of ANC visits and maternal education level against the continuous birth weight of the children taken at their birth. It was found that the poorest and richest women had their children weigh significantly differently at an average of 2.9 kg and 3.2 kg, respectively. When it came to the number of ANC visits, it appeared that most women went to the healthcare facility five times, and as a result, their new-borns weighed above 2.5 kg average weight as determined by the WHO. Specifically, these children weighed an average of about 3.1 kg at birth. It was even determined that the children born to the women, who visited a health care facility once, were much lighter than those who were born to the women who visited a health care facility up to 13 times during their pregnancy. That is, the former children weighed an average of about 2.8 kg at birth while the latter weighed about 3.5 kg. What could be seen here is that there was no clear pattern as a mother increases the visitation frequency. For instance, for visitations one to three, the children's weights at birth averaged about 2.8 kg, 2.7 kg and 3.0 kg respectively; whilst for visitations five to eight, the average birth weights were 3.054 kg, 3.049 kg, 2.968 kg and 3.053 kg respectively. This behaviour may as well suggest a non-linear behaviour between birth weight and the frequency of ANC visits.

Furthermore, the data suggested a relatively positive association between the children's birth weight and maternal education level. For instance, the women who had primary education or no education at all had children weighing an average of about 2.9 kg while those with secondary education had their children weigh an average birth weight of 3.045 kg. At the very top end, the women with higher education levels gave birth to new-borns weighing 3.274 kg on average while holding all other factors constant. This shows that the weight of a new-born may be maximised by a woman with higher levels of education. This may then suggest that these women are more exposed to information pertaining to healthier lifestyle patterns, which in turn benefit the child at birth and beyond.

Figure 2: The percentage of under-five children with/without LBW in Lesotho by Wealth Status



In the above graph (in Figure 2), it is evident that the greatest numbers of children born with LBW are in the poorest wealth quintile in Lesotho, followed by those from the fourth (rich), middle, second (poor) and the richest wealth quintiles. The extreme ends appear to be behaving as would be anticipated based on the known literature. That is, the left-most part is higher than the right-most bars. This may be suggestive of the ability of the richest mothers to be afforded the best health care, which translates to better health outcomes later. The empirics indicate that from the poorest to the richest wealth quintile, about 8%, 3.5%, 4.2% and 2.5% respectively, were the proportions of the children with LBW in those wealth status rankings.

In line with the context of this study, it is evident that there are those differing behaviours in birth weight by both household and maternal characteristics. These cement further that there are some lingering inequalities in the distribution of the birth weight of children under five years, and it may not be a misguided claim that these inequalities may exist in the LBW for these children in Lesotho.

In the broader essence prior to the investigation of the inequalities in LBW amongst the children under the age of five, the Kernel density was estimated to depict the distribution of the birth weights of these children under-five years in Lesotho:

Figure 3: Kernel density estimate graph for birth weights of children aged under-five years in Lesotho.

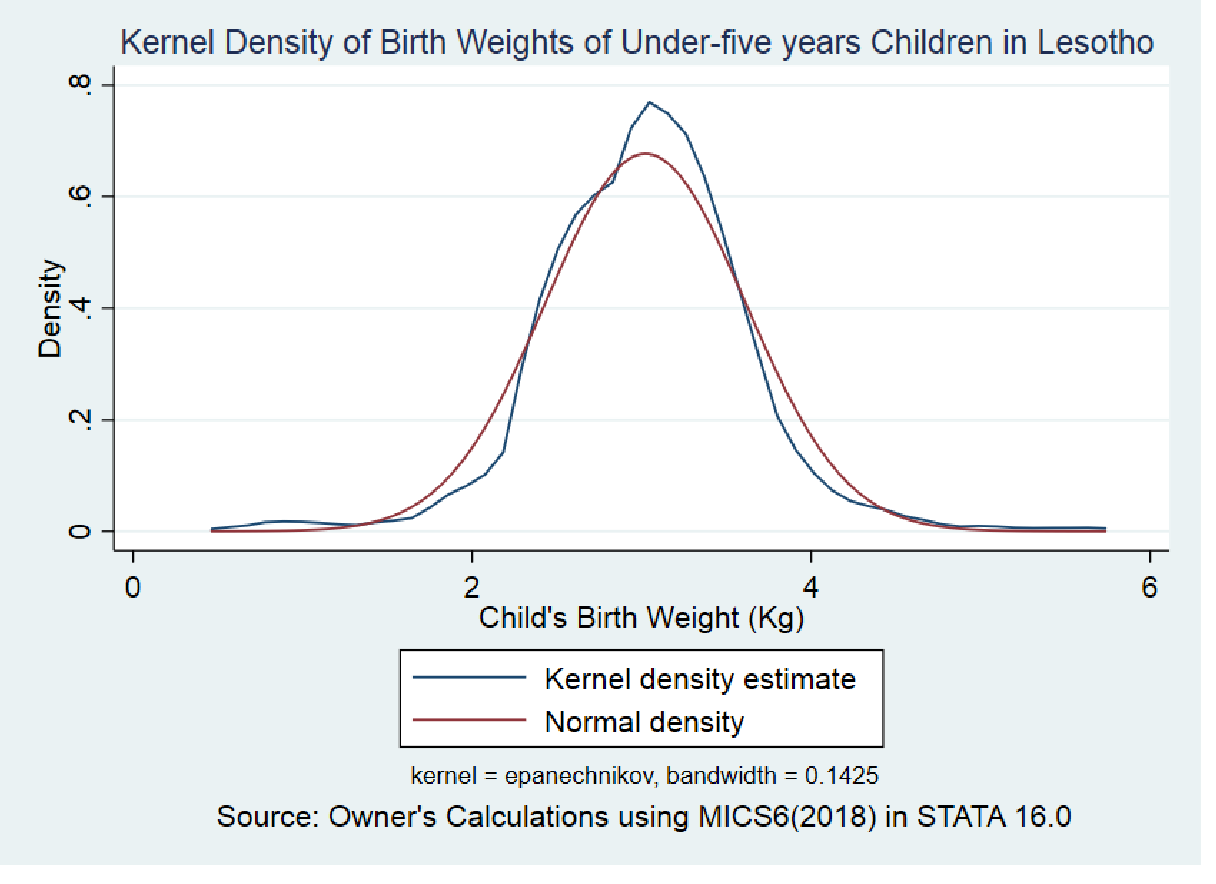


Figure 3 above shows that the birth weight of under-five children is not a clear-cut normal in its distribution, especially in the first half of the bell-shape. It may be interesting to point out that around 78% of the sample of children, whose birth weights were recorded during the interview by MICS6/2018 personnel, has an average birth weight of about 3.2 kg. This means that about 78% of time, a child is likely to be born with an average weight of 3.2 kg. Although this is a good health phenomenon, it may not necessarily be worth leaving unimproved if there is room for such. This may be postulated given that the density shows that there is a possibility of over 40% that a child may be born with a below average weight of 2.5 kg, thus leading them to fall within the LBW sub-group, which is susceptible to the raised potential consequences. The above Kernel estimate suggests a multimodal distribution of the birth weight of children in Lesotho at approximately 2.5 kg, 2.8 kg and 3.2 kg. Each indicates that a child has a chance of being born with a respective weight by about 50%, 62% and 78%. This distribution also cements the overestimated threshold. That is, this study overestimates LBW similar to Abeywickrama's (2020) study by using a threshold of less than or equal to 2.5 kg. This is due to the potentiality of heaping on birth weight data.

Furthermore, there was a 17% chance of a child weighing about 2.3 kg at birth, and there was a 20% probability of a child being born with 3.8 kg birth weight. These were, nonetheless, lower than normal. Alternatively, the 50% probability of a child weighing 2.5 kg was greater than normal. On average, the children appear to weigh between about 600 grams and 5.6 kg in Lesotho. However, the likelihood of children being born with these extreme weights is relatively below one percent, thus making it almost negligible.

4.3 Results

This section presents the results of the respective methodologies, which have been proposed to address the stated objectives herein in chapter 3.

4.3.1 Measuring the Inequality

To respond to the first objective on measuring the inequalities in LBW of under-five children in Lesotho, the researcher estimates three rank-dependent inequality indices: the standard CI, Erreygers Index (Erreygers, 2009a) and the Wagstaff Index (Wagstaff A., 2005). First, the researcher estimates the standard CI from which he was able to produce a respective concentration curve in Figure 4, and therefore, has found the results below:

Table 3: Inequality results for all the rank-dependent indices

	Erreygers Index (Main)	**Wagstaff Index**	**Concentration Index**
Result	-0.086*	-0.129*	-0.102*
Std. Err	(0.034)	(0.051)	(0.042)
F-stat	100.99	100.99	.

N	717	717	717
Comparison by Locality:			
Rural	-0.148***	-0.224***	-0.177***
	[p>|t| = 0.0002]	[p>|t| = 0.0002]	[p>|t| = 0.0002]
Urban	-0.038	-0.055	-0.043
	[p>|t| = 0.5371]	[p>|t| = 0.5371]	[p>|t| = 0.5371]

Notes: The Std. Err, F-stat and N denoted the standard error, the estimated F-distribution statistic and sample size/number of observations used, respectively. The standard errors are reported in parentheses. The significance levels are indicated with *, together with the corresponding significance levels. That is, * p<0.05; ** p<0.01; ***p<0.1. The results above were obtained using STATA command packages: the first two were obtained using CONINDEX while the last was obtained using CIXR as developed by O'Donnell *et al*. (2008) then by O'Donnell *et al*. (2016), respectively. As such, the relevant Concentration Curve (Figure 4) was obtained for the standard CI under its respective command package only.

Source: Owner's Calculations using MICS6/2018 in STATA 16.0.

Table 3 above records that there is the existence of inequality in the distribution of LBW for the children under the age of five years in Lesotho, and the inequality is concentrated in the poorest wealth quintile. This decision was guided by the decision rule that the inequality index (for example, the CI, EI and/or WI), is bound between -1 and 1 (-1 < (·) I < 1), where negative (positive) values indicate that the inequality is pro-poor (pro-rich); and 0 point out that there is no inequality. Specifically, the CI estimate of -0.1025 indicates that the inequality in LBW is more pronounced towards the poorest women living in the rural areas of Lesotho, and this may as well be seen as a national estimate. This can be seen in the table above as it is statistically significant at all levels.

Since the CI supports the Concentration Curve provided below, it has, however, been supported by other health inequality indices being the EI and the WI. These three indices all confirm that there is statistically significant pro-poor LBW inequality in Lesotho. The variations may be explained by the properties that each possesses over the other. For instance, the CI has the transfer assumption, which states that a small transfer from a richer to a poorer individual leads to a pro-poor change in the index and vice versa (Kjellsson & Gerdtham, 2013). Although all these indices assume the transfer property, the WI built on this by adding the mirror and the cardinal invariance properties[8]. These two properties could be the main reasons behind the correction of the underestimated value of the CI. Over and above the WI

[8] According to Kjellsson and Gerdtham (2013), the mirror property assumes that the inequalities in health and ill-health acts as mirror images of each other, and while the cardinal invariance states that any linear transformation of the health variable, LBW in this case, does not change the value of the index significantly.

and the CI, the EI added the level, independence property. This property allows an equal addition of health for all the individuals not to affect the index even amid fixed bounds of the variable (Erreygers, 2009a; Kjellsson & Gerdtham, 2013). This property is pivotal in tightening the behaviour of the index to ensure accurate placement of all the individuals such that, regardless of the setting, all the individuals will remain in the rank to which they belonged before any transformation took effect without overestimation.

On the regional level, Table 3 goes even a step further to reveal that most of this national inequality in LBW is not only pro-poor, but it is also significantly pronounced in the rural areas of Lesotho. This is not surprising for the above observation to be as it is in this country as the majority of the inhabitants are poor and are rural residents because they are usually excluded in most economic activities (World Bank, 2019). For instance, the most remote and/or uneasily accessible rural areas lack healthcare facilities due to their associated topology. Despite this common attribute, it has been seen that most rich people have chosen to settle in the remote places due to favourable ventilation, serenity and clean water,[9] and this urban-rural migration could be the reason behind the earlier-stated peculiarity in the Figure 2. Although it is statistically insignificant in the urban areas, LBW inequality is still directed towards those in the poorest wealth quintile in Lesotho. This goes as far as disclosing that LBW is mostly affecting those in the poorest wealth quintiles regardless of their area of residence or locality.

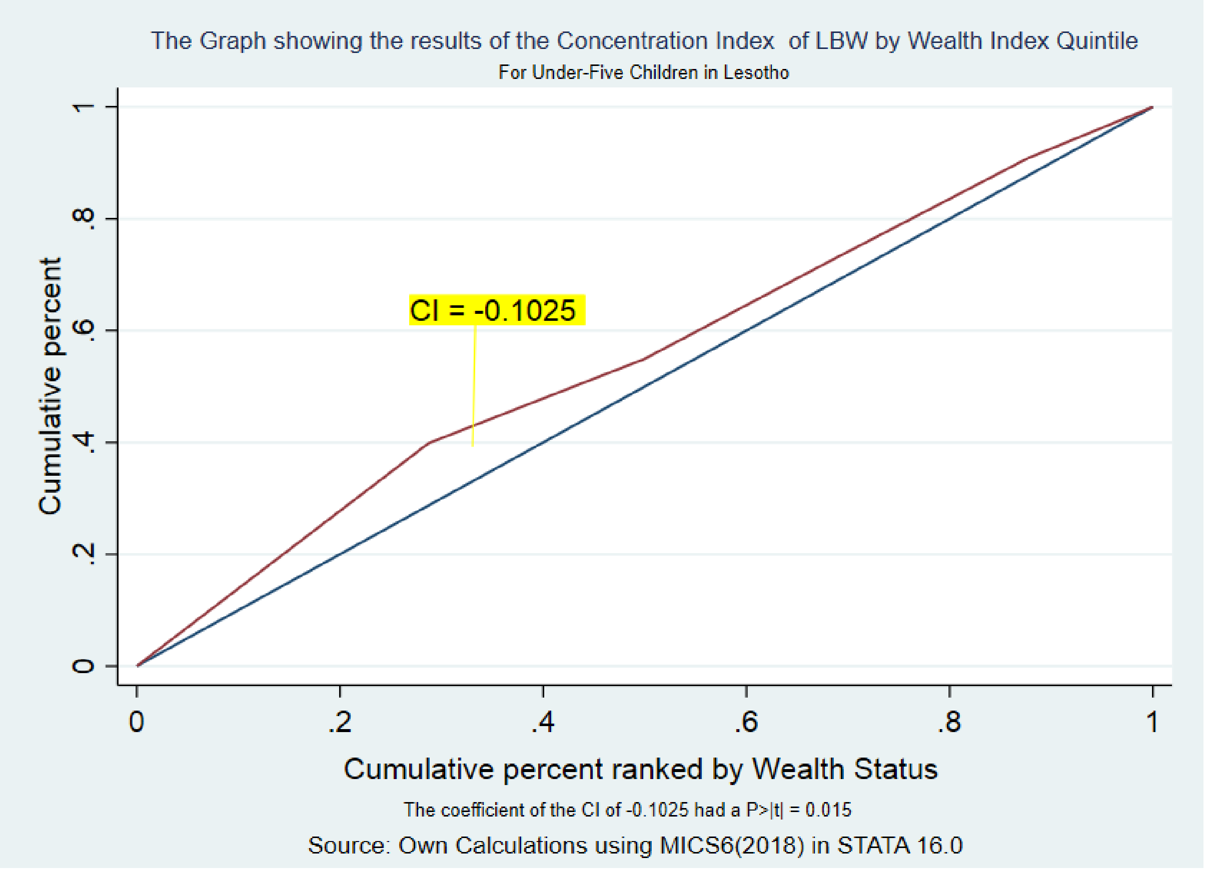
Additionally, the aggregate results obtained still show that LBW is indeed existent amongst the poorest inhabitants of Lesotho across all three inequality indices. Thus, the results are robust. The standard CI, the normalised EI and WI estimate the inequality in the distribution of LBW by wealth index ranking to be commensurate to about 10.25%, 8.6% and 12.9% respectively. All these findings have been found to be statistically significant at both the five and ten percent significance levels.

As such, the researcher can conclude that there is statistical evidence that there is inequality in LBW amongst the children under the age of five in Lesotho. This end is guaranteed by the ability of the CC to identify whether socio-economic inequality exists in any health sector variable like LBW, and whether that inequality is more focused in one point relative to the other or not (O’Donnell *et al*., 2008). Figure 4 below also corroborates these findings as it

[9] See the newspaper article by (Obose, 2010) and the Lesotho Meteorological Services article (Climate of Lesotho, 2017)

conceptually displays the CI[10] using the Concentration Curve (CC). This is because the CI summarises the information from the CC (O'Donnell *et al*., 2008). The CC graphically plots the cumulative percentage of the health outcome, LBW, against the cumulative percentage of the population using a ranking variable (from the poorest to the richest), being the wealth index quintile of the household to which a mother and a new-born belong (World Bank, 2023).

Figure 4 - A Concentration Curve showing the Concentration Index results.



4.3.1.1 Other Findings

A Pearson Chi-Square test of association between the explanatory variables and LBW was conducted to identify variables, which are responsible for the variation in LBW in children under the age of 5 years in Lesotho. The results are summarised in Annex 1. However, the following analysis may be worth discussing.

[10] The CI is defined as double the area between the concentration curve (lighter colour) and the line of equality (the darker 45° line running from the bottom left corner to the right top corner), as depicted in Figure 4.2 (Count Down 2030, 2023).

The Chi-Square test reveals that 20.24% and 37.78% of children with LBW were born to the mothers with functional disabilities and the mothers without functional disabilities, respectively. This means that a statistically significant relationship was found between LBW and maternal functional disabilities at all significance levels. 22.7% of children with LBW was from the urban areas while 20.93% was from the rural areas of Lesotho. However, the chi-square test of 0.1649 was found to be statistically insignificant at all significance levels; thus, there is no association between the area of residence/locality of the mother and LBW.

About 20.24% of the women with functional disabilities had the children born with LBW. Similarly 37.78% of children with LBW were born to the mothers without any form of functional disabilities. About 22.29% and 20.93% of the children with LBW were from the urban and rural areas, respectively. The higher the mother moved on the education ladder, the more the chances of LBW reduced amongst their children. For instance, the women with primary or no education, the women with secondary education and the women with tertiary education had the children with LBW at 27.74%, 19.85% and 4.76%, respectively. This suggests beyond that education can help reduce the incidence of LBW in Lesotho. The women in the poorest wealth quintile had about 29.61% of their children born with LBW. Peculiarly, those from the second (poor) wealth quintile had about 15.13% of the children suffering from LBW while those in the middle wealth index quintile were about 20.45%.

Moreover, about 33.33% of the children born into families, which the women depended on surface water as their main source of water, had LBW. In contrast, about 25.39% and 50% of children with LBW were from homes relying predominantly on no (none/bush/field) toilet facility and other forms of energy sources, respectively. As would be expected, the women with access to information via internet access had only 17.16% of their children born with LBW relative to those without any internet access at 23.83% having LBW. This latter finding may be closely related to that of maternal education, which shows clearly that the internet access educates the women about most issues, including, pregnancy issues at the reach of their fingers. As a result, the more informed a woman is, the more she is likely to lower the LBW amongst the children at birth. It could be that when they perceive anything irregular during pregnancy, these women research about it. This results in them taking much more informed decisions either through seeking some professional help or by self-diagnosing, thus preventing any harm to the child (for instance, LBW).

In conclusion, similar to the earlier study conducted in Lesotho, these chi-square tests show clearly that LBW in this country is significantly linked to the maternal functional disabilities and maternal education (Nwako *et al*., 2020) and wealth index quintile. These have also been found to be statistically significant at all significance levels. Moreover, internet access and ANC visits (Nwako *et al*., 2020) were also found to relate to LBW in Lesotho, and these relationships have been statistically significant at five percent while the type of water facility has been statistically and significantly linked to LBW in Lesotho at 10% significance level. Thus, the tetanus toxoid injections, maternal age, household size, gender of the child (Nwako *et al*., 2020), type energy source, type of toilet facility, maternal marital status and locality had no role in explaining LBW in Lesotho.

4.3.2 Decomposition

To better understand the impact of diverse maternal and household factors on the LBW of under-five children in Lesotho, a decomposition analysis was undertaken. As such, the results in Table 4 were obtained in response to the second objective of decomposing the existing inequality in LBW in Lesotho. Specifically, these results have been found using the Oaxaca-Blinder (OB) adaptation that uses the RIF decomposition approach, which can be referred to as the RIF-OB Decomposition Approach. Unlike the standard RIF regressions, the OB adaptation allows the RIF approach to use linear regressions and their approximations to identify the counterfactual statistic (Rios-Avila, 2019) to provide a broader understanding of the impact of several factors on LBW. It does this by decomposing the differences in mean outcomes between two groups into the influences caused by the group differences in the levels of explanatory variables and the other, which is due to the differential magnitudes of the regression coefficients (Hlavac, 2022).

Due to the ability of RIF decomposition approach to decompose multiple indices as stated earlier, the results below have been obtained from the decomposition of the Erreygers Index as the main index considered in this study. Thus, Table 4 below displays the results of how various factors affect the inequality in LBW due to small changes in the distributional characteristics between the rural and the urban areas of Lesotho by considering both linear and non-linear differences in the joint distributions across those groups (Rios-Avila, 2019).

Table 4 : Results of the RIF-OB decomposition using the Erreygers Index

Overall	Group – Urban	-0.038
		(0.60)
	Group – Rural	-0.148
		(3.63)**
	Difference	0.110
		(1.45)

	Explained	0.024
		(0.35)
	Unexplained	0.085
		(0.88)
Explained	ANC Visits	-0.009
		(0.98)
	Tetanus Toxoid Injection Doses	0.002
		(0.26)
	Maternal Functional Disabilities	-0.002
		(0.27)
	Maternal Marital Status	-0.005
		(0.79)
	Maternal Age	0.005
		(0.52)
	Maternal Education Level	-0.048
		(1.57)
	Child's Gender	-0.002
		(0.56)
	Household Size	-0.009
		(0.37)
	Internet Access	0.024
		(0.88)
	Type of Toilet Facility	-0.003
		(0.07)
	Energy Source	-0.039
		(1.03)
	Main Water Source	0.033
		(1.44)
	Wealth Index Quintile	0.075
		(0.81)
Unexplained	ANC Visits	0.370
		(2.02)*
	Tetanus Toxoid Injection Doses	-0.229
		(1.23)
	Maternal Functional Disabilities	-0.017
		(0.71)
	Maternal Marital Status	-0.056
		(0.57)
	Maternal Age	0.065
		(0.16)
	Maternal Education Level	-0.052
		(0.19)
	Child's Gender	-0.047
		(0.61)
	Household Size	0.099
		(0.55)
	Internet Access	0.003
		(0.04)
	Type of Toilet Facility	-0.378
		(0.70)
	Energy Source	0.485

		(1.76)
	Main Water Source	0.301
		(1.36)
	Wealth Index Quintile	-0.420
		(0.91)
	Constant	-0.038
		(0.04)
N		.

Notes: The results were grouped by the locality/area of residence of the mother. Groups 1 and 2 are the urban and the rural groups, respectively. Standard errors are noted in parentheses while the significance levels are denoted as * $p<0.05$; ** $p<0.01$. The number of observations from the rural (group 2) is 497 while those from the urban are 220. This gives a total of N=717 observations.

Source: Own Calculations using MICS6/2018 in STATA 16.0.

Most importantly, it can be seen from Table 4 that the inequality is pro-poor and is still very much statistically significant in the rural areas of Lesotho. This was at one percent significance level. Also, the overall results illustrated in Table 4 corroborate the Erreygers Index results shown in Table 3. Even though the inequality in LBW has been focused in the rural sub-group, the mean differences in the inequality measures estimated for both groups have not shown any statistical, significant differences to exist between the rural and the urban residents of Lesotho. There is reason to suspect that this be due to some underlying differences balancing each other out as these are average estimates. For instance, it is common practise in Lesotho for wealthy people to resettle in the rural areas to escape all the overcrowding associated with the urban areas. Therefore, migration dynamics may be behind these results.

The RIF-OB decomposition results reveal that at the amassed wealth status, the share of the residential effect (explained) is holistically about 21.8% of the entire differences. This means that only about 21.8% of the residential LBW gap could be explained by differences in observable characteristics between those living in the rural and urban areas of Lesotho. The wealth status, maternal education, type of energy source, main water source and access to information (internet access) are found to be the largest contributors to the residential effect of the LBW gap in Lesotho. Even though the distributional differences in LBW between the rural and urban areas of Lesotho have been statistically insignificant, several economic lessons could be drawn from the findings in Table 4. For example, seeing as maternal educational level reduces inequality in LBW, it may prove more effective if investments made in strengthening the quality of education in the rural areas resemble those in the urban areas – such as better science labs, computer labs, internet access, etc. this further cements the dual importance between health and education.

Additionally, the child's gender, ANC visits, household size, type of toilet facility, type of energy source, mother's functional disabilities, marital status and education reduce the residential LBW gap. Despite any statistical, significant impact, these findings may, however, be explained. The results are consistent with the earlier arguments made that maternal education and the frequency of pregnant women to health care facilities lower LBW incidence. Thus, it may be vital to keep striving for women to ascend the educational ladder while still encouraging them to be regulars at health care facilities for antenatal care.

On the contrary, maternal age, internet access and wealth status may act to widen the gap between these two areas of residence. This is sensible as known in medical literature that older women are often exposed to numerous risks associated with poor foetal growth and other birth complications than younger women (Cavazos-Rehg *et al*., 2015), and lack of access to relevant information may hinder a woman from practising a proper lifestyle during the gestational period.

It is worth disclosing that the unexplained effect is often attributed to the discrimination effect and captures the effects of the gender differences but in this study the discrimination effect may be defined by residential differences in this study in all of the unobserved variables (Jann, 2008). The results reveal that it could not be explained why the ANC visits have significantly increased the disparities in the LBW of under-five children between these two extreme residential regions. It may, however, be inferred that this may be due to the inherent ability of influence functions to take into consideration the influence of an individual observation on the Erreygers concentration index as a distributional statistic (Zhao, 2020). Specifically, it may be unobservable why one woman who had visited a health care facility 13 times had their child weigh around 3.5 kg, which was quite the outlier.

It is, however, interesting to discover that the abovementioned maternal factors could not statistically and significantly explain the differences in the distribution of LBW between rural and urban residents. However, the economic nuance is quite accurate about why factors, like internet access (and/or increased access to information), may broaden the gap between the LBW seen in the rural areas relative to the urban areas, and why maternal education level may reduce the gap between these two sub-groups. The reasons may be that for the former, most remote areas still have network barriers (Research ICT Africa, 2017). For instance, despite over 80% of internet-using people using a smart-phone for access, most of them cannot even use it due to the high cost of data. This may be cemented by the fact that about 70% of the Basotho does not use the internet despite having greater than 80% of 3G coverage in this country (Research ICT Africa, 2017).

Concerning the education factor, the World Bank Group has invested in a school retention project for poor households in the rural areas of Lesotho to enhance educational attainment (World Bank, 2022). Such projects can be seen to boost maternal educational attainment in the long run; hence, they help to narrow the gap in the inequality in LBW between under-five children hailing from the rural and urban areas of Lesotho. There have been other projects, which could have well contributed to this maternal-educational-level effect on LBW in Lesotho, such as free primary school education supported by the United Nations, in collaboration with the Lesotho's Ministry of Education and Training (MoET) (United Nations, 2022).

To verify these results, the Wagstaff decomposition analysis was used to expose the contributions that each factor makes towards the LBW concentration index estimated earlier. This estimation is crucial as it expands the measurement information by adding more explanation of the inequalities in LBW for under-five children in Lesotho. Distinctively, this approach demonstrates that the health CI can be decomposed into the contributions of individual factors to this income-related health inequality. Each of these contributions is expressed as the product of the sensitivity (elasticity) of LBW to those respective factors and reveals the degree of this income-related inequality in that specific factor (O'Donnell *et al.*, 2008).

Table 5: Decomposition results of the Concentration Index for LBW of under-five children in Lesotho

Variable	**Elasticities**	**Concentration Indices**	**Contribution**	**Percentage Contribution**
ANC Visits	-2.492	0.165	-0.411	3.198
Tetanus Toxoid Doses	1.171	-0.030	-0.035	0.275
Household Size	0.601	-0.340	-0.204	1.587
Internet Access	-0.077	1.403	-0.108	0.841
Maternal Functional	0.198	0.288	0.057	-0.445

Disabilities				
Locality	-1.597	-1.362	2.175	-16.919
Child's Gender	0.429	-0.093	-0.040	0.310
Toilet Facility	0.658	-0.287	-0.189	1.468
Energy Source	2.475	0.635	1.572	-12.234
Maternal Marital Status	0.195	-0.032	-0.006	0.049
Maternal Age	1.346	0.121	0.163	-1.272
Maternal Education Level	-2.803	0.469	-1.314	10.224
Water Source	0.686	-0.531	-0.364	2.833
Wealth Index Quintile	-2.132	1.275	-2.718	21.146

Notes: Results were obtained using the Wagstaff *et al*. (2003) methodology for the Wagstaff Decomposition of the CI. Here, the estimation was made using the household weights as the sampling weights and the wealth Quintile weights as the analytical weights.

Source**:** Own Calculations using MICS6/2018 in STATA 16.0

The results in Table 5 substantiate the results reported in Table 4 to some degree. For example, Table 5 above confirms that the ANC visits, maternal education and the woman's wealth status do work to reduce the inequality in the distribution of LBW in under-five children in Lesotho. As before, the concentration estimates have the negatives showing that Tetanus Toxoid Doses, household size, locality, new-born's gender, type of toilet facility, the main energy source, maternal marital status and main source of water, all acts to influence the higher risk of LBW to be more pronounced towards those in the poorer socio-economic status.

It is important to note that, theoretically, the CI ranges between -1 and 1, and this may not necessarily be empirical[11]. That is, empirically, these contrasting bounds of the standard CI, including their corrected versions, depend both on the sample size and the sampling weights (Ataguba, 2022)[12]. Even though normalising by one minus the mean may be a solution (Wagstaff, 2005), the Wagstaff's normalised concentration index may give rise to a spurious concentration of a dichotomous health variable amongst the poor and the rich; however, it is rare (Ataguba, 2022). Therefore, the analysis to follow extends the above knowledge.

[11]According to Wagstaff (2005), the bounds of the CI for a binary variable are not -1 and 1. However, they depend on the mean of the variable. As such, the feasible range of the index may arise as the mean rises where for large samples, the lower bound is the mean less 1, and the upper bound is 1 less the mean of the binary variable.

[12] Ataguba (2022) further argues that the interpretations may be "counter-intuitive" for policy in such normalised cases.

As expected, the wealth status positively contributed a greater portion to the inequality in LBW for under-fives in Lesotho at 21.15%. This was followed by the maternal educational level, ANC visits and the type of water source, the household size, and the type of toilet facility at 10.22%, 3.20%, and 2.83%, 1.59% and 1.47%, respectively. From these positive contributions, robustness was further asserted as maternal education, the ANC visits and the woman's wealth status have been found to still be the key drivers of the inequality in LBW in Lesotho. Moreover, some negative contributors to LBW inequality in Lesotho include the residential area/locality and the type of energy source used at 16.92% and 12.23%, respectively. This then suggests that these negative contributors widen the LBW inequality gap in Lesotho.

Specifically, it may not be surprising for the type of energy source to broaden this inequality gap because non-clear energy has been found to be connected to prohibited ventilation to the child's brain during pregnancy and underweight children at birth (Sarizadeh *et al.*, 2020). This may then lead to deformities in the development of the unborn child, thus making them more susceptible to LBW relative to their counterparts.

Finally, the estimated elasticities are found to back up the above findings for the positive contributions of these factors. Since negative and positive percentage contributions suggest that there is an increase and decrease in the LBW inequality by these elasticities, the maternal functional disabilities, energy source and maternal age increase the inequality in LBW in this country. On the other side, the locality/residential area and access to information (internet access) have responded by reducing the inequality in LBW in under-five children in Lesotho, together with the wealth status, maternal educational level and ANC visits.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

This section of the study consolidates the findings of the study and then concludes all supporting discussions made. It then connects them to the research question which was answered to this effect. Thereafter, it gives the recommendations which may be helpful to alleviate the effects of LBW in Lesotho – both in the short-run as well as in the long-run.

5.1 Summary of Findings

The main objective of this study was to investigate the inequalities in LBW in under-five children in Lesotho using the MICS/2018 dataset. Inequality in LBW was determined to be existent in Lesotho, particularly between the rural and urban areas of Lesotho. The findings of this study significantly revealed an association of LBW with the ANC visits. Nonetheless, it appeared that there are some unexplained latent influences of the ANC visits in explaining the gap in LBW by the area of residence in Lesotho. Despite this knowledge, what remains clear is that frequenting antenatal care facilities significantly lowers the chances of the child to be born with LBW. The mother's education also showed satisfactory results when it came to the explanation of the inequalities in LBW in Lesotho. Of course, the woman's wealth status cannot be left out of this. As expected, the wealth status of the woman does exacerbate the inequality in LBW between localities. This corroborates the fact that, indeed, income perpetuates inequalities in Lesotho. Consequently, this further suggests that the reduction in the income gap will reduce that of the distribution in LBW in Lesotho. The abovementioned analyses show that all these three factors being maternal education, ANC visits and areas of residence: a) suggest that exposure to information pertaining to pregnancy and maternal health are vital, and that improved wealth status. In fact, it affords a child better chance of being born without LBW; and b) that there can be some inferences drawn, because all these factors are significantly associated with good nutrition, good maternal nutrition may significantly lower the chances of a child having LBW at birth.

Therefore, it is evident that LBW exists among under-five children in Lesotho, and it is more pronounced in the rural areas of Lesotho. Additionally, ANC visits and maternal education do show that they play a vital role in influencing LBW, and this suggests that women empowerment in these areas can significantly lower the number of LBW cases in Lesotho.

5.2 Recommendations

Since the ANC visits outline a larger role, much attention should be in line with them. Increased awareness may prove a vital tool through relevant educational outreaches at national and community level for pregnant women to access antenatal care facilities as much as possible. This may be done through intensified ANC awareness programmes. Financial empowerment may, as well be encouraged. For instance, there could be incentives given to mothers based on the frequency of their visits to antenatal care facilities. This could increase turnout and maximisation of such services. Even though adequate data on nutrition were not available, maternal nutritional status must be encouraged.

As depicted in Figure 2, it is, however, peculiar how the fourth wealth quintile numbers are not switched with those from the second wealth quintile as would be expected from the understanding that the more an individual is higher up the wealth ranking, the better chances they have to curb LBW. Given this peculiarity, I recommend a study be undertaken to explore what may be underlying causes of those irregularities. Additionally, if possible, incorporating the state of a mother's mental health into the study may be interesting to observe. I suggest a study of this nature be undertaken in the future. Finally, I suggest a similar study be undertaken in the human sciences fraternity with variables which capture hereditary and genetic build-up.

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ANNEXES

Annex 1

Results from the cross-tabulation analysis

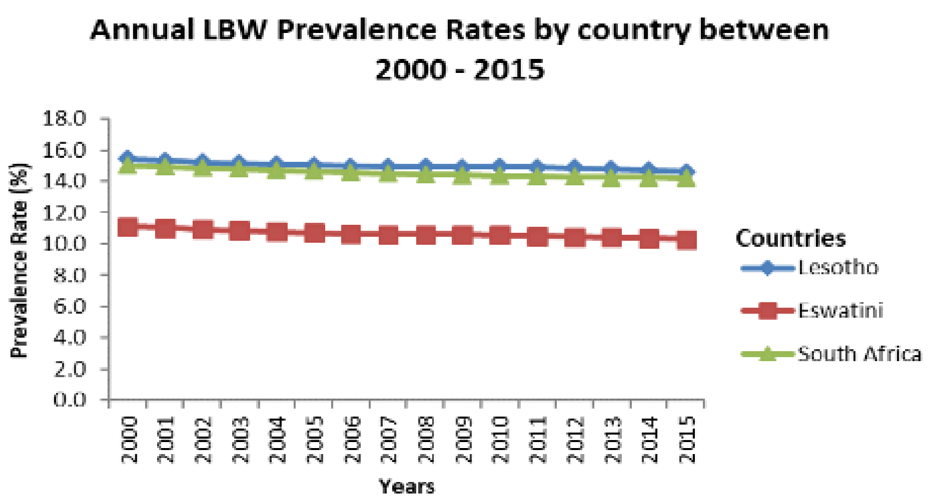
Variables	Categories	Y=0 (No LBW)	Y=1 (Child has LBW)	p-Value	Pearson x^2 value
Maternal Functional Disabilities	1=None	28 (62.22)	17 (37.78)	0.005	7.7299
	0=Present	536 (79.76)	136 (20.24)		
Locality	1=Rural	393 (79.07)	104 (20.93)	0.685	0.1649
	0=Urban	171 (77.73)	49 (22.29)		
Maternal Educational Level	1=Primary/None	185 (72.27)	71 (27.73)	0	17.0781
	2=Secondary	319 (80.15)	79 (19.85)		
	3=Tertiary	60 (95.24)	3 (4.76)		
Maternal Marital Status	1=Married	450 (78.67)	122 (21.33)	0.939	0.7996
	2=Widowed	17 (85.00)	3 (15.00)		
	3=Divorced	6 (75.00)	2 (25.00)		
	4=Separated	11 (73.33)	4 (26.67)		
	5=Never Married	80 (78.43)	22 (21.57)		
Wealth Index Quintile	1=Poorest	145 (70.39	61 (29.61)	0.009	13.6137
	2=Second	129 (84.87)	23 (15.13)		
	3=Middle	105 (79.55)	27 (20.45)		
	4=Fourth	111 (79.86)	28 (20.14)		
	5=Richest	74 (84.09)	14 (15.91)		
Type of Water Source	1=Piped	434 (80.07)	108 (19.93)	0.089	8.0646
	2=Well	43 (84.31)	8 (15.69)		
	3=Spring	81 (69.83)	35 (30.17)		
	4=Tanked	2 (100.00)	0 (00.00)		
	5=Surface	4 (66.67)	2 (33.33)		

Type of Toilet Facility	1=Flush	9 (81.82)	2 (18.18)		
	2=Pit	411 (80.12)	102 (19.88)	0.273	2.5988
	3=None/Bush/Field	144 (74.61)	49 (25.39)		
Type of Energy Source	1=Paraffin	350 (78.30)	97 (21.70)		
	2=Electricity	209 (80.38)	51 (19.62)	0.068	5.3888
	3=Other(e.g., Biomass)	5 (50.00)	5 (50.00)		
Internet Access	1=Yes	222 (82.84)	46 (17.16)	0.035	
	0=No	342 (76.17)	107 (23.83)		
Gender of the Child	1=Female	300 (79.79)	76 (20.21)	0.364	0.8237
	0=Male	268 (77.01)	80 (22.99)		
Household Size	N/A	N/A	N/A	0.119	19.1345
Maternal Age	N/A	N/A	N/A	0.431	28.6401
ANC Visits	N/A	N/A	N/A	0.042	24.2831
Tetanus Toxoid Injection Doses	N/A	N/A	N/A	0.292	6.1487

Notes: Y denotes the outcome variable, LBW, while p-value is the probability value. The last four variables have the "not applicable" (N/A) function in those selected columns due to their continuous nature. The presentation of the data would quite tedious. The percentages are recorded in parentheses.

Source**:** Own Calculations using STATA 16.0

Annex 2



Source: UNICEF/WHO Low Birth Weight Estimates data (UNICEF & WHO, 2019)

Annex 3

Mathematical Process of RIF Regression Decomposition Method Proposed By Heckley *et al*. (2016)

Please note: This mathematical process outlined in this annex 2 was summarised was by (Cai *et al*., 2017), who derived it from the paper of Heckley *et al*., 2016). Readers can also refer to the study of Heckley *et al*., 2016).

Measuring socioeconomic-related health inequality

To represent different forms of health inequality measures, Heckley *et al*. (2016) [1] used a general form of the rank dependent inequality index to derive different forms of inequality indices.

The function of the general form of the inequality index (I) is as follows,

$$I = v^I\left(F_{H,F_Y}\right) = v^{w_I}(F_H)\, v^{AC}\left(F_{H,F_Y}\right) \tag{1}$$

H is the health indicator with probability measure denoted as F_H. $v^{w_I}(F_H)$ is a weighting function specific to a particular form of inequality index. Y is an individual's income. The cumulative distribution function (CDF) of Y, F_Y, is the relative rank of the individual by income Y. The joint distribution of H and F_Y is denoted as F_{H,F_Y}. The absolute concentration index (AC) is given by twice the covariance between H and F_Y:

$$AC = v^{AC}\left(F_{H,F_Y}\right) = 2cov(H, F_Y) \tag{2}$$

When using standard concentration index (CI) in our study, then the weighting function is as follows:

$$v^{w_{CI}}(F_H) = \frac{1}{\mu_H} \tag{3}$$

where μ_H is the mean of health variable H. Thus, the standard CI can be given as:

$$CI = v^{CI}(F_{H,F_Y}) = \frac{1}{\mu_H} 2cov(H, F_Y) \quad (4)$$

For Erreygers index (EI) [2], the weighting function is as follows:

$$v^{wEI}(F_H) = \frac{4}{b_H - a_H} \quad (5)$$

where the health variable of interest has both an upper and lower bound denoted as b_H and as a_H, respectively.

Thus, the EI can be given as:

$$EI = v^{EI}(F_{H,F_Y}) = \frac{4}{b_H - a_H} 2cov(H, F_Y) \quad (6)$$

For Wagstaff index (WI)[3], the weighting function is as follows:

$$v^{wWI}(F_H) = \frac{b_H - a_H}{(b_H - \mu_H)(\mu_H - a_H)} \quad (7)$$

Thus, the WI can be given as:

$$WI = v^{WI}(F_{H,F_Y}) = \frac{b_H - a_H}{(b_H - \mu_H)(\mu_H - a_H)} 2cov(H, F_Y) \quad (8)$$

For attainment-relative concentration index (ARCI) [1,4], the weighting function is as follows:

$$v^{wARCI}(F_H) = \frac{1}{\mu_H - a_H} \quad (9)$$

Thus, the ARCI can be given as:

$$ARCI = v^{ARCI}(F_{H,F_Y}) = \frac{1}{\mu_H - a_H} 2cov(H, F_Y) \quad (10)$$

For shortfall-relative concentration index (SRCI) [1,4], the weighting function is as follows:

$$v^{wSRCI}(F_H) = \frac{1}{b_H - \mu_H} \quad (11)$$

Thus, the SRCI can be given as:

$$SRCI = v^{SRCI}\left(F_{H,F_Y}\right) = \frac{1}{b_H - \mu_H} 2cov(H, F_Y) \qquad (12)$$

The RIF for a general bivariate rank dependent index

The influence function and the re-centred influence function

The RIF is derived from the influence function (IF). The IF is a specific form of a directional derivative. A directional derivative is used to find the influence of a perturbation or contamination in a distribution, for example, from F_H towards a new distribution on a statistics. The IF is the particular form of a directional derivative, where the new distribution denoted as δ_h, equals a cumulative distribution function for a probability measure that puts mass 1 at a particular value h:

$$\delta_h(l) = \begin{cases} 0, & if\ l < h \\ 1, & if\ l \geq h \end{cases}, \qquad (13)$$

where l is a draw from H. To define the IF of the functional $v(F_H)$ evaluated at point h, denoted as $IF(h; v)$, G_h is defined as a mixing probability distribution of F_H and δ_h:

$$G_h = (1 - \varepsilon)F_H + \varepsilon\delta_h, \qquad (14)$$

where $\varepsilon \in (0,1)$ is a probability, or a weight, representing the relative change in the population through the addition of δ_h. That is, G_h is a distribution that is ε away from F_H in the direction of δ_h. IF $(h;\ v)$ is then defined as:

$$IF\ (h;\ v) = \frac{\partial v(G_h)}{\partial \varepsilon}\Big|_{\varepsilon=0} = lim_{\varepsilon \to 0} \frac{v(G_h) - v(F_H)}{\varepsilon}, \qquad (15)$$

The RIF is a minor transformation of the IF and is obtained from the IF by adding back the original functional, $v(F_H)$:

$$RIF(h; v) = v(F_H) + IF\ (h;\ v). \qquad (16)$$

The RIF for a general (bivariate) rank dependent index

As the rank dependent index, I is the functional of the joint probability distribution F_{H,F_Y}. To get the RIF for a bivariate rank dependent index, it is necessary to extend the definitions in

Eqs. (13)– (16) from a univariate to a bivariate setting. Let $G_{h,F_Y(y)}$ be a bivariate distribution function obtained by an infinitesimal contamination of F_{H,F_Y} in both h and $F_Y(y)$:

$$G_{h,F_Y(y)} = (1-\varepsilon)F_{H,F_Y} + \varepsilon\delta_{h,F_Y(y)} . \tag{17}$$

Here $\delta_{h,F_Y(y)}$ denotes a joint cumulative distribution function for a joint probability measure that gives mass 1 to $(h,\ F_Y(y))$ jointly:

$$\delta_{h,F_Y(y)}(l,r)=\begin{cases}0, & if\ l < h\ or\ r < F_Y(y)\\ 1, & if\ l \geq h\ \ or\ r > F_Y(y)\end{cases}, \tag{18}$$

where l and r draws from H and F_Y, respectively. In analogy with Eq. (15), the bivariate IF of $v^I(F_{H,F_Y})$ evaluated at point $(h,F_Y(y))$, then it is defined as:

$$IF\ (h, F_Y(y); v^I) = \frac{\partial v^I(G_{h,F_Y(y)})}{\partial\varepsilon}|_{\varepsilon=0} = lim_{\varepsilon\to 0}\frac{v^I(G_{h,F_Y(y)}) - v^I(F_{H,F_Y})}{\varepsilon}, \tag{19}$$

Finally, the RIF of I is then defined as:

$$RIF(h,F_Y(y); v^I) = v^I(F_{H,F_Y}) + IF\ (h,F_Y(y); v^I). \tag{20}$$

The RIF formulas may appear complex; however, they are just a linearisation of the statistic. Practical implementation of RIF estimations is straight forward.

RIF Regression Decomposition

Two parameters of interest are estimated using the RIF regression: the marginal effect of covariates X on a functional, which is an individual effect, and the unconditional partial effect, which is a population effect measure (Heckley *et al*., 2016). The estimates for these two parameters are as follows.

The re-centring of the IF yielding the RIF implies that $v^I(F_{H,F_Y})$ could be expressed as an expected value of the RIF:

$$v^I(F_{H,F_Y}) = \int_{-\infty}^{\infty} RIF(h,F_Y(y); v^I)\cdot dF_{H,F_Y}(h,F_Y(y)) = E[RIF(H,F_Y; v^I)] \tag{21}$$

To link $v^I(F_{H,F_Y})$ to the covariates X, the law of iterated expectations is applied to express $v^I(F_{H,F_Y})$ as a conditional expectation [5]:

$$v^I(F_{H,F_Y}) = \int_{-\infty}^{\infty} RIF(h, F_Y(y); v^I) \cdot dF_{H,F_Y}(h, F_Y(y))$$
$$= \int_{-\infty}^{\infty} E[RIF(H, F_Y; v^I)|X = x] \cdot dF_X(x) \quad (22)$$

where F_X is the CDF of X.[13] Thus, the decomposition of $v^I(F_{H,F_Y})$ comes down to a problem of estimating a conditional expectation, which can be solved by standard regression methods. Then, for the general function of covariates X and an error term denoted as $\lambda(X, \epsilon)$, the conditional expectation of $RIF(h, F_Y(y); v^I)$ can be expressed as:

$$E[RIF(H, F_Y; v^I)|X = x] = \lambda(X, \epsilon) \quad (23)$$

The first parameter of interest, the marginal effect with respect to X, is given by the partial derivative of the regression estimates of (7):

$$\frac{dE[RIF(H, F_Y; v^I)|X = x]}{dx} = \frac{d\lambda(X, \epsilon)}{dx} \quad (24)$$

The second parameter of interest is the unconditional I partial effect, denoted as $\gamma(v^I)$. It is a vector of average partial derivatives expressed as:

$$\gamma(v^I) = \int_{-\infty}^{\infty} \frac{dE[RIF(H, F_Y; v^I)|X = x]}{dx} \cdot dF_X(x) = \int_{-\infty}^{\infty} \frac{d\lambda(X, \epsilon)}{dx} \cdot dF_X(x) \quad (25)$$

Assuming $\lambda(.)$ to be linear and applying ordinary least square (OLS) to estimate the parameters can yield an estimator, which Heckley *et al*. (2016) [1] refer to as RIF-CI-OLS. Following Heckley *et al*. (2016) [1], the study used RIF-I-OLS, which is both simple and attractive from an operational perspective to conduct decomposition.

RIF-I-OLS identifies the parameters of interest, the marginal effect and the unconditional I partial effect under the assumptions of additive linearity and zero conditional mean. Thus, the Eq. (8), Eq. (9), and Eq. (10) can be rewritten as:

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[13] Noting that $F_{H,F_Y}(h, F_Y(y)) = \int F_{(H,F_Y)|X}(h, F_Y(y)|X = x) \cdot dF_X(x)$, which is substituted into Eq. (22).

$$E[RIF(H, F_Y; v^I)|X = x] = X^{'}\psi + \mu \tag{26}$$

$$\frac{dE[RIF(H, F_Y; v^I)|X = x]}{dx} = \frac{d[X^{'}\psi + \mu\,]}{dx} = \psi \tag{27}$$

$$\gamma(v^I) = \int_{-\infty}^{\infty} \frac{d[X^{'}\psi + \mu\,]}{dx} \cdot dF(x) = \psi \tag{28}$$

Thus, under the linearity and zero conditional mean assumptions, the marginal effect and the unconditional partial effect are the same, and the RIF regression is optimally estimated using OLS.

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Latex Equation Code

```
\begin{equation}

\gamma($v$^I) = \integral_{-\infinity}^{\infinity}\frac{$d$E[RIF(H,F_Y;$v$Î)|X=$x$]}{$dx$}\dot$d$F_X($x$) = \integral_{$d$\lam(X,\epsilon)}^{$dx$}\dot$d$F_X($x$)

\end{equation}
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