THREE ESSAYS ON HEALTH AND EDUCATION IN GUYANA.

BY

MS. NICHOLA LATOYA WILLIAMS

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Newcastle University Business School

Newcastle University

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Abbreviations

BCG	Bacillus Calmette-Guérin vaccine
CAPE	Caribbean Advanced Proficiency Examination
CARICOM	Caribbean Community and Common Market
COVID-19	Coronavirus disease
CHS	Community High Schools
CPCE	Cyril Potter College of Education
CSEC	Caribbean Secondary Education
CSHE	Carnegie School of Home Economics
DES	Digest of Education Statistics
DPT	Diphtheria, Pertussis (whooping cough), and tetanus
EDs	Enumeration districts
GBOS	Guyana Bureau of Statistics
GDHS	Guyana Demographic and Health Survey
GITC	Guyana Industrial Training Centre
GLFS	Guyana Labour Force Survey
GoG	Government of Guyana
GSSs	General Secondary Schools
GTI	Government Technical Institute
HAZ	Height-for-age z-scores
IPCC	Intergovernmental Panel on Climate Change
MICS	Multiple Indicator Cluster Survey
MoE	Ministry of Education
NATI	New Amsterdam Technical Institute
OLS	Ordinary Least Square
PIAAC	Program for the International Assessment for Adult Competencies
PSU	Primary Sampling Unit
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
USE	Universal Secondary Education
WHO	World Health Organisation
SD	Standard Deviation
SSEE	Secondary School Entrance Examination
SSPE	Secondary School Proficiency Examination

Abstract

This dissertation, through a set of three substantive chapters, examines the effects of weather shocks, educational reform and birth order on health and education-related outcomes in Guyana. In doing so, this dissertation brings a wealth of new literature for Guyana, which remains an underexplored context. Findings from this dissertation have implications for enhancing the economic and social well-being of the nation.

The first chapter examines the effects of in-utero exposure to extreme weather events on early childhood health in flood-prone Guyana. Using three waves of the Multiple Indicator Cluster Surveys, we find that prenatal exposure to higher-than-average rainfall events or positive rainfall shocks (i.e., floods) negatively affects the height-for-age z score and increases the likelihood of stunting and severe stunting. Given the importance of exposure to weather shocks in early gestation, we examine the impact by trimesters and find that positive rainfall shocks in the first trimester matter the most.

The second chapter examines the effects on educational attainment and labour market outcomes of a Universal Secondary Education (USE) policy during 2003-07 for the conversion of schools from a pre-vocational track into an academic track. Using data from the Guyana Labour Force Surveys and the Digest of Education Statistics, we find that greater exposure to the USE leads to an increase in the completion of secondary or tertiary education in Guyana. Our findings suggest that the exposure to the USE policy reform had positive effects on the completion of secondary or tertiary education and the potential to earn higher wages in Guyana. Overall, we find that the USE (2003-2007) policy reform did not close the achievement gaps in education across ethnicities.

The final chapter examines the effects of birth order on early childhood health in Guyana and finds that the height-for-age z-score increases more for second-and third-born male children when compared to first-born children. We also find that mothers both breastfed and invested more in vaccinations for children whose birth order is higher than one. In addition, we find that third-born and fourth-born and higher Muslim children tend to have higher birth weights when compared to firstborn children.

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CHAPTER 1: - Introduction

1.1 Background and Motivation

In the literature, health and education are seen as the two main types of investments in human capital that predict the economic well-being of every society at large. The two topics are interconnected in various ways, i.e., they are substantial returns to education when improved health exists, and health complements education in rising the returns to labour (Hunt-McCool and Bishop, 1998). Through three distinct chapters, this dissertation sheds light on these topics of immense relevance for a country like Guyana. Guyana is a suitable context to study these questions because ninety percent of its inhabitants live on its coastal plain, which is below sea level, making Guyana one of the most endangered countries in the world and its country's capital prone to extreme weather conditions and flooding (World Bank, 2022). Furthermore, Guyana's educational sector has undergone a Universal Secondary Education (USE) policy reform that has not been empirically analysed to determine its success. For these reasons, coupled with the fact that Guyana has rich sources of data, which can be analysed to determine whether the government has reasons to be concerned with the country's human capital and overall economic well-being. Furthermore, the results of this dissertation have possible policy implications which can be used by policymakers to make informed decisions to improve the economic well-being of Guyana.

In the 21st century, global warming has been the focus of every country across the globe, and Guyana is no exception to the harmful effects of global warming on its economy. Furthermore, variations and changes in rainfall and temperature, and the frequency and intensity of extreme weather events such as floods and droughts can negatively affect child health outcomes such as stunting of growth, wasting and severe stunting (Glewwe and King, 2001; Alderman et al., 2006 Victora et al., 2008; Ogasawara and Yumitori, 2018; Aguilar and Vicarelli, 2022). Consequently, over the years, Guyana has witnessed a rise in stunting (i.e., height-for-age z-score < -2) among children under 5 (Kaieteur News, 2014; UNICEF, 2019). Furthermore, Chapter one of this dissertation investigates weather shock's effects on Guyana's childhood health.

Guyana's secondary institutions suffered from high levels of dropout in the 1990s due to its three-tier secondary education structure that offered unequal learning opportunities among the secondary departments of primary schools or Primary Tops and Community High Schools, which offered a more pre-vocational curriculum than General Secondary Schools who were more academic in nature (Jennings and Miller 1999; Gafar 2003; World Data on Education, Guyana 2006/07). However, the Universal Secondary Education (2003-2007) policy reform was created with the aim of converting secondary classes in Primary Tops and Community High Schools into General Secondary Schools (World Bank, 2013; Ministry of Education, 2022). More important, the USE policy reform made secondary education universally available to all secondary school students in Guyana. Consequently, all secondary school students can have equal access to a more academic curriculum rather than a pre-vocational one. A study has shown that academic qualifications attract higher wage premia than vocational qualifications (Dearden et al., 2002). Studies have also shown that educational policy reforms tend to increase educational attainment (Riphahn, 2012; Duflo et al., 2021; Brudevold-Newman, 2021). As such, Chapter two of this dissertation examined the effects of a school conversion policy on educational attainment and labour market outcomes in Guyana.

As it relates to birth order and childhood health in Guyana, existing literature finds a strong positive correlation between birth order and the health of babies at birth/newborns, i.e., birth weight tends to increase among later-born when compared to first-borns (Björkegren and Svaleryd 2016; Brenøe and Molitor, 2017; Pruckner et al., 2019). Literature has also shown that there can be policy implications of birth order effects when mothers spend considerable time breastfeeding and on postnatal investments (Björkegren and Svaleryd, 2016). According to Guyana Demographic and Health Survey (2009), the average number of children per family is 2.8 children per family. In recent years, Guyana has also witnessed a rise in single-parent households headed by women. Furthermore, 30 percent of Guyana’s households are headed by women (Office of the United Nations High Commissioner for Human Rights, 2020). Consequently, the third chapter of this dissertation examined the birth order effects and early childhood health in Guyana.

To the researcher’s knowledge, to date, there has been no previous study on the effects of weather shocks, birth order and the impact of the Universal Secondary Education (2003-2007) policy reform in Guyana. Consequently, this research is both novel and timely given the reports in the media on extreme weather events that are caused by the changing climatic conditions, the need for the reduction of child mortality and improve maternal health and the Ministry of Education’s goal of achieving quality USE for all secondary school children in Guyana. Moreover, the socioeconomic implications for children, mothers and the country compel a closer examination of the problems highlighted in this research. Therefore, this study aims to examine the effects of weather shocks, birth order and educational reform on health and education-related outcomes in Guyana. To achieve this objective, the following research questions are proposed and addressed by this research:

- How do weather shocks affect childhood health in Guyana?
- How has the USE (2003-2007) policy reform impacted Guyana's educational attainment and labour market outcomes?
- How can birth order affect childhood health in Guyana?

Furthermore, the rest of the chapter will provide information on the research context, Guyana's colonial history and independence, economic growth and country comparison, Guyana's health and education sectors, and the chapter concludes with the dissertation layout.

1.2 Research Context

The geographic focus of this research is the Cooperative Republic of Guyana. Guyana, formerly known as British Guiana, is the only English-speaking country in South America. It is in the north-eastern corner of South America between 2^0N and 8^0N Latitude and shares borders with Suriname to the east, Brazil to the south and southwest, Venezuela to the west, and the Atlantic Ocean to the north. Guyana is the third-smallest sovereign state in South America after Uruguay and Suriname. Guyana has a land area of 83,000 square miles and a population of approximately 800,000 inhabitants (World Bank, 2022).

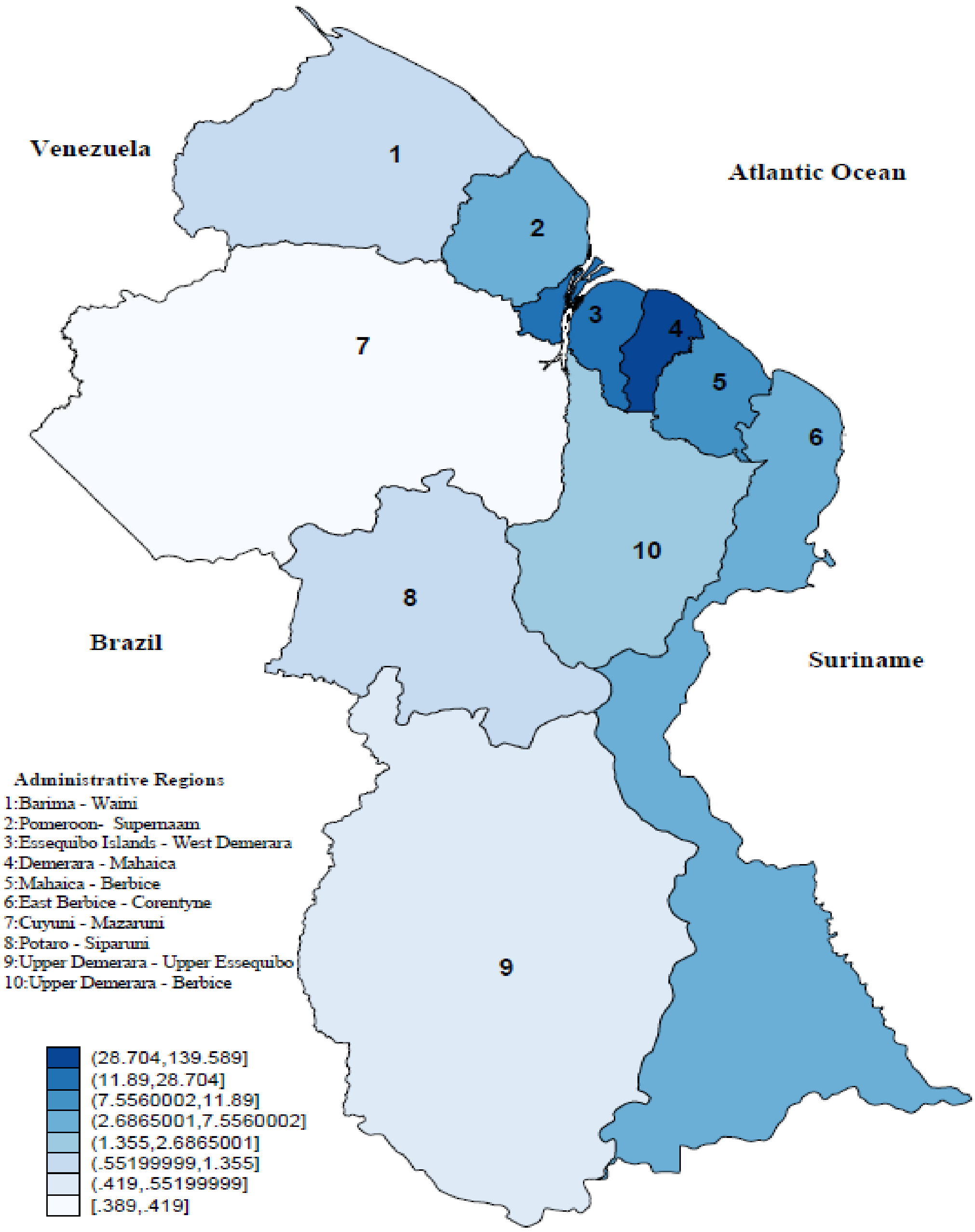

Figure 1.1: Map of Administrative Regions and Population Density of Guyana.
***Source**:* Author's illustration based on Guyana's Population Density (2012 Census) provided by Bureau of Statistics, Guyana.

Guyana is a word derived from one of the native Amerindian languages meaning "land of many waters." This name was given due to the numerous rivers that traverse long distances in the country, with the main rivers being Essequibo, Demerara, Berbice and Corentyne. As Figure 1.1 shows, Guyana comprises ten administrative regions and nine towns. The capital city of Georgetown is situated in region 4, and it is the largest city in Guyana. Georgetown is also the most densely populated region and home to 80% of Guyana's population (World Bank, 2022).

1.3 Guyana's Colonial History and Independence

The history of Guyana can be traced back to its first people who were said to have travelled from Eurasia way before the 12th Century. These are known as the Amerindians or Indigenous people of Guyana (Sanders, 1995). In the colonial era of the 15th Century, Guyana's government was defined by successive policies of the Spanish, French, Dutch, and British settlers. In the mid-17th century during the period of the Transatlantic Slave trade, Guyana's second largest ethnic group (the Africans) were brought as slaves by Dutch settlers (Khemraj, 2016). The British first occupied Guyana during the Napoleonic Wars in 1814 and in 1831, Guyana was declared a British colony. In 1834 slavery was abolished in Guyana, and in 1838, the then British Guiana commenced the Indian Indentureship system, where East Indians (Guyana's largest ethnic group to date) were brought to Guyana to work on sugar plantations. In 1838, the Portuguese also arrived in Guyana from Madeira to work on the sugar plantations under the indentureship system (Khemraj, 2016). In 1851, Chinese indentured labourers arrived in Guyana to serve the estates.

Guyana's colonial past created a rich multi-ethnical and multi-cultural economy (Khemraj, 2016). Consequently, Guyana has six ethnic groups: Amerindian, East Indian (Indo-Guyanese), African (Afro-Guyanese), Chinese, Portuguese, and Mixed race. In terms of employment, the Indo-Guyanese (East Indians) dominated both employment and income distribution categories in Guyana during 2006-2016 when compared to Afro-Guyanese (Africans) (Constantine, 2021). Furthermore, in terms of education, the East Indians and Africans excel comparably in both primary and secondary levels of examinations in Guyana (Guyana Chronicle, 2011).

In 1966, British Guiana became an independent nation under the new name Guyana. On February 23rd, 1970, Guyana was proclaimed a cooperative republic within the British Commonwealth and was named 'The Co-operative Republic of Guyana or Guyana.' In 1970, Guyana also welcomed its first President (of Chinese descent), Mr Raymond Arthur Chung, and Mr Forbes Burnham (of African descent) was declared the Prime Minister. In Guyana, executive power is exercised by the President, advised by a cabinet. Furthermore, in the late 1970s, Guyana was declared a socialist nation by then-President Forbes Burnham.

In 1973 Guyana, along with three other Caribbean countries (Jamaica, Barbados, and Trinidad and Tobago), formed an alliance known as CARICOM (or 'The Caribbean Community') to allow better trade agreements and movement of people between countries. At present, CARICOM consists of fifteen Caribbean nations and dependencies (CARICOM, 2022). In the early 1980s, Guyana followed a series of inward-looking policies, and in 1985, the country's economic situation started to deteriorate (Chandisingh, 1983; Gafar, 1996: Khemraj, 2016). In response to rescuing the country from its economic downturn, in 1988, International Monetary Fund (IMF) and Commonwealth were invited to review the economy. In 1989, Guyana embraced the structural reforms instituted by the IMF and embarked on a new era of outward-looking policies to better stimulate the economy.

Guyana's political climate is one marked by racial tension due to ethnicity-based politics among the two most predominant races, i.e., the East Indians and Africans (Ryan, 2020). In 2001, the People's Progressive Party (PPP) (a predominantly East Indian party) won and went on to lead the country. However, in 2015 the opposition party 'A Partnership for National Unity' (APNU), a coalition of the main opposition party and other smaller parties headed by former President David Granger (of African descent) won the elections and led the country up until 2020. In 2020, the PPP won the general and regional elections in Guyana and President Irfaan Ali was appointed as President.

1.4 Economic Growth and Country Comparison

Guyana is richly endowed with vast deposits of minerals such as gold, diamond, bauxite, and manganese which are all major exports. The government of Guyana has invested heavily in mechanising the country's gold and bauxite mining sectors to improve production (World Atlas, 2022).

In 2015, the government of Guyana estimated that 83.95 percent of the country's total land area was covered with forests. Guyana has positioned itself to become 'the Breadbasket of the Caribbean' as its rich soil and climate make it ideal for agricultural exports of its traditional crops such as rice, sugar, and non-traditional crops such as coconut and vegetables. Guyana also has a large fishery and livestock sector.[1]

With a GDP per capita of US$9,374.8 in 2021, Guyana is considered as an upper middle-income country (World Bank, 2022). However, it is among the poorest countries in South

[1] The Breadbasket of the Caribbean – Kaieteur News (kaieteurnewsonline.com)

America due to 43.4 percent of the population living on less than US$5.5 per person a day in 2011 Purchasing Power Parity (World Bank Factsheet, 2020).

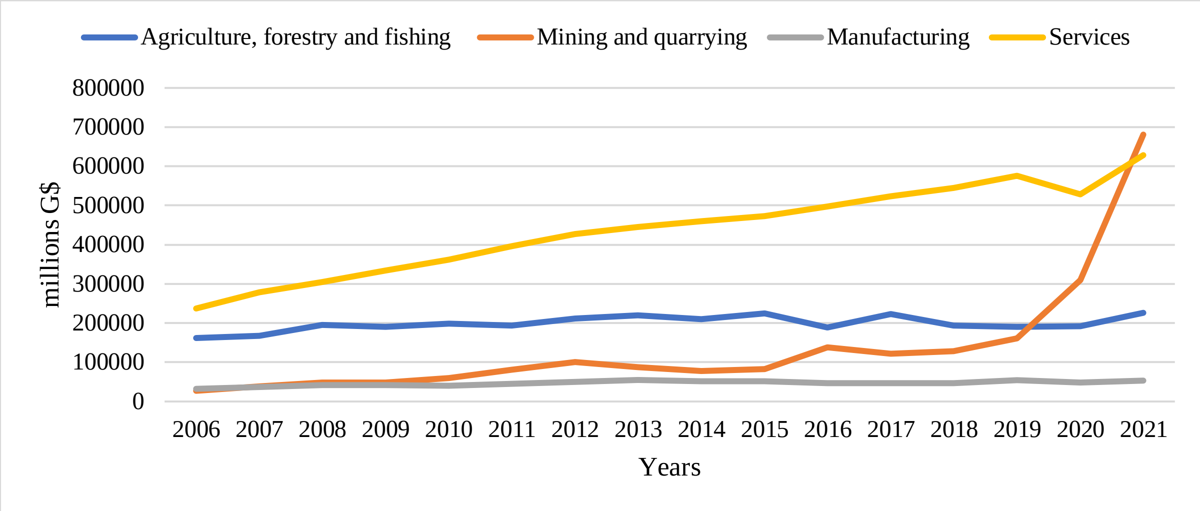

Figure 1.2: GDP by Economic Activity at Current Prices (G$'M) 20006-2021.
Source*: Bureau of Statistics, Guyana, 2022.*

Figure 1.2 shows the Gross Domestic Product by Economic Activity at Current prices for the period 2006-2021. Over the period 2006-2021, Guyana has witnessed a steady rise in the service sector's contribution to the Gross Domestic Product of the country. However, in recent times, Guyana's mining and quarrying sectors have witnessed a stack increase, owing to the exploration of oil in the country.[2] The Agriculture and Manufacturing sectors have witnessed a steady growth in GDP contribution averaging at GY$46 million and GY$136 million respectively.

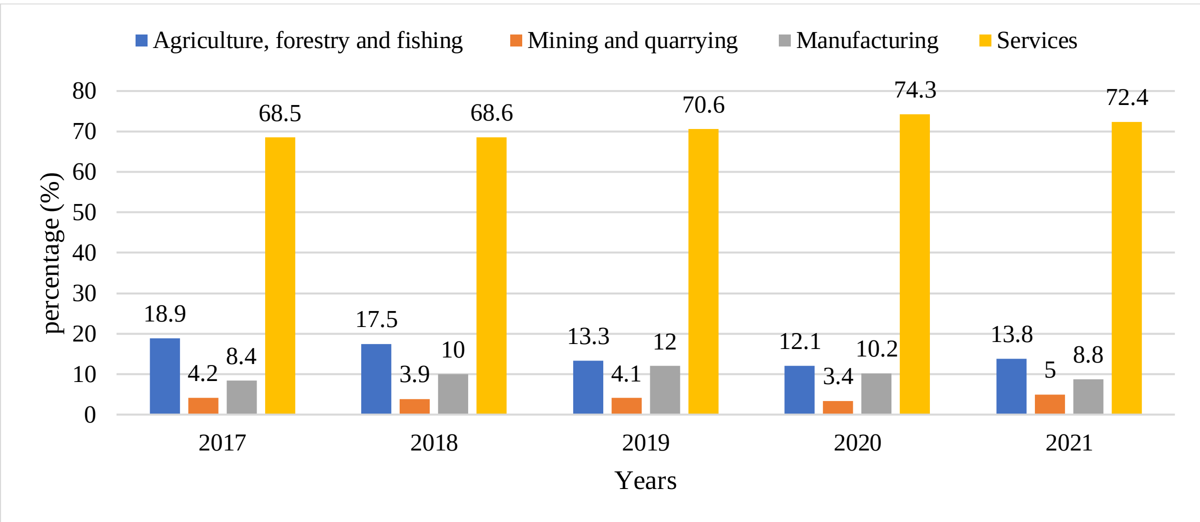

Figure 1.3: Employment by Economic Sectors (2017-2021).
Source: Guyana Labour Force Survey, Bureau of Statistics, Guyana, 2022

[2] Exxon makes three new oil discoveries in Guyana and boosts reserves | Reuters

Figure 1.3 shows the employment by economic sectors for the period 2017-2021. Guyana's service sector is responsible for an average of 71 percent of its employment, while the agriculture, forestry and fishery employ approximately 15 percent of its labour force, followed by manufacturing and mining and quarrying sectors with an average of 4 percent and 10 percent respectively.

In May 2015, a US-based company Exxon Mobil announced the discovery of a significant amount of oil in the Stabroek Block, Georgetown, 120 miles offshore Guyana in the North Atlantic Ocean.[3] In recent times, Exxon Mobil has announced several new oil discoveries in the Stabroek Block, with an anticipated recoverable oil exceeding eight billion barrels.[4] To draw a comparison, Venezuela, Guyana's neighbour hosts the world's largest oil reserves, i.e., more than 300 billion barrels.[5] Moreover, these recent oil discoveries place Guyana in the list of the top 20 countries with the largest proven oil reserves.[6] Consequently, Guyana is poised to experience a major boost in its GDP by 300-1000 percent by the end of 2025.[7]

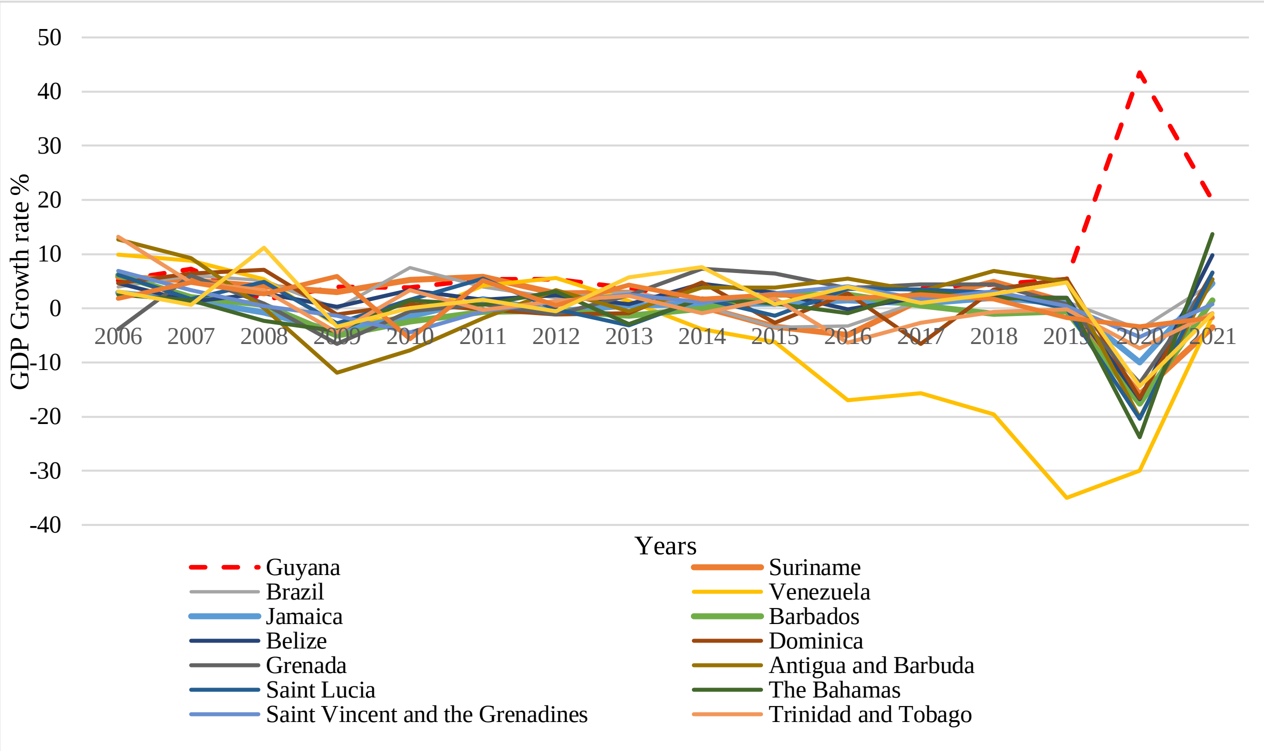

Figure 1.4: The GDP growth rate comparison for Guyana, its neighbouring counties and 11 CARICOM countries.
Source*: World Bank (2022)*

[3] ExxonMobil announces significant oil discovery offshore Guyana
[4] Guyana project overview | ExxonMobil
[5] International - U.S. Energy Information Administration (EIA)
[6] Guyana is number 17 for largest oil reserves in the world | OilNOW
[7] Will Guyana soon be the richest country in the world? - BBC News

Figure 1.4 shows the GDP growth rate comparison between Guyana, its neighbouring countries and 11 CARICOM countries. Over the period 2006-2019, Guyana and the CARICOM countries had relatively similar growth rates, however in 2020, Guyana recorded a GDP growth rate 43.5 percent, this represents a 38.1 percent increase over 2019.

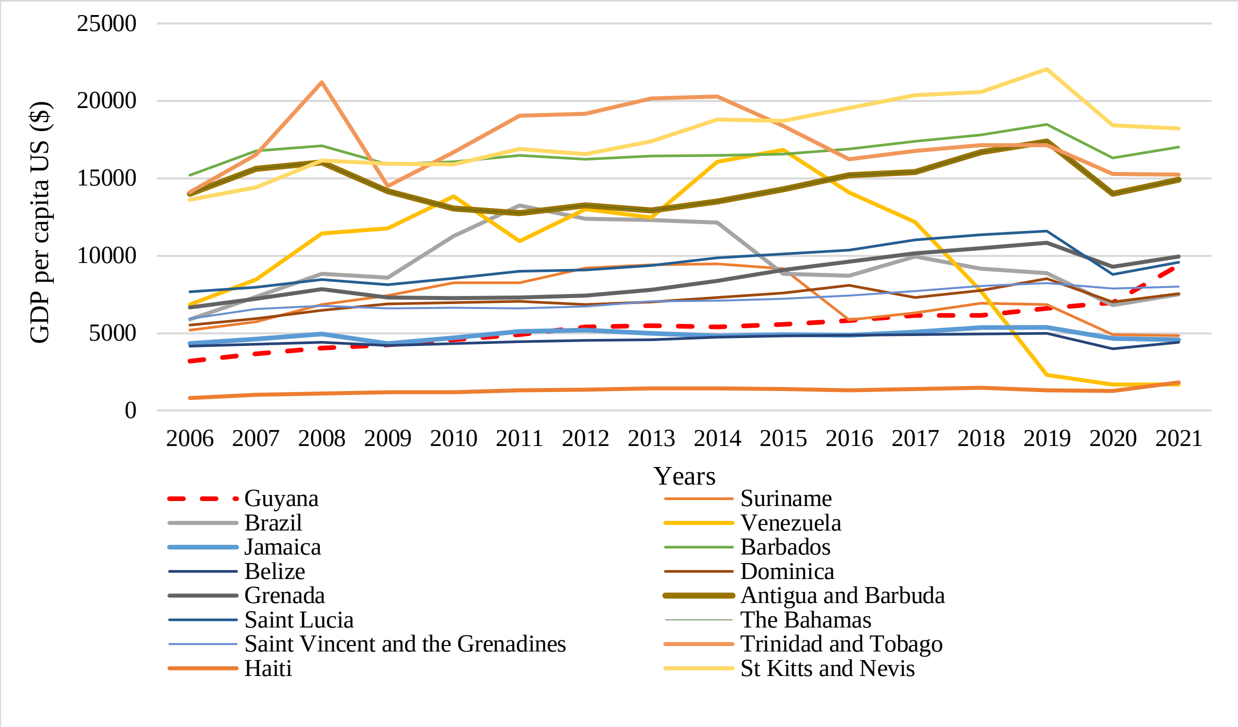

Figure 1.5: The GDP growth rate comparison for Guyana, its neighbouring counties and 11 CARICOM countries.
***Source**: World Bank (2022)*

Figure 1.5 shows the GDP growth rate comparison for Guyana, its neighbouring countries and 11 CARICOM countries. Over the years, Guyana's GDP per capita has increase, however in 2020 Guyana witnessed a sharp increase owing to oil extraction from Guyana's recent oil discovery. For the period 2006-2021, St Kitts and Nevis, Barbados, Suriname and Antigua and Barbados are the countries with the highest GDP per capita. While Venezuela has witnessed a sharp decline in their GDP per capita.

As it relates to climate change, Guyana is extremely susceptible to the effects of climate change due to its low-lying coastline which is prone to damage due to rising sea levels (World Bank 2022; Lakhan, 2014).[8] This and the other effects of climate change pose a major threat to economic growth

[8] World Bank Document

1.5 Guyana's Health and Education Sectors

The Government of Guyana (GoG) continues to invest heavily in Guyana's health and education sectors. In 2022 GoG allocated 26.7% of its GY$552.9 billion budget to the education (GY$74.4 billion) and health (GY$73.2 billion) sectors (Guyana Budget Bulletin, 2022). In Guyana, an average of 28% of its yearly budget is allocated towards its Health and Educational Sectors (Ministry of Finance, Guyana, Budget Speech, 2022). Figure 6 below shows the yearly budget by the government of Guyana to the Health and Educational Sectors (2007-2022). The Health and Education sectors remain top priorities for the GoG, as such based on Figure 1.6, the budget expenditure has steadily increased over the period 2007-2022. However, the stark increase in the budget expenditure for the health and education sectors in 2021-2022 is due mainly to controlling the Covid-19 pandemic.

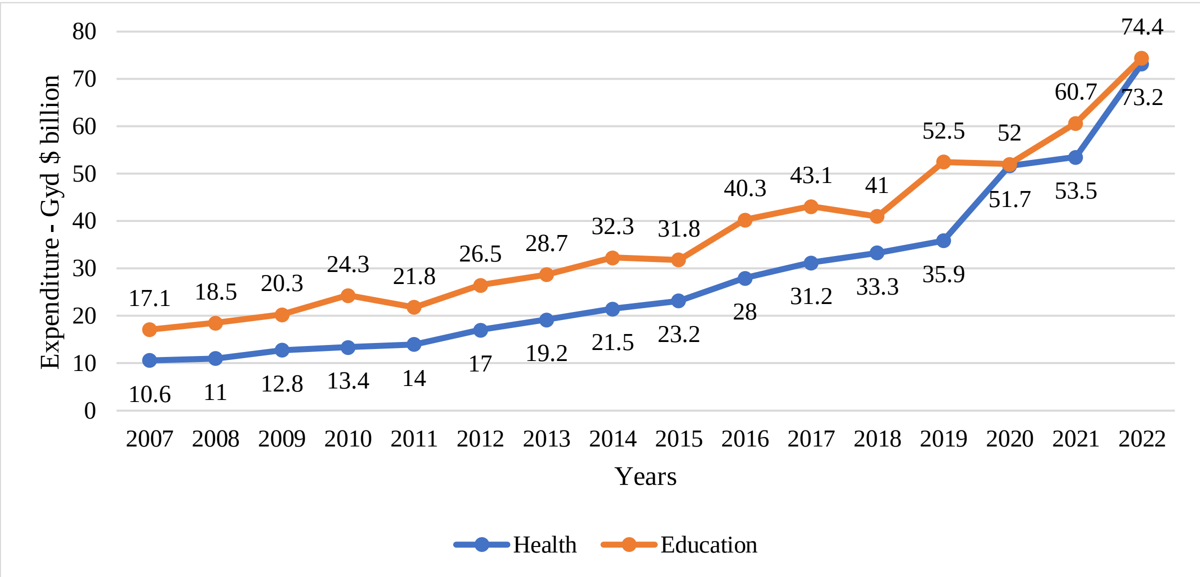

Figure 1.6: Guyana's yearly Budget Allocation to its Health and Education Sectors (2007-2022)
***Source**: Ministry of Finance, Guyana*

According to the World Bank Data, Guyana's government expenditure, total (% of GDP) on education and health sectors is approximately 9 percent for the period 2007-2018 while its larger neighbouring country Brazil is 14.3 percent. Furthermore, with respect to the CARICOM countries, the average government expenditure as a total % of GDP on these sectors is 10 percent (World Bank Data, 2022).

Guyana operates a universal healthcare system where primary healthcare facilities and services provided by the Georgetown Public Hospital Corporation (GPHC) are free to access to every citizen and resident of Guyana (Ministry of Health, Guyana, 2022). Furthermore, healthcare, and medical facilities in Guyana are provided by both the public and private sectors. Although primary healthcare is free of cost, complex procedures are partially subsidized.

Although public healthcare is free, the early-life health of children remains a major concern. According to the World Bank, the (1971-2014) records on the prevalence of stunting (i.e., an height-for-age z score < -2) for children under 5, Guyana witnessed an increase in stunting from 14 percent in 1998 to 19.5 percent at the end of 2009, however it witnessed a record low in 2014 of 12 percent.[9] Furthermore, in 2016 UNICEF disclosed that 1 in every 4 Amerindian child in the remote interior areas of Guyana is considered as suffering from stunted growth.[10] In 2020, it was noted that 28 percent of children in hinterland regions experienced stunted growth. It was also noted that 21 percent of mothers in these regions practice exclusive breastfeeding, which is below the South American average of 57.3 percent.[11] Consequently, childhood health remains a major concern for the Government of Guyana (UN Network, 2020).

In 2022, the GoG with the support of the Inter-American Development Bank (IADB) continues to advance efforts to improve the standard of healthcare, and this is reflected in increased life expectancy (which was 69.91 years as of 2019); reduction in maternal and child mortality; decreased incidence, prevalence and mortality from communicable diseases; high levels of immunization coverage; greater awareness of environmental health issues; and improved water and sanitation facilities (Ministry of Health, Guyana, 2022).

In 1961, the GoG established the Ministry of Education (MoE).[12] After gaining independence from Britain in 1966, Guyana inherited a well-established educational system with a curriculum and educational aims patterned after the British system. During the 1976 - mid-1990s, under the market socialism regime, education was free from nursery to university (UNWOMEN,

[9] https://www.ceicdata.com/en/guyana/health-statistics/gy-prevalence-of-stunting-height-for-age--of-children-under-5
[10] https://guyanatimesgy.com/1-in-4-amerindian-children-considered-stunted-unicef/
[11] https://www.unnetworkforsun.org/news/fueling-gains-nutrition-harnessing-guyanas-oil-boom-invest-human-development
[12] The statutory age for beginning compulsory education in Guyana is 5 years 6 months to 15 years.

2021). However, in the early 1990s, under the IMF structural reform period, access to education became free from nursery to secondary and this reform exists in modern-day Guyana.[13]

Guyana's secondary institutions have also experienced major reforms under the Universal Secondary Education (USE) (2003-2007) policy reform. Prior to 2003, secondary education in Guyana operated under a tier system where they were three types of secondary schools, namely, secondary departments of primary schools (popularly known as "Primary Tops"), Community High schools (CHSs) and General Secondary Schools (GSSs). The USE policy reform sought to make secondary education universally available to all students. Although the Ministry of Education has successfully converted the CHSs into GSSs, as of 2020, there are some Primary Tops that are still to be converted. Consequently, the MoE has set the attainment of quality USE as a major objective in its current Education Strategic Plan (Ministry of Education, 2022).

1.6 Layout of the Dissertation

In addition to this initial chapter, this study comprises of five chapters. Chapter 2 presents the effects of weather shocks on childhood health in Guyana. Chapter 3 explores the effects of a school conversion policy (namely the Universal Secondary Education, 2003-2007 policy) on educational attainment and labour market outcomes in Guyana. Chapter 4 presents the effects of birth order on child health in Guyana. Chapter 5 summarises the key findings and explores the overall policy implications and opportunities of future research emerging from this dissertation.

[13] Guidelines and procedures for the placement of students at the various levels of the Education System.

CHAPTER 2

The effects of weather shocks on early childhood health in Guyana.

2.1 Introduction

Over time, the world has witnessed a rise in global temperatures and an increase in the frequency and severity of natural disasters such as earthquakes, bush fires, tsunamis, floods, droughts, and hurricanes, all largely attributed to climate change (López et al., 2015; IPCC, 2022). These catastrophic events have been shown to have negative effects on countries' GDP, investments, employment and earnings, education, and health (Botzen et al., 2019). Moreover, lower-income countries are especially affected by climate change, and this hinders them from attaining the Sustainable Development Goals (United Nations, 2019). Consequently, it is important for governments in developing countries to understand the effects of such shocks and accordingly devise effective strategies to mitigate the adverse effects of weather shocks.

In this study, we analyse the effects of in-utero weather shocks on early childhood health in Guyana. This is the first study to address this question in the context of Guyana. We use rich anthropometric data for children under age 5, from three rounds of the Guyana Multiple Indicator Cluster Survey (MICS) and combine that with rainfall shocks in the region and year of birth, constructed using geo-spatial precipitation data. These large-scale data are underutilized in the Guyanese context and allow us to shed light on the health impacts of weather shocks in a middle-income flood-prone country. In doing so, we provide evidence related to the 'fetal origins hypothesis'.[1] This hypothesis states that the intra-uterine environment determines the long-run health outcomes of children and their human capital achievements. We focus on three measures of early childhood health: height-for-age z-score (hereafter, HAZ), and indicators for stunting and severe stunting. A child's HAZ is an important measure that captures lingering effects of any growth disturbances that might have occurred earlier in their life (Leroy et al., 2015).[2] Stunting, or low height-for-age, is the most prevalent measure of child malnutrition, and it usually reflects insufficient nutrient intake during the early stages of development. Stunting generally occurs before age two and once established, is usually permanent, and most children do not regain the height lost or achieve a

[1] Almond and Currie (2011) and Almond et al. (2018) provide overviews of this literature.
[2] While the weight-for-age z-score which captures short term illness, HAZ captures chronic illnesses (Victora et al., 2008)

normal body height. Some consequences may be extremely severe: stunted growth in childhood due to incomplete development of vital organs may lead to premature death later in life. Less extreme effects also include delayed development, impaired cognitive function, and poor school performance (UNICEF, 2007; WHO, 2015).

Our results show that prenatal exposure to positive rainfall shocks (i.e., where rainfall is significantly above the long-term regional average) in the nine months preceding birth increases the likelihood of being stunted and severely stunted while negative rainfall shocks (i.e., where rainfall is significantly below the long-term regional average) do not affect growth significantly. We also consider the timing of these shocks in terms of the trimester of exposure. We find that the adverse effects of positive rainfall shocks on HAZ and stunted and severely stunted growth are greater during the first trimester. We also find that negative rainfall shocks in the third trimester positively impact the HAZ. Moreover, when examining heterogeneous effects, we find that positive rainfall shock increases height-for-age z-scores in urban areas as compared to rural areas. However, we do not find any differential effects of rainfall shocks on health outcomes based on child gender and maternal education.

This study and its findings contribute to the broader literature on shocks and their impact on childhood health. Studies have empirically shown that exposure to adverse conditions in early childhood – disasters, conflict, diseases, famine, and pollution – has significant negative impacts on health outcomes such as HAZ and stunting (e.g., Glewwe and King, 2001; Alderman et al., 2006; Victora et al., 2008; Ogasawara and Yumitori, 2018; Aguilar and Vicarelli, 2022). Furthermore, exposure to shocks in-utero also leads to growth faltering i.e., a slower rate of weight gain in childhood than normal for age and sex (Almond et al., 2009; Banerjee et al., 2010; Dercon and Porter, 2014). This is important as children who experience slow height growth are found to perform worse in school, score poorly on tests of cognitive function, and have poorer psychomotor development and fine motor skills. They also tend to have lower activity levels, interact less frequently in their environments, and fail to acquire skills at normal rates (Salm and Schunk, 2012). Rainfall shocks during the in-utero period led to long-term negative impacts such as lower overall total years of schooling and lower wages in adulthood (Almond et al., 2018; Rosales-Rueda, 2018). Further, negative rainfall fluctuations in-utero are associated with lower birth weight, premature labour, high infant mortality rate, lower academic test scores, higher incidence of delayed enrolment and higher dropouts and grade repetition (Rocha and Soares, 2011). Consequently, environmental, and economic shocks experienced in-utero and in early childhood may have long-lasting impacts on one's health and economic outcomes in adulthood (Currie and Vogl, 2013; Strauss and Thomas, 2008).

Our findings also speak to the literature on whether positive or negative weather shocks affect household welfare and health outcomes more. The literature studies both positive rainfall shocks (floods) and negative rainfall shocks (droughts) on health and human development outcomes and the results are not always consistent. For instance, Leight et al. (2015) find that both positive and negative rainfall shocks in-utero had significant negative effects on children's HAZ in China, but only positive rainfall shocks negatively impacted their cognitive skills in primary school. Carrillo (2020) finds that negative effects of prenatal droughts on adult outcomes were smaller relative to the negative effects of floods.

Maccini and Yang (2009) find that positive rainfall in one's birth year and birth district have a positive relationship with adult height, completed years of education, and wealth in adulthood for women in Indonesia. On the contrary, Skoufias et al. (2011) studied the impacts of rainfall shocks on the welfare of households in rural Mexico and revealed that positive rainfall shocks are associated with lower HAZ while negative rainfall shocks had different impacts based on regions and socioeconomic characteristics. Rocha and Soares (2015) studied water scarcity and birth outcomes in Brazil's semiarid regions and found that negative rainfall shocks during the in-utero periods are correlated with higher infant mortality, lower birth weight, and shorter gestation periods. Kumar et al. (2016) also documents that exposure to drought in-utero is associated with lower weight-for-age z-scores and increased probabilities of being underweight for children in India.

Our findings also contribute to an understanding of critical periods where shocks can have the greatest health impacts. Some studies find that birth outcomes are most sensitive to maternal stress during the first trimester of pregnancy (Camacho, 2008; Currie and Rossin-Slater, 2013; Bozzoli and Quintana-Domeque, 2014). However, Kramer (1987) and Stein et al. (2000) posit that nutritional deficit impact birth weight mostly in the third trimester of pregnancy. Rosales-Rueda (2018) finds that children who had prenatal exposure to severe floods in Ecuador during the 1997-1998 El Niño phenomenon, particularly during the third trimester of pregnancy, scored relatively lower on cognitive tests and were shorter five and seven years later. Carrillo (2020) finds that the long-run effects on educational and health outcomes from exposure to floods and droughts occurred mainly in the first trimester of gestation. Moreover, Randell et al. (2020) finds that greater than average rainfall in Ethiopia during the third trimester in utero is positively associated with severe stunting, however, a child's HAZ increases with greater exposure to early-life rainfall. Le and Nguyen (2021) find that exposure to excess rainfall in the first trimester in fifty-five low- and middle-income countries led to a reduction in children's HAZ by 0.14 standard deviations and an increase in stunting by 0.03 percentage points. They also find that exposure to excess rainfall in the second and third trimesters lead to a reduction in children's HAZ by 0.14 and 0.14 standard deviations respectively. Moreover, when examining the lack of rainfall, they also found similar results.

There are several mechanisms through which in-utero weather shocks have been shown to affect child health. Firstly, through poverty and loss of income, weather shocks can have serious welfare consequences both in the short and long run (Edoka, 2013). Further, it can lead to intergenerational effects which can lead to poverty traps particularly for the disadvantaged groups (Almond et al., 2018). Secondly, this can lead to maternal stress and malnutrition for the mother which can exacerbate the incidence of negative health impacts on the developing foetus. Kramer (1987) posits that the increase in the likelihood of low birth weight may be driven by intrauterine growth restriction, which is largely determined by poor maternal nutrition. Aguilar and Vicarelli (2022) showed that negative effects of floods on income, food consumption, and diet composition during early childhood appear to be key mechanisms behind the impacts on children's outcomes. Thirdly, the incidence of positive rainfall shocks can lead to a disease environment through water-borne diseases such as leptospirosis, malaria, yellow fever, dengue fever among others (Maccini and Yang, 2009). Finally, there can be difficulties in access to health facilities during periods of excessive rainfall (Bonjean et al., 2012; Dimitrova and Bora, 2020) due to damaged road infrastructure and shortage of staff availability and this is another mechanism that contributes to the adverse effects of weather shocks on child health.

Over the period, there are several reports of flooding in Guyana in both urban/rural or coastal/inland areas. According to Pelling (1999), ninety percent of the Guyanese population are at risk from contemporary flood hazard, the potential impacts of climate change and sea-level rise. For instance, in 2005, Guyana experienced high levels of rainfall which resulted in regions 3, 4 and 5 being flooded. Regions 1, 2 and 6 were also affected. According to the Word Bank (2005) report, the 2005 flood adversely affected sectors such as health, education, water and sanitation, food, agriculture, and infrastructure. The flood results in health centers and clinics being closed due to equipment and drug supplies being damaged. As such, public health programs in the affected areas been interrupted. In addition, water treatment plants were out of service due damages.[3] The 2005 flood also resulted in economic impacts that were estimated to be around US$465 million (59% of the Guyana's then GDP). Majority of the losses were seen in Guyana's Rice sector, thus resulting in thousands of acres of rice and other sources of economic activities that were concentrated in the low-lying coastal plains and most fertile agricultural regions 4 and 5.[4]

Moreover, in January 2006, Guyana experienced yet another episode of flooding regions 1, 2, 3, 5, 6 and 9, where regions 2 and 5 were officially declared disaster areas.[5] In January 2012, heavy rainfall resulted in several communities being flooded in regions 1, 2, 3, 4, 5, and 6.[6]

Moreover, studies have shown that urban areas are better able to deal with weather shocks as they are better equipped in all ways to withstand and recover from shocks when compared to rural areas (Burgess, 2014; Hallegate et al., 2020). Furthermore, based on the heterogeneity by urban/rural areas, it is evident that in the case of Guyana, urban areas were better able to cope with weather shock impacts on child health outcomes than in rural areas. Consequently, it is expected that the mechanism listed above might have affected in-utero exposure to weather shocks.

Furthermore, the estimates in this chapter are thus a combination of the effect on actual affected people and the proportion of people affected by a shock. We argue that the proportion of people affected by a shock is close to 100% at the regional level.

The rest of the paper is organised as follows. Section 2.2 provides a background on Guyana and its climate. Section 2.3 describes the data sources and descriptive statistics. Section 2.4 introduces the empirical strategy. Section 2.5 presents the results and Section 2.6 concludes.

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[3] https://www.gfdrr.org/sites/default/files/publication/pda-2005-guyana.pdf
[4] https://www.gfdrr.org/en/floodpreventioninguyana
[5] file:///Users/nichola/Downloads/gyfl03.pdf
[6] https://www.cdema.org/index.php?option=com_content&view=article&id=1040:flooding-in-guyana-situation-report--3&catid=125:guyana

2.2 Background on Guyana and its Climate

The Co-operative Republic of Guyana is the third-smallest sovereign state in mainland South America with an area of 214,970 km^2. It is classified as an upper-middle-income country (World Bank, 2020) with 41.2 percent of its people living below the USD 5.50 a day poverty line (Inter-American Development Bank, 2017). Approximately, ninety percent of Guyana's population inhabits flood-prone areas along the coastal plains which is half to one metre below sea level. Further, the coastal plains are also home to seventy five percent of the country's economic activities.

Guyana has an equatorial climate that is characterised by a high level of rainfall variability and the seasons and climate are determined by this variability. Consequently, there is high humidity and small variations in temperature owing to it being located just above the equator (Guyana Second National Communication to the United Nations Framework Convention on Climate Change, 2012). The mean temperature in Guyana is 25-27.5^{o}C throughout the year in most regions except for the upland regions in the west, where the mean temperature is 20-23^{o}C (World Bank Climate Change Knowledge Portal, 2020).

In general, most of Guyana has two rainy and two dry seasons. However, in the southernmost parts there is one peak period of rainfall. The rainy seasons vary by location. The first one runs from December to early February (the small rainy season) and affects mainly the northern, coastal regions which receive approximately 6-12 inches of rainfall per month. The second begins in late April and lasts until early July (the main rainy season). Consequently, most of the country receives an average monthly rainfall of 10-18 inches between May and July. However, the periods in between are drier, but not extremely dry, since, during the two drier periods (February – April and July – November), the average precipitation per month based on month variability lies between 2.3 – 7 inches of rainfall.

Studies conducted by Douglas (1995) and Smith et al. (1999) indicate "that the sea level on the region of Guyana is increasing at a rate in excess of 10mm/year – or 2 to 5 times faster than the global estimate." (Guyana Second National Communication to the United Nations Framework Convention on Climate Change, 2012, pp. 23). Therefore, changes in the sea level increase the severity of individual rainfall events, and variations in annual rainfall levels pose significant threats to Guyana's East Demerara Water Conservancy system, a 150-year-old storage system providing irrigation and safe water to ninety percent of people living in the coastal plains. The rise in sea level also affects the drainage infrastructure and future agricultural production (see Figure 2.1 below for a map of Guyana showing the average annual rainfall by regions). For instance, in 2011 coastal farmers in Guyana were hit by the rising sea levels and failing seawalls which resulted in agricultural losses (Thomson Reuters Foundation News, 2011).

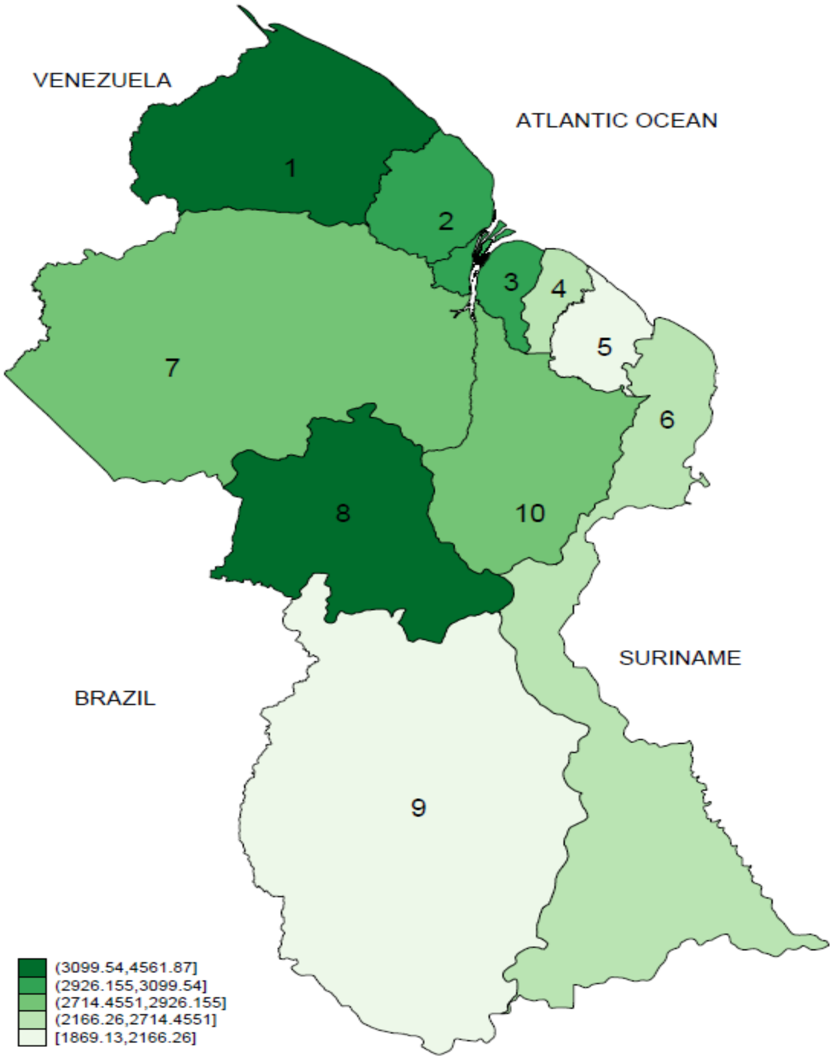

Figure 2.1: Map of the average annual rainfall by regions of Guyana.
Source: Author's illustration based on rainfall data provided by Guyana Hydrometeorological Service and the University of Delaware (UDEL).

According to the projections of land inundation during minimum and maximum storm surges, Guyana is expected to experience increases in temperature and increased rainfall in the rainy season and less precipitation in months where there are already water deficits. In Guyana, it is evident that the topography makes it susceptible to flooding, which has health impacts on the populace.

2.3 Data Sources and Descriptive Statistics

2.3.1 Multiple Indicator Cluster Surveys (MICS)

This paper uses individual-level data from the Multiple Indicator Cluster Surveys (MICS) for Guyana. The three rounds of Guyana MICS in 2000, 2006-07 and 2014 were carried out by the Guyana Bureau of Statistics in collaboration with UNICEF. MICS is a nationally representative sample survey of households and was designed to provide estimates on a variety of indicators about children and women across the country. It gathers information from women aged 15-49 on demographic topics such as birth history, anthropometric data, health service utilisation, and nutritional status of mothers and young children under the age of five.

The Guyana MICS uses the 2002 and 2012 Population and Housing Censuses to divide the regions into 300 enumeration districts (EDs). The sample sizes for the women who were successfully interviewed in each round of the MICS 2000, 2006-07 and 2014 were 4,801, 5,035 and 5,076 respectively, resulting in a total of 14,912 women. Each survey aimed at targeting approximately 6,000 households in 300 EDs, i.e., 20 households per ED. The total number of households was then divided by the number of sample households per ED and 300 clusters were allocated to two domains (coastal/urban and interior/rural) across the 10 regions.

Our outcome variables are height-for-age z-scores (HAZ), and dummy variables for stunted and severely stunted growth. In this study, the HAZ was taken directly from the MICS surveys.[7] In essence, the z-score is calculated by standardising a child's height, given age and sex, against an international standard of well-nourished children. 'Stunted' is a dummy variable that takes a value of 1 if the child's height is -2 SD below the age-sex standardised height of a healthy reference population, and 0 otherwise. Similarly, 'severely stunted' is a dummy variable that takes a value of 1 if the child's height is more than -3 SD below the mean on the WHO Child Growth Standards and 0 otherwise.

All rounds of the MICS collected detailed information on the month and year of birth of the child, region of birth, and height/length of children that were measured by MICS enumerators for children aged 0-4. While the overall sample across all 3 rounds of MICS comprises 8,720

[7] The HAZ is calculated by comparing the child's height/length with the median value in the reference population. The difference is divided by the standard deviation of the reference population as illustrated by the formula: Z-score = (Individual value of the child – median value of children in the reference population)/Standard deviation of the reference population.

children aged 0-4, the HAZ scores are available for 7,636 children, and therefore, we limit the sample to those children for this study.

Control variables used in this analysis is a dummy for the gender of the child (takes the value 1 if male and 0 if female), a dummy for maternal higher education (which takes the value 1 if mother has higher education and 0 otherwise), a dummy for the location of the household (takes the value 1 for urban areas and 0 for rural), month of birth, year of birth, and region of birth fixed effects, and MICS survey wave fixed effects.

2.3.2 Rainfall Data

This paper uses monthly rainfall data from the Guyana Hydrometeorological Service (HydroMet) for 1980-2014 for 68 weather stations spread across the ten regions. As there were approximately 15 percent missing station data in the HydroMet, we conducted correlation tests between the University of Delaware (UDel) gridded high-resolution station (land) data for precipitation and HydroMet data for those stations with complete data in both datasets and found that the two datasets were highly correlated.[8] Consequently, we used the UDel 1980 - 2014 precipitation data to fill the small gaps in the Guyana HydroMet service rainfall records. We use the monthly station-level data to calculate monthly averages for each region. The advantage of taking this approach is to have accurate station-level data within the ten regions used in the analysis.

To construct measures for rainfall shocks, we first need to establish historical means and standard deviations. The historical mean and standard deviation are calculated for each region and month over 1980-2014 (e.g., mean historical rainfall for region 1 for January is calculated as the average of rainfall in January across all years spanning 1980-2014; similarly for standard deviation). Accordingly, we define a given month as having ‘normal rainfall’ if rainfall fell within plus/minus 1 standard deviation of the historical monthly mean for that region. Similarly, we can construct indicator variables for ‘positive rainfall shocks’ and ‘negative rainfall shocks’ for a given region and month if the rainfall is more than plus 1 or less than minus 1 standard deviation with respect to the historical monthly mean of that region respectively. Based on the above, we define in-utero positive, negative, and normal rainfall

[8] Bovolo et al., 2011 paper shows the gaps in the Guyana Hydromet Service Data in 1999-2001. See: Finescale regional climate patterns in the Guianas, tropical South America, based on observations and reanalysis data (ncl.ac.uk)

shocks as the fraction of months during the 9 months preceding the month of birth that the positive, negative, and normal rainfall indicators equal one. For example, if an individual was born in September, then in-utero exposure to positive (negative) rainfall is computed as the share of positive (negative) rainfall months during the 9 months spanning January-September.

In addition, to gain an understanding of which periods of pregnancy are most critical in terms of impact of shocks, we also calculate the shocks based on trimesters of birth, i.e., first trimester (embryonic), second trimester (foetal) and third trimesters (perinatal). We construct variables for positive and negative rainfall shocks in each trimester of birth. The first trimester positive (negative) rainfall is the fraction of months during the 6-8 months before birth that the positive (negative) rain indicator equals one. Similarly, the second and third trimesters are defined as 3-5 months and 0-2 months preceding birth respectively.

It is important to note that using this approach does not provide any absolute measure of the rainfall shocks, as it varies by years, months, and regions. That is, for each month, there is one value for the climatical average or historical mean. For instance, for the month of January, the average rainfall is the mean for Januarys between the years (1980-2014) for all the stations within the regions and constitutes the historical mean or climatological average. Hence, each regional result is relative to its own normal rainfall conditions (every region and month would have their own historical means based on the (1980-2014) period) as rainfall patterns and amounts are considerably varied both spatially and temporally across the country (See Figure 2.1). The historical mean was calculated by taking several years for the same month. Therefore, if the rainfall in that year and month is greater than the historical mean for that month and year plus 1 SD standard deviation then it is classified as a positive rainfall shock. This rainfall shock is not indicative of flood conditions, merely wetter than normal conditions as there are no available flood records for the country.

2.3.3 Summary Statistics

Table 2.1 below provides descriptive statistics of the key variables used in our analysis. The HAZ for children ranges from -9.62 to 6.58 with a mean of -0.655 and a standard deviation of 1.54. On average 16 percent of the children have stunted growth while 5 percent are severely stunted. 52 percent of the children are male. On average, 11 percent of the prenatal period of 9 months was characterised by positive rainfall shocks, 5 percent by negative rainfall shocks and

84 percent by normal rainfall. These figures are similar across the different trimester-specific rainfall shock variables. About 2 percent of the mothers have no education, 23 percentage have primary education and 75 percent have higher education (classified as those with secondary or university education). 74 percent of the children reside in urban locations.

Table 2.1: Summary statistics

Variable	Mean	Standard deviation	Min	Max	N
Rainfall shock-related variables					
Fraction of Positive rainfall (in-utero)	0.108	0.112	0	0.556	7626
Fraction of Negative rainfall (in-utero)	0.053	0.089	0	0.556	7626
Fraction of Normal rainfall (in-utero)	0.839	0.131	0.333	1	7626
Fraction positive rain – 1st trimester	0.112	0.189	0	0.667	7626
Fraction positive rain – 2nd trimester	0.103	0.181	0	0.667	7626
Fraction positive rain – 3rd trimester	0.109	0.188	0	0.667	7626
Fraction negative rain – 1st trimester	0.055	0.141	0	1	7626
Fraction negative rain – 2nd trimester	0.055	0.141	0	1	7626
Fraction negative rain – 3rd trimester	0.050	0.135	0	1	7626
Fraction normal rain – 1st trimester	0.834	0.218	0	1	7626
Fraction normal rain – 2nd trimester	0.842	0.213	0	1	7626
Fraction normal rain – 3rd trimester	0.841	0.215	0	1	7626
Fraction positive rain – 12 months after	0.107	0.101	0	0.5	7626
Fraction negative rain – 12 months after	0.046	0.074	0	0.5	7626
Fraction of positive rain (90th10th percentile)	0.088	0.095	0	0.444	7626
Fraction positive rain (90th 10th) – 1st trimester	0.089	0.169	0	1	7626
Children Characteristics					
Male	0.515	0.499	0	1	7626
Height-for-age (z-score)	-0.641	1.521	-5.99	5.91	7626
Stunted	0.157	0.364	0	1	7626
Severely Stunted	0.051	0.220	0	1	7626
Postnatal investments					
BCG vaccination	0.993	0.082	0	1	5161
DPT vaccination	0.927	0.261	0	1	4375
Measles vaccination	0.855	0.355	0	1	4366
Ever breastfed	0.928	0.260	0	1	6433
Mother Characteristics					
No education	0.023	0.148	0	1	7626
Maternal primary education	0.220	0.415	0	1	7626
Maternal higher education	0.756	0.429	0	1	7626
Urban	0.739	0.439	0	1	7626

Notes: The sample is restricted to the MICS 2000-2014 on individuals born between 1995 and 2014 and to observations where height-for-age z scores are available. Higher education comprises both Secondary and tertiary education. Rainfall shocks were constructed using data from the Guyana Hydrometeorological Service and the University of Delaware Precipitation V5.01.

2.4 Empirical strategy

To measure the relationship between in-utero rainfall shocks and early childhood health, we employ linear regressions using the following specification:

$$H_{ijmt} = \alpha + \beta_1 R_{1ijmt} + \beta_2 R_{2ijmt} + \beta_3 Z_{ijmt} + \theta_j + \lambda_t + \varphi_m + \eta_w + \varepsilon_{ijmt} \quad (1)$$

where H_{ijmt} is the dependent variable of interest and it represents either HAZ for child *i* born in region *j* in month m and year *t*, dummy for being stunted (i.e., HAZ < -2 SD) or dummy for being severely stunted (i.e., HAZ < -3 SD). The coefficients of interest β_1 and β_2 measures the effects of prenatal exposure to rainfall shocks on childhood health. R_{1ijmt} is the fraction of positive rainfall months during the 9 months preceding birth while R_{2ijmt} is the fraction of negative rainfall months during the 9 months preceding birth. Z_{ijmt} is a vector of controls which includes a dummy for the gender of child (takes the value 1 if male, 0 if female), a dummy for location (takes the value 1 if urban, 0 if rural), and a dummy for maternal education (takes the value 1 for higher education, 0 if otherwise). We also include region-of-birth fixed effects (θ_j), which absorb any unobservable time-invariant region-level determinants of child health, including geography, infrastructure such as roads and area-specific risks of diseases. The year-of-birth fixed effects (λ_t) and month-of-birth fixed effects (φ_m) capture any climatic or socioeconomic conditions or aggregate shocks impacting the entire country in a certain year and month and secular trends in health outcomes. η_w is the vector of the MICS survey wave fixed effects. ε_{ijmt} is the stochastic error term clustered at enumeration district (ED) level from MICS.

Additionally, to understand the effect of trimester-specific positive and negative rainfall shocks, we estimate an equation below similar to equation 1, but where the key variables of interest (ω_{ijmt}) are the vectors of trimester-specific shocks.

$$H_{ijmt} = \alpha + \Upsilon_1 \omega_{ijmt} + \Upsilon_2 Z_{ijmt} + \theta_j + \lambda_t + \varphi_m + \eta_w + \varepsilon_{ijmt} \quad (2)$$

In Section 4, we examine factors that might differentially influence the effects of rainfall shocks on childhood health. In particular, we examine the heterogeneous effects based on child's gender, maternal higher education, as well as the location of households (rural or urban). The following specifications are estimated building on equation 1:

$$H_{ijmt} = \alpha + \alpha_1 R_{1ijmt} + \alpha_2 R_{2ijmt} + \alpha_3 Z_{ijmt} + \alpha_4 X_{ijmt} + \alpha_5 M_{ijmt} + \alpha_6 Z_{ijmt} \text{ x } R_{1ijmt} + \alpha_7 Z_{ijmt} \text{ x } R_{2ijmt} + \theta_j + \lambda_t + \varphi_m + \eta_w + \varepsilon_{ijmt} \quad (3)$$

$$H_{ijmt} = \alpha + x_1 R_{1ijmt} + x_2 R_{2ijmt} + x_3 Z_{ijmt} + x_4 X_{ijmt} + x_5 M_{ijmt} + x_6 M_{ijmt} \text{ x } R_{1ijmt} + x_7 M_{ijmt} \text{ x } R_{2ijmt} + \theta_j + \lambda_t + \varphi_m + \eta_w + \varepsilon_{ijmt} \quad (4)$$

$$H_{ijmt} = \alpha + \Phi_1 R_{1ijmt} + \Phi_2 R_{2ijmt} + \Phi_3 Z_{ijmt} + \Phi_4 X_{ijmt} + \Phi_5 M_{ijmt} + \Phi_6 X_{ijmt} \text{ x } R_{1ijmt} + \Phi_7 X_{ijmt} \text{ x } R_{2ijmt} + \theta_j + \lambda_t + \varphi_m + \eta_w + \varepsilon_{ijmt} \quad (5)$$

where $\alpha_1, \alpha_2, x_1, x_2, \Phi_1, \Phi_2$ in equations 3-5 represents the main effect of in-utero exposure to positive (negative) rainfall shocks on early childhood health. For instance, if α_1 (α_2) in equation 3 is negative, this would suggest that the exposure to positive (negative) rainfall shocks had a negative impact on early childhood health and if the coefficients are positive the opposite is true. $\alpha_6 - \alpha_7$ in equations 3 are the coefficients on interactions of prenatal rainfall with the child's gender dummy and urban location dummy. α_6 *and* α_7 gives the heterogeneous effects, i.e., it gives the differential effects of the child's gender, urban location and the mother's education of those children who had experienced positive (negative) rainfall shocks while in-utero. Note, that this analogy would also hold in the case of equations 4 and 5.

Moreover, if α_6 and α_7 are positive, this would suggest that the positive shocks have differentially more positive effect on childhood health for male, while negative α_6 and α_7 would suggest the opposite. Likewise, this analogy would also hold when examining maternal higher education and urban/rural location in equations 4 and 5 respectively.

Given that the sample is based on surviving children only, the problem of selective mortality (either during pregnancy or in early infancy) may be of concern. Studies have shown that most miscarriages occur in the first trimester (Maconochie et al., 2006; Yakusheva and Fletcher, 2015). Consequently, if the exposure to rainfall shocks affects this selection process, then the estimated impacts after birth would need to be a combination of selection and a direct treatment effect. However, using this selected sample would bias the estimates towards zero. Therefore, the estimates in this paper should then be taken to the lower bound of the true effect.

It is also important to note that between the years (2000-2014), Guyana's under-five mortality rate declined sharply from 47 in 2000 to 34 per 1,000 live births in 2014 respectively (UNICEF, 2023; Guyana MICS 2014). As such, based on the available data provided by the World Bank and UNICEF, it is evident that child mortality rates in Guyana have been decreasing in recent years. Furthermore, according to the Ministry of Health, there were no known weather shock related deaths of children under the age of five years old in Guyana during the 1995-2014 period. In addition, the MICS 2006-07 and MICS 2014 reported 41 and 34 per thousand birth under-five mortality respectively. Thus, representing lower under five mortality rates (see MICS 2006-07 report and MICS 2014 report).

In addition, when comparing child mortality between Guyana and other developing countries in the low-middle income bracket based on the 2000-2014 period, Bangladesh recorded 58 and 40 per thousand birth under-five mortality rates respectively in the year 2007 and 2014, while Bolivia a country in South America recorded 50 and 33 per thousand birth under-five mortality rates respectively in the year 2007 and 2014(World Bank Data, 2023). Furthermore, the average under-five mortality rate for all low-middle countries for the year 2000, 2007 and 2014 stood at 84, 64 and 48 per thousand births respectively (World Bank Data, 2023). Therefore, within the 2000-2014 period, the under-five child mortality rate in Guyana was lower than the average for countries in the same bracket.

2.5 Results

2.5.1 Regional Rainfall Condition (1995-2014) and HAZ scores

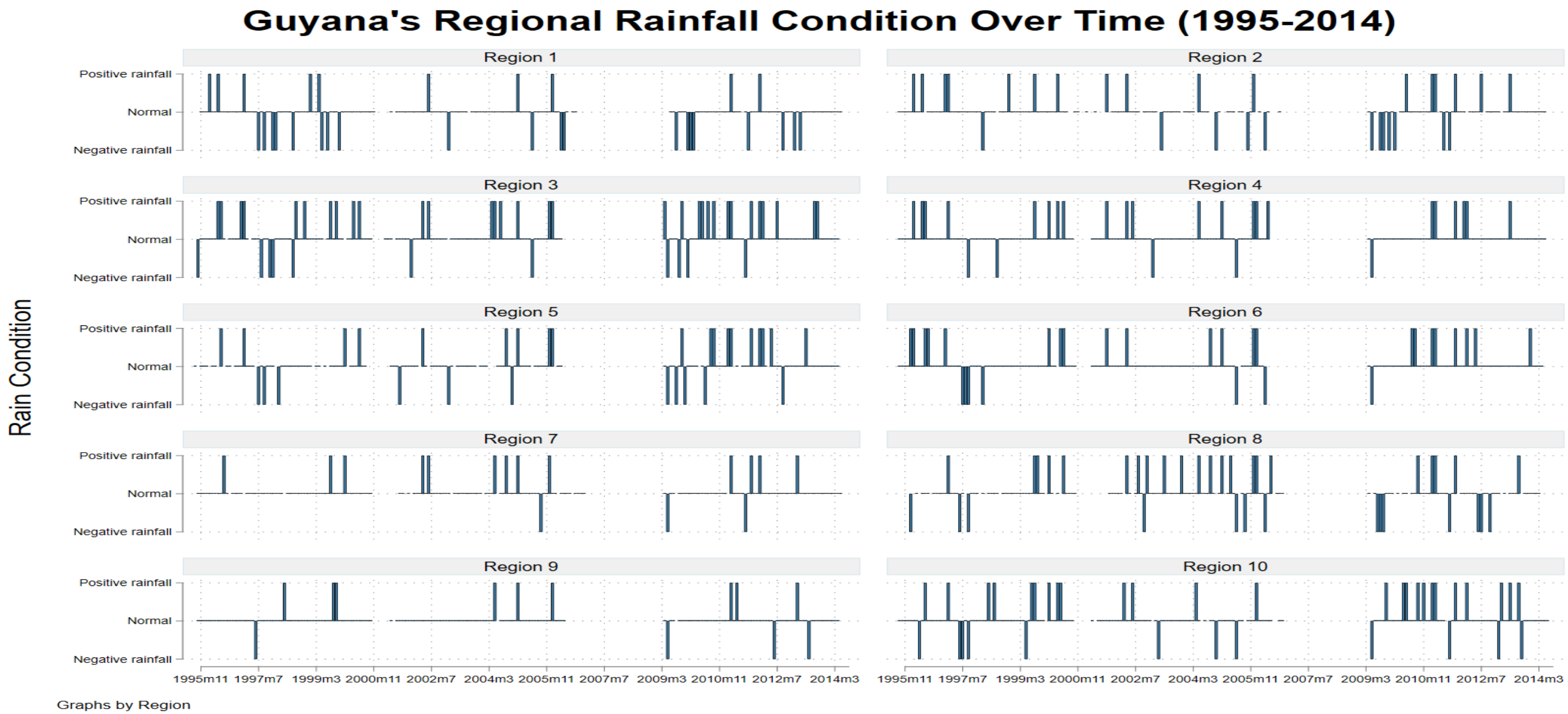

Figure 2.2: Showing Guyana's Regional Rainfall Condition for the period (1995-2014)

Figure 2.2 above shows the rainfall condition at regional levels based on positive, negative, and normal rainfall shocks. The rainfall data is at the regional level. The regions are large areas with low population density and centralised health services. The smaller coastal regions of 3, 4 and 6 has densely populated small areas along the coastal stirp with better transportation and health services infrastructure. Considering that the finest resolution of the MICS data is regional scale, the rainfall shocks were calculated at the regional level. Figure 2.2 provides a depiction of the impact of the positive and negative shocks by regions for children born within the nineteen-year period (1995-2014) based on the MICS surveys done in Guyana. It is important to make the distinction that the study scales the rainfall between what are defined as positive and negative shocks and not floods as individual flood events and extents are not available for the regions.

Based on Figure 2.2, the regions that were most affected are regions 3, region 4, region 6, region 8 and region 10. However, in the MICS 2000, 2006-07 and 2014, the greater sample which comprised of 3589 respondents were found in regions 3, 4 and 6 (MICS 2000, 2006-07 and 2014 Reports). According to the 2012 Census, Guyana's region population distribution in regions 3, 4 and 6 were 107,416, 313, 429 and 109,431of Guyana's 746,955 population respectively. These three areas make up 71 percent of Guyana's population. Consequently, these three regions are the most density populated regions in Guyana (Guyana National Land Use Plan, 2013; BOS, 2023).[9] Moreover, according to the MICS 2000, 2006-07 and 2014, regions 3, 4 and 6 comprised of an average of 16 percent, 45 percent, and 18 percent of the sample population respectively (MICS 2000, 2006-07 and 2014 Reports). As such, regions 3, 4 and 6 are not only populous but also flat, so the excessive rainfall (as measured by a positive shock) is likely to make more damage there compared to a hilly region (World Bank Climate Change Knowledge Portal, 2023). On the other hand, Regions 8 and 10 are inland regions that are relatively hilly and are less flood prone and comprised of approximately 3 percent and 5 percent respectively of the population sample (MICS 2000, 2006-07 and 2014 Reports).

2.5.2 The effect of rainfall shocks during the gestational period

Tables 2.2 and 2.3 below present the main results where we regress our main outcome variables of HAZ score, and indicator variables for stunted and severely stunted growth on prenatal

[9]https://observatorioplanificacion.cepal.org/sites/default/files/plan/files/2013%20NLUP%20Guyana.pdf; https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/2012_Preliminary_Report.pdf

rainfall shocks. Table 2.2 considers separately the fraction of positive and negative rainfall shocks during the 9 months preceding birth as the primary variables of interest using equation 1 while Table 2.3 presents the rainfall shocks variables in the first, second and third trimester of gestation.

Table 2.2: The effects of in-utero rainfall shocks on child health

	(1) Height for age z score	(2) Stunted	(3) Severely Stunted
Positive Rainfall	-0.248	0.116**	0.075**
	(0.192)	(0.053)	(0.031)
Negative Rainfall	0.172	-0.034	-0.032
	(0.225)	(0.066)	(0.036)
Male	-0.100***	0.018**	0.004
	(0.034)	(0.008)	(0.005)
Urban	-0.008	-0.020	0.000
	(0.086)	(0.021)	(0.010)
Maternal higher education	0.258***	-0.059***	-0.023***
	(0.041)	(0.011)	(0.006)
Constant	-1.460***	0.313***	0.088***
	(0.161)	(0.046)	(0.025)
Month of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	7626	7626	7626
R^2	0.095	0.058	0.023

Notes: Sample restricted to 2000, 2006-07 & 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). Positive (negative) rainfall is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. Positive and negative shocks are defined as +/- 1 standard deviation respectively with respect to the historical monthly mean of each birth region calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware Precipitation V5.01. Standard errors in parentheses are clustered at the enumeration district level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

In Table 2.2, the coefficient on the positive rainfall shock for HAZ score in column 1 is negative indicating that higher exposure to positive rainfall shocks during the 9 months in-utero adversely affects child height, but it is not statistically significant. However, when examining stunted and severely stunted growth in columns 2 and 3 in Table 2.2, we find that a one standard deviation increase in positive rainfall in the 9 months before birth increases the likelihood of being both stunted and severely stunted by 1.30 and 0.84 percentage points respectively.[10] On the other hand, the coefficients of the fraction of months with negative rainfall shocks are not

[10] NB:// The percentage point for height-for-age z-score, stunted, and severely stunted are calculated by using their coefficient values x the standard deviation of positive (negative) rainfall in the 9 months (trimesters (1st, 2nd and 3rd)) before birth x 100.

statistically significant. The total number of children under 5 in Guyana for the period 1995-2014 was approximately 132,719 (Bureau of Statistics, Guyana, 2016). Therefore, a 1.30 percentage point increase in stunted growth (or 0.013/0.157 = 8 percent increase, when taking into consideration the mean of stunted) would increase Guyana's overall stunted growth by approximately 0.013 x 132,719 = 1,725 children.

Similarly, a 0.84 percentage point increase in severely stunted growth (or 0.0084/0.051 = 16.5 percent increase when taking into consideration the mean of stunted) would increase Guyana's overall severely stunted growth by approximately 0.0084 x 132,719 = 1,115 children. However, these are non-trivial numbers.

Table 2.3: The trimester-specific effects of in-utero rainfall shocks on child health

	(1) Height for age z score	(2) Stunted	(3) Severely Stunted
1st trimester- positive	-0.245***	0.048*	0.030*
	(0.093)	(0.026)	(0.016)
2nd trimester - positive	-0.025	0.044*	0.026
	(0.106)	(0.027)	(0.016)
3rd trimester - positive	0.017	0.023	0.020
	(0.105)	(0.026)	(0.015)
1st trimester - negative	0.063	0.000	0.002
	(0.139)	(0.034)	(0.021)
2nd trimester- negative	-0.124	-0.022	-0.001
	(0.123)	(0.036)	(0.020)
3rd trimester - negative	0.264**	-0.011	-0.034*
	(0.126)	(0.036)	(0.019)
Male	-0.100***	0.018**	0.004
	(0.034)	(0.008)	(0.005)
Urban	-0.008	-0.020	0.000
	(0.086)	(0.021)	(0.010)
Maternal higher education	0.256***	-0.059***	-0.023***
	(0.041)	(0.011)	(0.006)
Constant	-1.474***	0.310***	0.087***
	(0.164)	(0.046)	(0.025)
Month of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	7626	7626	7626
R^2	0.096	0.058	0.023

Notes: Sample restricted to 2000, 2006-07 and 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). Positive (negative) rainfall in Panel A is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. 1st trimester positive (negative) rainfall is the fraction of months during the 6-8 months before birth that the positive shock (negative shock) indicator equals one.

2nd trimester positive (negative) rainfall is the fraction of months during the 3-5 months before birth that the positive shock (negative shock) indicator equals one. 3rd trimester positive (negative) rainfall is the fraction of months during the 0-2 months before birth that the positive shock (negative shock) indicator equals one. Positive and negative shocks are defined as +/- 1 standard deviation respectively with respect to the historical monthly mean of each birth region calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware Precipitation V5.01. Standard errors in parentheses are clustered at the enumeration districts level. * $p < 0.10$, **$p < 0.05$, *** $p < 0.01$.

Examining the role of trimester-specific shocks in Table 2.3, we find that positive rainfall shocks in the first trimester negatively impact HAZ (column 1). Therefore, on average children who experienced a 1 SD increase in positive rainfall in the first trimester in-utero exhibit a decline in their HAZ by 0.046 SD. Further, we find that a one standard deviation increase in positive rainfall during the first trimester increases the likelihood of stunted and severely stunted by 0.91 and 0.57 percentage points respectively. This finding is consistent with previous findings. For instance, Le and Nguyen (2021) who studied 55 lower- and middle-income countries and found that exposure to excess rainfall in the first trimester leads to a reduction in HAZ and an increase in stunting. Carrillo (2020) found exposure in the first trimester had long-run effects on health outcomes in Brazil. We also find that a one standard deviation increase in positive rainfall in the second trimester increases the likelihood of stunted growth by 0.80 percentage points respectively. However, when looking at negative rainfall shocks, we find that a one standard deviation increase in negative rainfall shocks in the third trimester increases the HAZ by 0.037 SD. This result is comparable to Skoufias et al. (2011), who found that negative rainfall shocks resulted in increases in HAZ in some regions of Mexico. The results in Table 2.3 highlight the value of considering trimester-specific exposure to shocks.

Studies have found that often it is not just in-utero shocks but also those in the first year after birth that matter for determining child health (Rosales-Rueda, 2018; Duque et al., 2018; Carrillo, 2020). To examine that, we also compute positive and negative rainfall shocks during the first twelve months after the child's birth in addition to the rainfall shocks during the 9 months of gestation.[11]

Table 2.4 presents the results where we control for positive and negative rainfall shocks in the 12 months after birth as well as during each of the trimesters in the gestation period. The results indicate that greater exposure to positive rainfall shocks during the first year of life is associated with lower HAZ though the coefficients are not statistically significant. However, when

[11] The sample size is now reduced, as it now considers children who were at least 1 year old (i.e., 1-4 years old) at the time of the survey.

looking at negative rainfall exposure, we find that exposure to negative rainfall shocks in the 12 months after birth negatively affect height for age z scores by 0.051 SD and positively impacted severely stunted growth by 1.17 percentage point. Rosales-Rueda (2018) also finds floods in the first year of life to negatively affect height, however, her point estimates were not statistically significant. Results show that exposure to negative rainfall shocks during the third trimester is associated with an increase in the HAZ by 0.045 SD.

Table 2.4: The effects of prenatal and postnatal rainfall shocks on child health

	(1) Height for age z score	(2) Stunted	(3) Severely Stunted
Pos 1-12 months after birth	-0.003	-0.032	-0.069
	(0.287)	(0.070)	(0.045)
Neg 1-12 months after birth	-0.689*	0.142	0.158**
	(0.362)	(0.098)	(0.063)
1st trimester – Positive rainfall	-0.166	0.048	0.027
	(0.108)	(0.029)	(0.018)
2nd trimester – Positive rainfall	0.001	0.045	0.020
	(0.113)	(0.031)	(0.019)
3rd trimester – Positive rainfall	0.136	0.004	0.011
	(0.114)	(0.028)	(0.017)
1st trimester – Negative rainfall	0.096	-0.006	-0.004
	(0.158)	(0.040)	(0.022)
2nd trimester – Negative rainfall	-0.079	-0.023	-0.001
	(0.133)	(0.039)	(0.021)
3rd trimester – Negative rainfall	0.335**	-0.022	-0.040**
	(0.134)	(0.038)	(0.020)
Male	-0.069*	0.013	0.001
	(0.035)	(0.009)	(0.005)
Urban	0.096	-0.044*	-0.013
	(0.091)	(0.023)	(0.011)
Maternal higher education	0.289***	-0.066***	-0.023**
	(0.044)	(0.013)	(0.007)
Constant	-1.405***	0.324***	0.101***
	(0.180)	(0.054)	(0.029)
Month of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	6180	6180	6180
R^2	0.099	0.069	0.030

Notes: Sample restricted to 2000, 2006-07 & 2014 Guyana Multiple Indicator Cluster Survey (MICS) for individuals born between 1995 and 2014 (age 0-4 years old). Positive (negative) rainfall is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. Positive and negative shocks are defined as +/- 1 standard deviation respectively with respect to the historical monthly mean of each birth region calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware

Precipitation V5. Standard errors in parentheses are clustered at the enumeration districts level. * $p < 0.10$, $^{**}p < 0.05$, *** $p < 0.01$.

2.5.2 The effect of rainfall shocks on postnatal investments

In this section, we examine whether parents make investments depending on the conditions faced while the child was in-utero. Studies have found evidence that parents often try to equalise (Breining et al., 2015), reinforce (Almond & Mazumder, 2013; Adhvaryu and Nyshadham, 2016), or undertake compensatory investments for weaker children because of altruism and to afford them an equal opportunity to be productive to compete with their peers in their adult life (Behrman et al., 1982; Bhalotra, 2004; Aizer and Cunha, 2014). Studies have also shown that childhood vaccination and breastfeeding among others are all fundamental actions that protect children from communicable disease outbreaks after positive rainfall shocks (Mach et al., 2009; Gribble et al., 2011; Greenwood, 2014). Consequently, given that access to health facilities is limited in Guyana, particularly to those living in the rural areas (The Pan American Health Organisation, 2001); vaccinations are seen as an important health variable. We focus primarily on children whose parent would have reported that their children have some of the WHO's recommended dose of BCG, DPT and measles vaccinations.[12] Similarly, breastfeeding is also an input because it is an important source of nutrition for infants, particularly for those in vulnerable environments where access to safe drinking water is inadequate. WHO recommends that mothers exclusively breastfeed infants for the first six months of their life. In addition, breastfeeding is of critical importance during and after negative rainfall shocks (Quinn et al., 2008; Mach et al., 2009) and there is some evidence to suggest that it is also associated with better childhood cognitive development (Kramer et al., 2008; Del Bono et al., 2012).

The Guyana MICS Survey provides detailed information on postnatal investments such as vaccinations (measles, DPT and BCG) and whether the child was breastfed (but not the duration of breastfeeding). Consequently, we create dummy variables for measles, DPT, BCG and breastfed. In Table 2.5, we find that greater exposure to positive rainfall shocks by 1 standard deviation during the 9 months in-utero leads to lower likelihood of getting the measles and DPT vaccinations by 1.22 and 1.85 percentage points respectively and an increase in

[12] In Guyana, the recommended vaccination schedule is BCG within weeks after birth, DPT at two months, four months and six months, and measles at 9-11 months after birth (Guyana, PAHO/WHO, 2018).

breastfeeding practices by 1.23 percentage points. It is expected that mothers will invest more in postnatal vaccinations, as they try to reduce the risk of their infant contracting infectious diseases from the amplification of the disease environment during periods of positive rainfall shocks while in-utero. However, given that measles is the vaccination with the lowest population coverage (85.5 percent), such a finding seems plausible. Moreover, DPT and BCG had a vaccination coverage rate of 92.6 percent and 99.3 percent respectively. We find that BCG was the least responsive to weather shocks, as almost the entire population was vaccinated. Further, there is essentially a zero effect of negative in-utero rainfall shocks on postnatal investments.

Table 2.5: The effects of in-utero rainfall shocks on postnatal investments

	(1)	(2)	(3)	(4)
	Child ever breastfed?	Measles Vaccination	DPT Vaccination	BCG Vaccination
Positive Rainfall	0.110***	-0.109***	-0.165***	-0.015
	(0.037)	(0.033)	(0.035)	(0.011)
Negative Rainfall	-0.050	0.021	0.016	-0.015
	(0.044)	(0.042)	(0.037)	(0.016)
Male	0.002	-0.001	-0.002	0.006**
	(0.007)	(0.005)	(0.005)	(0.002)
Urban	-0.001	-0.008	-0.021**	-0.004
	(0.014)	(0.011)	(0.012)	(0.004)
Maternal higher education	0.011	0.016**	0.013*	0.000
	(0.009)	(0.007)	(0.007)	(0.003)
Constant	0.927***	1.141***	1.054***	1.003***
	(0.034)	(0.023)	(0.028)	(0.007)
Month of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	6433	4366	4375	5161
R^2	0.028	0.733	0.531	0.023

Notes: Sample restricted to 2000, 2006-07 and 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). Outcome variables are all dummy variables. Positive (negative) rainfall in Panel A is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. Positive and negative shocks are defined as +/- 1 standard deviation respectively with respect to the historical monthly mean of each birth region calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware Precipitation V.501. Standard errors in parentheses are clustered at the enumeration district level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Upon examining postnatal investment responses to trimester-specific shocks in Table 2.6, we find that children with greater exposure to positive rainfall shocks in the first and second trimesters have a higher probability of being breastfed. Greater exposure to first trimester positive shocks and second trimester negative rainfall shocks leads to a higher probability of children being vaccinated for measles, however the results were not significant. On the other hand, positive shocks in the second and third trimesters reduces the probability of being vaccinated for measles. Overall, we find that prenatal exposure to positive and negative shocks leads to mostly ambiguous results when it relates to postnatal investments.

Table 2.6: The trimester-specific effects of in-utero rainfall shocks on postnatal investments

	(1) Child ever breastfed?	(2) Measles Vaccination	(3) DPT Vaccination	(4) BCG Vaccination
1st trimester – positive rainfall	0.033*	0.014	-0.071***	-0.005
	(0.019)	(0.019)	(0.019)	(0.007)
2nd trimester – positive rainfall	0.060**	-0.048**	-0.067***	0.005
	(0.020)	(0.016)	(0.018)	(0.007)
3rd trimester – positive rainfall	0.022	-0.077***	-0.025	-0.015**
	(0.018)	(0.019)	(0.017)	(0.007)
1st trimester – negative rainfall	-0.008	-0.037	-0.040*	-0.011
	(0.026)	(0.026)	(0.024)	(0.011)
2nd trimester – negative rainfall	0.014	0.023	0.037	-0.007
	(0.027)	(0.019)	(0.023)	(0.010)
3rd trimester – negative rainfall	-0.053**	0.029	0.008	0.002
	(0.026)	(0.024)	(0.022)	(0.007)
Male	0.002	-0.002	-0.002	0.006***
	(0.007)	(0.005)	(0.005)	(0.002)
Urban	-0.001	-0.007	-0.021**	-0.004
	(0.014)	(0.012)	(0.012)	(0.004)
Maternal higher education	0.011	0.016**	0.013*	0.000
	(0.010)	(0.007)	(0.007)	(0.003)
Constant	0.925***	1.147***	1.064***	1.002***
	(0.034)	(0.023)	(0.029)	(0.007)
Month of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	6433	4366	4375	5161
R^2	0.029	0.734	0.532	0.024

Notes: Sample restricted to 2000, 2006-07 & 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). Outcome variables are all dummy variables. Positive (negative) rainfall in Panel A is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. 1st trimester positive (negative) rainfall is the fraction of months during the 6-8 months before birth that the positive shock (negative shock) indicator equals one. 2nd trimester positive (negative) rainfall is the fraction of months during the 3-5 months before birth that the positive shock (negative shock) indicator equals one. 3rd trimester positive (negative) rainfall is the fraction of months during the 0-2 months before birth that the positive shock (negative shock) indicator equals one. Positive and negative shocks are defined as +/- 1 standard deviation respectively with respect to the historical monthly mean of each birth region calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware Precipitation V.501. Standard errors in parentheses are clustered at the enumeration district level. * $p < 0.10$, $^{**}p < 0.05$, *** $p < 0.01$.

2.5.3 Heterogeneous Effects

In this section, we investigate whether there are heterogeneous effects of rainfall shocks on child health based on (i) the gender of the child; (ii) whether the child belongs to an urban household; (iii) and the education level of the mother. To analyse this, split the samples.

We first examine the sex of the child. For the past twenty years, the under-five mortality rate in Guyana is higher for male children as compared to females (UNICEF, 2020). In addition, research also shows that in times of trouble (i.e., severe weather conditions, earthquakes, natural disasters etc), maternal stress caused by the external environment around the time of conception exacerbates the difference, resulting in a reduction in the male to female sex ratio, thus suggesting that the male embryo is more vulnerable than that of a female (Kraemer, 2000). As such, in general, it would be a rational decision for households to direct more postnatal investments towards boys rather than girls in periods of adverse weather shocks.

Results presented in Table 2.7 (column 1), show that the interaction term for males and the positive and negative rainfall variables are positive but not statistically significant when examining the height-for-age z score. Therefore, there is no evidence to suggest that the effects of exposure to positive and negative rainfall shock significantly varies by gender. Moreover, we found similar results for stunting.

Weather shocks may have affected urban and rural households differently since access to medical facilities in urban and rural areas may be different due to greater road developments in urban areas (Rose and Corbin, 2017). Maternal education can be seen as an important determinant for the health of the children in-utero. Studies have shown that negative exposure to weather shocks are attenuated during the first trimester if the mother is more educated (Rosales-Rueda, 2018).

Table 2.7: Heterogeneous effects by gender of the child

	(1) Height for age z score	(2) Stunted	(3) Severely Stunted
Positive rainfall shock	-0.182	0.091	0.082*
	(0.249)	(0.063)	(0.042)
Negative rainfall shock	0.229	-0.048	-0.043
	(0.271)	(0.083)	(0.045)
Male	-0.081	0.011	0.005
	(0.052)	(0.013)	(0.008)
Urban	-0.008	-0.020	0.000
	(0.086)	(0.021)	(0.010)
Maternal higher education	0.257***	-0.059***	-0.023***
	(0.041)	(0.011)	(0.006)
Positive rain x Male	-0.127	0.047	-0.015
	(0.295)	(0.072)	(0.048)
Negative rain x Male	-0.107	0.027	0.023
	(0.359)	(0.088)	(0.051)
Constant	-1.470***	0.316***	0.088***
	(0.162)	(0.047)	(0.025)
Month of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	7626	7626	7626
R^2	0.095	0.058	0.023

Notes: Sample restricted to 2000, 2006-07 & 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). Positive (negative) rainfall is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. Positive and negative shocks are defined as +/- 1 standard deviation respectively with respect to the historical monthly mean of each birth region calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware Precipitation V5.01. Standard errors in parentheses are clustered at the enumeration districts level. * $p < 0.10$, $^{**}p < 0.05$, *** $p < 0.01$.

Second, we examine the role of urban versus rural location in Table 2.8. Socioeconomic factors and other variables are important when persons choose where they reside, hence, the importance of analysing the heterogeneity by location. Residential location can also influence childhood health outcomes through access to adequate health facilities in rural areas etc (Hailu et al., 2020). In Table 2.8, column 1 below, we find that positive rainfall shock increases height-for-age z-scores in urban areas (coefficient is 1.096 and significant at 1%) as compared to rural areas. The reason for the positive impact in urban areas is due to better access to medical services, infrastructure, disaster relief resources and resilience (Rözer, 2022). Whereas the rural areas have more sparse infrastructure and public service provision.

Table 2.8: Heterogeneous effects by location

	(1) Height for age z score	(2) Stunted	(3) Severely Stunted
Positive rainfall shock	-1.075***	0.208*	0.063
	(0.323)	(0.110)	(0.056)
Negative rainfall shock	0.436	-0.198	-0.092
	(0.488)	(0.149)	(0.063)
Male	-0.101***	0.018**	0.004
	(0.034)	(0.008)	(0.005)
Urban	-0.088	-0.022	-0.006
	(0.101)	(0.027)	(0.012)
Maternal higher education	0.259***	-0.060***	-0.023***
	(0.041)	(0.011)	(0.006)
Positive rainfall shock x Urban	1.096***	-0.120	0.017
	(0.374)	(0.118)	(0.063)
Negative rainfall shock x Urban	-0.330	0.221	0.083
	(0.551)	(0.160)	(0.065)
Constant	-1.413***	0.317***	0.093***
	(0.163)	(0.048)	(0.026)
Month of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	7626	7626	6693
R^2	0.096	0.061	0.022

Notes: Sample restricted to 2000, 2006-07 & 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). Positive (negative) rainfall is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. Positive and negative shocks are defined as +/- 1 standard deviation respectively with respect to the historical monthly mean of each birth region calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware Precipitation V5.01. Standard errors in parentheses are clustered at the enumeration districts level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

To examine the differential effects of maternal education on the effects of rainfall shocks on child health, we create binary variables that take the value of one if the mother had completed ‘secondary education’ or ‘tertiary education’, and zero otherwise (i.e., mothers with primary and no education). Studies have shown differential responses as it relates to maternal education, i.e., maternal education can play a significant role in mitigating the negative impacts of weather shocks on childhood health (Rosales-Rueda, 2018; Dimitrova and Bora, 2020). As such maternal education is an important variable to consider for heterogeneity. Results presented in Table 2.9 show that higher education of the mother positively affects the height-for-age z score and negatively affects stunted and severely stunted; however, when interacting mother’s education with the rainfall shock variables in (columns 1-3), we find that there are no heterogeneous effects of mother's education and the in-utero exposure to positive and negative rainfall shocks.

Table 2.9: Heterogeneous effects by mother's education

	(1) Height for age z score	(2) Stunted	(3) Severely stunted
Positive rainfall shock	-0.241	0.058	0.043
	(0.356)	(0.104)	(0.057)
Negative rainfall shock	0.068	-0.017	0.001
	(0.370)	(0.104)	(0.066)
Male	-0.100***	0.018**	0.004
	(0.034)	(0.008)	(0.005)
Maternal higher education	0.250***	-0.065***	-0.024**
	(0.065)	(0.017)	(0.010)
Positive rain shock x Higher	-0.010	0.075	0.041
	(0.381)	(0.105)	(0.061)
Negative rain shock x Higher	0.148	-0.026	-0.047
	(0.383)	(0.103)	(0.065)
Urban	-0.008	-0.020	0.000
	(0.086)	(0.021)	(0.010)
Constant	-1.453***	0.317***	0.088***
	(0.165)	(0.047)	(0.025)
Month of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	7626	7626	7626
R^2	0.095	0.058	0.023

Notes: Sample restricted to 2000, 2006-07 & 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). Positive (negative) rainfall is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. Higher education is a dummy variable that takes the value 1 for mothers who completed secondary and/or tertiary education and 0 otherwise (no education and primary education). Positive and negative shocks are defined as +/- 1 standard deviation respectively with respect to the historical monthly mean of each birth region calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware Precipitation V5.01. Standard errors in parentheses are clustered at the enumeration districts level. * $p < 0.10$, $^{**}p < 0.05$, *** $p < 0.01$.

2.5.4 Robustness Checks

For robustness, we consider alternative measures of rainfall shocks. More specifically, following Jayachandran (2006), we define a region-month-year as having a positive rainfall shock which takes a value of one if the rainfall in that month exceeds the ninetieth percentile of the region's historical monthly average, and 0 otherwise. A negative rainfall shock takes a value of one if the rainfall in that month is below the tenth percentile of the region's historical monthly average, and 0 otherwise. Similarly, normal rainfall lies within the ninetieth and tenth percentiles of the historical regional mean. We then compute the fraction of months in the 9 months preceding birth that is characterized by positive shocks, negative shocks, and normal rainfall, and we also split it into trimesters.

In Table 2.10 we find that the results for stunted, and severely stunted growth remain robust, i.e., positive rainfall shocks significantly increase the likelihood of being stunted and severely stunted by 1.74 and 0.97 percentage points respectively.

Table 2.10: The effects of in-utero rainfall shocks on child health (90th, 10th percentile measure)

	(1) Height for age z score	(2) Stunted	(3) Severely Stunted
Positive Rainfall	-0.357	0.155^{**}	0.087^{**}
	(0.221)	(0.057)	(0.033)
Negative Rainfall	0.018	-0.030	-0.006
	(0.177)	(0.049)	(0.024)
Male	-0.101^{**}	0.018^{**}	0.004
	(0.034)	(0.008)	(0.005)
Urban	-0.130	-0.019	0.000
	(0.087)	(0.021)	(0.010)
Maternal higher education	0.257^{***}	-0.059^{***}	-0.023^{**}
	(0.042)	(0.011)	(0.006)
Constant	-1.412^{***}	0.303^{***}	0.078^{**}
	(0.163)	(0.046)	(0.025)
Month of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	7626	7626	7626
R^2	0.095	0.058	0.023

Notes: Sample restricted to 2000, 2006-07 & 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). Positive (negative) rainfall is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. Standard errors in parentheses are clustered at the enumeration districts level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 2.11 presents the results for the impact of positive and negative rainfall shocks on each trimester in-utero. The estimates in column 1 suggest that on average children who experienced a standard deviation increase in positive rainfall in the first trimester in-utero exhibited a decline in their height-for-age z score by 0.044 SD. This result is quantitatively analogous to our main result in Table 2.3. In columns 2 and 3, we find that a one standard deviation increase in positive rainfall shocks in the first trimester also increases the likelihood of being stunted and severely stunted by 1.21 and 0.87 percentage points respectively. However, when looking at the impacts of negative rainfall shocks, the results are not very robust.

Table 2.11: The trimester-specific effects of in-utero rainfall shocks on child health (90th, 10th percentile measure)

	(1) Height for age z score	(2) Stunted	(3) Severely Stunted
1st trimester – positive rainfall	-0.233**	0.064**	0.046**
	(0.106)	(0.028)	(0.016)
2nd trimester – positive rainfall	-0.020	0.052*	0.022
	(0.118)	(0.030)	(0.017)
3rd trimester – positive rainfall	-0.108	0.038	0.021
	(0.114)	(0.029)	(0.017)
1st trimester – negative rainfall	-0.024	-0.004	0.017
	(0.098)	(0.026)	(0.015)
2nd trimester – negative rainfall	-0.027	-0.029	-0.010
	(0.099)	(0.026)	(0.016)
3rd trimester – negative rainfall	0.075	0.002	-0.013
	(0.097)	(0.027)	(0.013)
Male	-0.100***	0.018**	0.004
	(0.034)	(0.008)	(0.005)
Urban	-0.010	-0.019	0.000
	(0.087)	(0.021)	(0.010)
Maternal higher education	0.256***	-0.059***	-0.023**
	(0.041)	(0.011)	(0.006)
Constant	-1.419***	0.300***	0.076**
	(0.163)	(0.046)	(0.025)
Month of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	7626	7626	7626
R^2	0.095	0.058	0.023

Notes: Sample restricted to 2000, 2006-07 & 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). The 1st trimester positive (negative) rainfall is the fraction of months during the 6-8 months before birth that the positive shock (negative shock) indicator equal one. 2nd trimester positive (negative) rainfall is the fraction of months during the 3-5 months before birth that the positive shock (negative shock) indicator equals one. 3rd trimester positive (negative) rainfall is the fraction of months during the 0-2 months before birth that the positive shock (negative shock) indicator equals one. Positive (negative) rainfall shock=1 and 0 otherwise, if for a given region and month rainfall was above the 90th (below the 10th) percentile of the region's historical monthly average calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware Precipitation V5.01. Standard errors in parentheses are clustered at the enumeration districts level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

2.5.5 Placebo Test

Table 2.112: The effects of in-utero rainfall shocks on child health

	(1) Height for age z score	(2) Stunted	(3) Severely Stunted
Positive Rainfall	-0.248	0.116^{**}	0.075^{**}
	(0.192)	(0.053)	(0.031)
	[0.103]	[0.000]	[0.001]
Negative Rainfall	0.172	-0.034	-0.032
	(0.225)	(0.066)	(0.036)
	[0.337]	[0.457]	[0.275]
Month of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth FE	Yes	Yes	Yes
Survey wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	7626	7626	7626
R^2	0.095	0.058	0.023

Notes: Sample restricted to 2000, 2006-07 & 2014 Guyana Multiple Indicator Cluster Survey (MICS) for children born between 1995 and 2014 (age 0-4 years old). Positive (negative) rainfall is the fraction of months during the 9 months before birth that the positive shock (negative shock) indicator equals one. Positive and negative shocks are defined as +/- 1 standard deviation respectively with respect to the historical monthly mean of each birth region calculated over 1980-2014 using data from Guyana Hydrometeorological Service and the University of Delaware Precipitation V5.01. The results for positive and negative rainfall shocks were run separately. All regressions include controls for male, urban and maternal higher education. Standard errors in parentheses are clustered at the enumeration district level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

When performing randomization inference using the ritest command in STATA on the outcome variables. The results in Table 2.12 show that exposure to positive rainfall shocks in the 9 months preceding birth for the outcome variables stunted and severe stunted growth are significant, with p=c/n being 0.000 and 0.001 respectively. These results are also significant in our main regressions, thus indicating that results are robust when performing placebo tests.

However, when looking that the negative rainfall shocks the results were not significant. This is also like our results in our baseline equations.

2.6 Conclusion

This study uses historical weather data from the Guyana Hydrometeorology Service combined with the Guyana Multiple Indicator Cluster Survey microdata for 2000, 2006-07 and 2014 to generate insights into the effects of in-utero weather shocks on early childhood health as measured by HAZ and stunting of children. This study contributes to a growing body of economic evidence on the adverse effects of extreme weather events experienced in early childhood, by providing evidence of the effects of early-life exposure to positive and negative rainfall shocks in Guyana.

The findings reveal that a one standard deviation increase in the exposure to positive rainfall shocks during in-utero significantly increases the likelihood of being stunted and severely stunted. Findings also show that in-utero exposure to positive rainfall shocks in the first trimester of gestation negatively impacts the HAZ and increases the likelihood of stunted and severely stunted growth. We find some mixed evidence that parents are more likely to undertake postnatal investments in the form of vaccinations and breastfeeding for children who experienced more shocks during gestation. Our findings show that climatic variability also appears to have substantial heterogeneous impacts based on location, such that negative rainfall shocks have a greater effect on the probability of stunting in urban areas as compared to rural areas. Although this study looks at the early childhood impacts of weather shocks in Guyana, it is likely that this will lead to long-term impacts on adult health, education, and socioeconomic outcomes as highlighted by previous studies.

However, there have been several responses made by the Government of Guyana to mitigate the problem of increased flooding in Guyana. For instance, in 2010 the Ministry of Agriculture opened 4,500 acres of new land to allow traditional coastal farmers to start moving their homes and farms inland (Stabroek News, 2010). Moreover, the projected adaptation costs for building and reinforcing levees and seawalls to flood-proofing health clinics was approximately USD $1 billion which was equivalent to nearly 20 percent of Guyana's GDP in 2010. Furthermore, in 2013, the Hope Canal (East Demerara Water Conservancy-Northern Relief Channel) was constructed in response to the 2005 flood that affected regions 3, 4 and 5. The Hope Canal was constructed to mitigate the effects of flooding on more than 300 communities in region 4. Furthermore, in June 2021, the government of Guyana declared a disaster as flooding affected all ten regions. Consequently, the Government of Guyana had proposed to build three outfall channels for regions 3, 5 and 6 to mitigate Guyana's yearly flood phenomenon (Stabroek News, 2021).

Although policy has been enacted to mitigate the occurrence of floods in Guyana, one potential policy recommendation emerging from this study is that Guyana's Ministry of Health should consider collaborating with a multidisciplinary research team to specifically assess the medium-and long-term effects of adverse weather shocks on child and maternal health. Nutrition, and medical outreach programmes for pregnant mothers, in regions that are more susceptible to flooding should be considered. Furthermore, adding climatologists to this team to help monitor and predict the onset of these shocks would better prepare to put provisions in place to improve maternal and early childhood health in the aftermath of shocks.

Furthermore, this paper contributes to our understanding of the effects of such shocks on child health outcomes. Since we believe that the severity of climate change effects is likely to increase in the future, it is important to provide evidence to Guyana's authorities about the impact of rainfall shocks on child health, which is fundamental for the long-term health outcomes and, ultimately, for Guyana's economic prosperity.

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CHAPTER 3

Effects of a School Conversion Policy on Educational Attainment and Labour Market Outcomes in Guyana

3.1 Introduction

The fundamental role that education plays in the lives of individuals and modern labour markets is widely acknowledged. Education generates positive externalities, given that the social returns to education tend to exceed the sum of the individual returns to education (Sianesi, 2002; Psacharopoulos and Patrinos, 2018). It is also an important policy instrument to fight against poverty and promote the general well-being of individuals. Furthermore, studies in different countries and periods have posited that highly educated individuals earn higher wages, experience less unemployment and work in more prominent professions than their less-educated counterparts (Shavit and Müller, 2000; Enu et al., 2014; Kampelmann et al., 2018). Besides affecting wages and earnings, education may influence several other labour market outcomes, namely: the time to the first stable job; employment/unemployment spells; worker productivity; hours worked; nature of work; worker's health; and fringe benefits (Card, 1999; Heckman et al., 2006; Ye Chen, 2021).

In this study, we aim to shed light on the effects of a policy that enhances school completion and investigate its effects on educational attainment and labour market outcomes. We do this by exploiting a key policy change in Guyana: in 2002, Guyana adopted a five-year plan from 2003-2007 to achieve Universal Secondary Education (USE). The USE (2003-2007) reform policy was piloted through one main donor-funded project called the Secondary School Reform Project (SSRP). The SSRP was specifically designed for school conversions within all the regions of Guyana (Ministry of Education, Guyana, 2022). Prior to the USE (2003-2007) policy reform, Guyana's secondary education system operated under a differentiated three-tier system which consisted of three different types of secondary schools, namely: General Secondary Schools (GSSs), Community High Schools (CHSs), and the secondary department of primary schools, also known as Primary Tops. The latter two secondary schools were geared towards a pre-vocational curriculum, while the GSSs provided an academic curriculum (World Bank, 2013). This resulted in the yearly dropout rates being over 60 percent for children in Community High Schools (CHSs) and Primary Tops (Williams, 1993; Jennings, 2000; Gill-Marshall, 2000). Moreover, students who attended CHSs and Primary Tops had little to no job prospects because the certificates received from these institutions were based on a pre-vocational curriculum rather than an academic one (World Data on Education, Guyana, 2006/07; Jennings, 2000; London, 2018). Despite these certificates being used to enrol students into technical or vocational post-secondary school programs. Guyana's youth unemployment rate was among the highest in the Caribbean. Between 2001 and 2002, Guyana witnessed its highest youth unemployment rate, an alarming 50 percent; which was far above the World's average (Kaieteur News, 2015; Caribbean Development Bank, 2015).

In addition, Amerindian students were at a further disadvantage compared to the other ethnic groups because they resided in areas where access to general secondary education was limited and difficult (UNICEF, 2017). Consequently, this research also seeks to examine whether the USE (2003-2007) policy reform positively impacted secondary or tertiary education completion amongst Amerindian students. Furthermore, this research will also examine the heterogeneity across the various ethnic subgroups to determine the impact of the USE policy on the various groups, as they can be differences in economic outcomes and policy impacts by ethnicity, especially among ethnic minorities (Driessen, 2000).

The USE (2003-2007) policy reform was done through converting secondary classes in primary schools ("Primary Tops") and grades 7-10 in Community High Schools (CHSs) into General Secondary Schools (GSSs).

The World Bank funded the SSRP and provided a total of US$17.3 million to the USE (2003-2007) policy reform with the objectives of improving the quality, relevance, equity, and efficiency of secondary education in Guyana through improving the school environment by supporting rehabilitation and repairs, building extensions and construction of multi-purpose science and computer laboratories. In addition, the SSRP also developed measures to improve the quality and efficiency of lower secondary education by providing new curricula designed to improve the provision of 5 core subjects (namely, English, Mathematics, Science, Social Studies, and reading) supported by the distribution of textbooks and the training of teachers (World Bank, 2005).Therefore, the government expected that this conversion of schools from a pre-vocational track into an academic track would create a unified academic curriculum for all secondary school students, reduce secondary school drop-out rates, increase the number of qualified teachers in the secondary system and encourage an increase in the number of students who complete GSSs (World Data on Education, Guyana, 2006/07). Our study is the first to analyse the effects of this policy.

According to the Ministry of education (2023), there is no official age for entry into secondary school, however on a normal basis given the entry age of age 5 or 6 for the six-year programme for primary schools, students usually enter the secondary level at approximately 12 years old. Consequently, we defined the treated as age 11, as the Ministry of education confirms that children can also attend secondary school at 11 plus (Ministry of education, 2023).

According to the Ministry of education (2023), a child can be in a general secondary school as old as age 17-18 age old, depending on the age in which they have started secondary school. However, the occurrence of an 18-year-old student being in a GSS is very rare. Therefore, we have assumed that an individual would have been in general secondary education between the ages of 11-17 based on the Guyana Labour Force Survey (GLFS).

Consequently, this study utilises data from the Digest of Education Statistics (DES) for the period 1999-2019 provided by the Ministry of Education of Guyana, as well as the Guyana Labour Force Survey (GLFS) quarterly data for the period (2018-2019). These two rich datasets are underutilised and allow us to investigate the impact of the USE (2003-2007) policy reform on the completion of secondary or tertiary education and on labour market outcomes. As such, we focus on three major outcome variables for educational attainment: completion of secondary or tertiary education, completion of tertiary education, attendance of secondary or tertiary education. In addition, we consider labour markets outcomes such as wages and employment. We use a difference-in-difference specification which focuses on respondents who were aged 11-17 years in 2003 (the treated group) and 18-24 years old in 2003 (the control group) where 2003 is the year when the USE was introduced. We compute the intensity of exposure to the USE (2003-2007) policy using the share of non-GSSs institutions out of all secondary schools in each region in 2002, based on the DES. The findings from our study show that greater exposure to the Universal Secondary Education policy led to an increase in the completion of secondary or tertiary education in Guyana.

We also find that exposure to the policy led to an increase in the wages of treated cohorts. Furthermore, our results are robust when applying a range of alternative specifications.

This study and its findings contribute to the literature on supply-side policies aimed at increasing the supply of schooling and the conversion of vocational or technical education into an academic track. Several studies have shown that educational reform, such as school construction and secondary education fee-reduction programs led to an increase in the completion of education and higher earnings (Duflo, 2001; Barrera-Osorio et al*.,* 2013, Garlick, 2013; Duflo et al., 2021). For instance, Duflo (2001) studies the effects of the 1970s Indonesian's government school construction program on men's education and earnings and finds that it led to an increase in education and earnings in Indonesia. Studies have also shown that educational interventions through scholarships and mentoring in secondary schools were used as an incentive to encourage students. Secondary school scholarships in Ghana increased educational attainment, knowledge, skills, and preventative health behaviour, while reducing female fertility (Duflo et al., 2021).

The literature has also shown that there are beneficial results of abolishing or reducing school fees or introducing education subsidies for school attendance and enrolment (Alderman et al., 2001; Deininger, 2003; Schultz, 2004; İşcan et al., 2015; Kan and Klasen, 2021; Brudevold-Newman, 2021). Government policies in Kenya, such as fee reduction and capacity expansion through increasing class sizes and the number of classes, increased the proportion of students continuing from primary to secondary education (Brudevold-Newman, 2021). Studies have shown that, in general, free education policies result in positive impacts on educational attainment and financial inclusion. For instance, the Free Primary Education (FPE) policy in Kenya was associated with an increase in educational attainment and increased use of formal financial services (Ajayi and Ross, 2020). In addition, fee abolition in West German secondary schools resulted in an increase in educational attainment in upper secondary schools (Riphahn, 2012).

In general, studies have shown that formal education increases competency in basic skills in adults (OECD, 2013a; Massing and Schneider, 2017). For instance, Brunello and Rocco (2017) in their study using the Program for the International Assessment for Adult Competencies (PIAAC) dataset shows that persons who pursued an academic path had more basic skills and were more competent when it came to literacy and numeracy skills relative to those who had vocational education.

There are several studies that have shown that having academic qualifications increases the social returns, wages, and employment opportunities/typology of jobs of individuals. Psacharopoulos (1994) estimates the returns to vocational and academic qualifications from 32 studies and revealed that social returns to academic qualifications are approximately 15.5% per annum while the social returns for vocational qualifications are lower (at 11.7% per annum). The equivalent private returns are 10.6% and 10.5% respectively. Dearden et al. (2002) find that the wage premia for academic qualifications are higher than from vocational qualifications at the same level in Great Britain. Malamud and Pop-Eleches (2010) find that men in Romania who were affected by the 1973 educational reform requiring students in vocational education to attend two additional years of general education were less likely to work as manual workers and craftsmen than their counterparts who were born too early to be affected by the policy.

Studies have also found intergenerational impacts of education that are transmitted to future generations. For instance, Akresh et al. (2018), examined the long-term and intergenerational impacts of one of the largest primary school construction programs in Indonesia and finds that educational benefits persist for both men and women 43 years after the program. Furthermore, mother's program exposure led to education benefits that were transmitted to the next generation, with the largest effects in upper secondary and tertiary education when compared to father's exposure. Moreover, men who were exposed to the program were more likely to be formal workers, work outside agriculture and migrate.
Furthermore, there are many studies that provide evidence that education and earnings are positively correlated with each other; as such, higher education increases one's earning abilities or return to schooling (Ashenfelter and Krueger, 1994; Harmon et al., 2003: Heckman et al., 2006; Peet et al., 2015).

Education reforms via the voucher system also led to positive impacts on education attainments and labour market outcomes. Consequently, a Universal Voucher System reform which provided subsidised school funding in Chile resulted in both an increase in the graduation rate among secondary school children and an increase in the percentage of students completing at least two years of college. In addition, the Universal Voucher System reform also increased lifetime utility and reduced earning inequality in Chile (Bravo et al., 2010). Murnane et al. (2017) also investigated the consequences of educational voucher reform in Chile and found that on average, students' test scores increased and income-based gaps in those scores declined by one-third in the five years after the reform. Psacharopoulos and Patrinos (2018), in their study on returns to investment in education, find that women experience higher average rates of return to schooling and the returns are higher in low-income countries. They also find that private sector employment had higher returns, thus supporting the productive value of education. Furthermore, studies that evaluate the impacts of formal education on occupational choice found that, for men, education increases the probability of wage work (Duflo, 2004) and decreases the probability of self-employment (Ozier, 2018).

Consequently, this study is the first-ever study to analyse a USE policy reform that converts secondary schools with a vocational curriculum into academic curriculums. The study also contributes to the methodological and economic literature for Guyana, as it is the first study for Guyana to investigate the effects of a secondary education policy reform on the completion of secondary or tertiary education and labour market outcomes. The rest of the paper is organised as follows. Section 3.2 provides context on Guyana's education system. Section 3.3 describes the data sources, and Section 3.4 introduces the empirical strategy. Section 3.5 presents the results, and Section 3.6 concludes.

3.2 Context

This section provides background on Guyana's education system and the labour market context throughout our study period, ending before the onset of the COVID-19 pandemic crisis.

3.2.1 Guyana's Education System

Education in Guyana is largely free from nursey to secondary levels. However, there are some private institutions where one must pay tuition. Although not compulsory, education in Guyana begins with two years of nursery or kindergarten education, followed by six years of mandatory primary education (grades 1-6).

Furthermore, as it relates to secondary education, based on the performance at the SSEE examinations, students were rewarded either a senior general secondary (i.e., an optional seven-year curriculum for the top 5% performers – Grades 7-13) or a junior general secondary school (i.e., five-year curriculum – Grades 7-11) (Gafar, 2003). Grades 12 and 13 are classified as sixth form or post-secondary (see Figure 3.1 for the structure and organisation of Guyana's educational system prior to the USE (2003-2007) policy reform).[1]
Prior to 2003, secondary education operated under a tier system, where it comprised of a secondary department of a primary school (formally known as 'Primary Tops'), Community High Schools (CHSs) and General Secondary School (GSSs).

According to Gafar (2003), access to GSSs was based both on the completion of the Secondary School Entrance Examination (SSEE or the United Kingdom's Standardised Assessment Tests (SATs) equivalent exam) or (11+) exam, and the number of places available in the GSSs. Following the SSEE, the top 55 percent were placed in the more prestigious GSSs whilst the remaining students with low scores were placed in CHSs, or Primary Tops.

Furthermore, Jennings and Miller (1999) argued that CHSs classrooms were poorly equipped and did not foster an environment conducive to learning. They also reported that a 1990 survey done on 71 CHSs and Primary Tops revealed that only 38.5 percent of the students graduated, and 61.2 percent dropped out in their final year without proper certification. The reason for the high dropout rate was due to shortage of textbooks, lack of qualified teachers and poor facilities. The courses offered in Primary Tops and CHSs were more tailored towards prevocational training while those offered in GSSs were more academic in nature. Some courses provided in CHSs, and Primary Tops were woodworking, technical drawing, home economics, health and physical education, music, art and craft, agriculture, and industrial arts and other vocational courses.

[1]Thirteen public senior secondary schools offer the sixth form in Guyana (Ministry of Education, 2022).

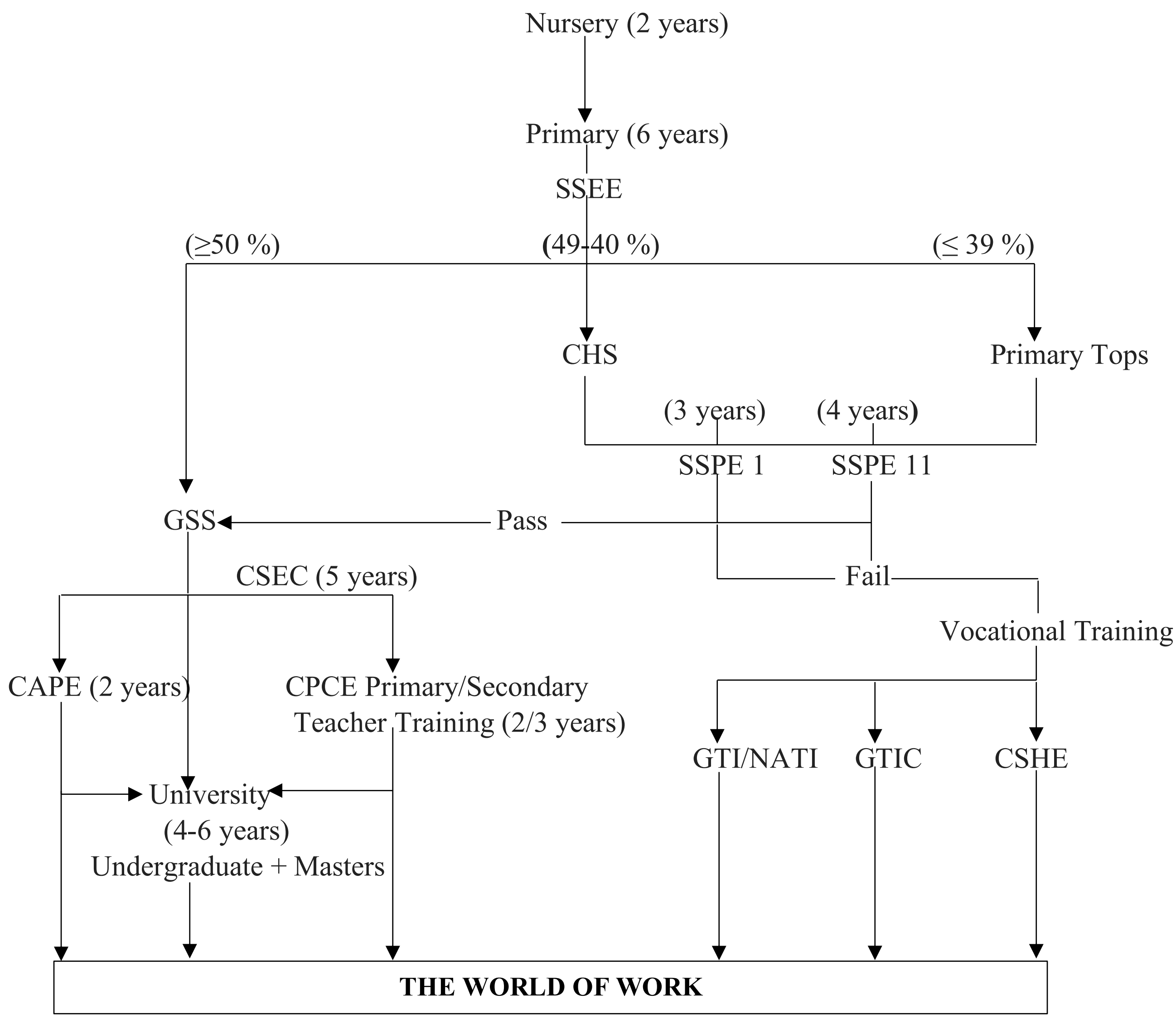


Figure 3.1: The structure and organisation of the education system prior to the USE (2003-2007) policy reform.
Source: Author's illustration based on Digest of Education Statistics Reports (MOE).

Furthermore, the Primary Tops and CHSs provided a four-year curriculum which also prepared students to sit the SSPE in year three (Grade 9) and year four (Grade 10) (World Data on Education, Guyana, 2010/11). The SSPE curriculum in the CHSs covered four core subject areas (English, Mathematics, Social Studies, and Integrated Science), written in two parts (Parts 1 and 11). Students who passed Part 1 in their third year of study were able to transfer to a junior general secondary school, to pursue a more academic curriculum. Part 2 was administered at the end of the fourth year (Grade 10) and was designed to give the students who had failed Part 1 a second chance of attending a GSS (World Data on Education, 2006/07). Consequently, this examination once passed allowed students the opportunity to be accepted into a junior GSS and prepare for the CSEC examination or the United Kingdom's General Certificate of Secondary Education (GCSE). On the other hand, the student that did not pass Part 1 nor Part 2 of the SSPE went onto to graduate (in Grade 10) from the CHS schools was awarded with a SSPE results certificate to either apply for a job or to enrol into one of the technical or vocational after-school programs such as Guyana Industrial Training Centre (GITC) programs in furniture making, electrical installation and automotive mechanics etc. However, it has been noted that employers held this certificate in low esteem, and it was very difficult for graduates to gain employment (World Data on Education, Guyana, 2010/11; London, 2018).[2] On the other hand, the GSSs have always offered a five-year programme that is largely academic in nature, i.e., in the first three years it is compulsory for students to study English Language, English Literature, Mathematics, Social Studies, Integrated Science, Agricultural Science along with other core subjects. However, more teaching periods are given to English Language and Mathematics which are the two core courses that are required for both tertiary education and job search.

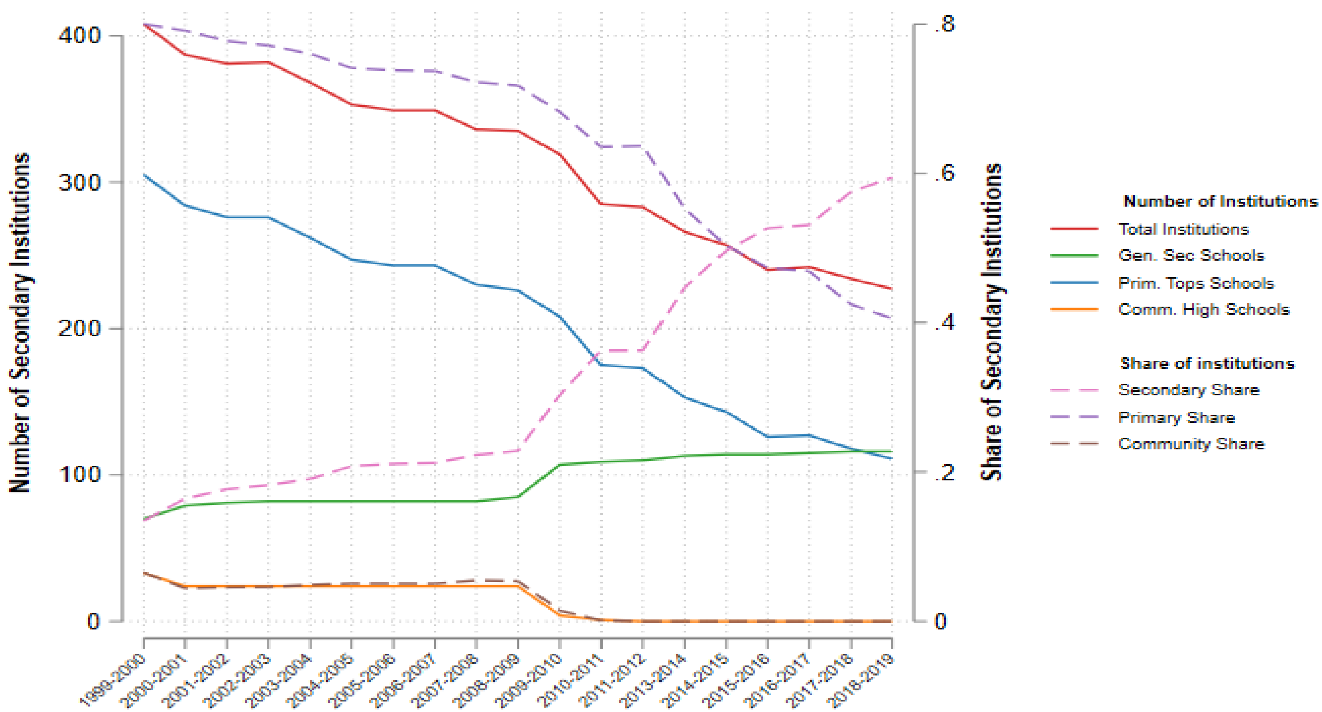
After completing the fifth form in GSSs, students can either go onto the sixth form at a senior secondary school to complete the Caribbean Advance Proficiency Examination (CAPE) or the London General Certificate of Education (GCE) A-Levels equivalent. They can also apply directly to the tertiary institutions in Guyana, i.e., the University of Guyana, Turkeyen or Berbice Campus and teacher training at the Cyril Potter College of Education (CPCE) (Gafar, 2003).
The University of Guyana requires students with a minimum of five CSEC General Proficiency (Grades 1 and 2; and 3 from 1998 onwards) or a minimum of five passes at CAPE, including the English Language, which is applicable for the pursuit of all majors. However, passes in Mathematics is applicable only for designated programmes such as Medicine, Chemistry, Biology, Medical Technology, Engineering, Computer Science, Economics and Business Management, Accounting and Finance among others (University of Guyana, 2022). Consequently, given that the USE (2003-2007) seeks to provide access to GSSs education universally to all students, it may

[2] See the link below for the explanation of the Primary Tops and CHSs SSPE examinations:
http://www.educoas.org/portal/bdigital/contenido/interamer/bkiacd/interamer/interamerhtml/millerhtml/mil_jen.htm, Secondary School | K12 Academics

increase students' access to tertiary education in Guyana, thus leading to improved labour market outcomes.

3.2.2 Description of the changes caused by the USE policy reform.

In this section, we present some descriptive analysis below using the DES (1999-2018) to illustrate what Guyana's education system looked like pre-reform as it relates to the number of secondary institutions, the number of students in secondary institutions, the year-on-year percentage change for students in secondary institutions and the dropout rate.

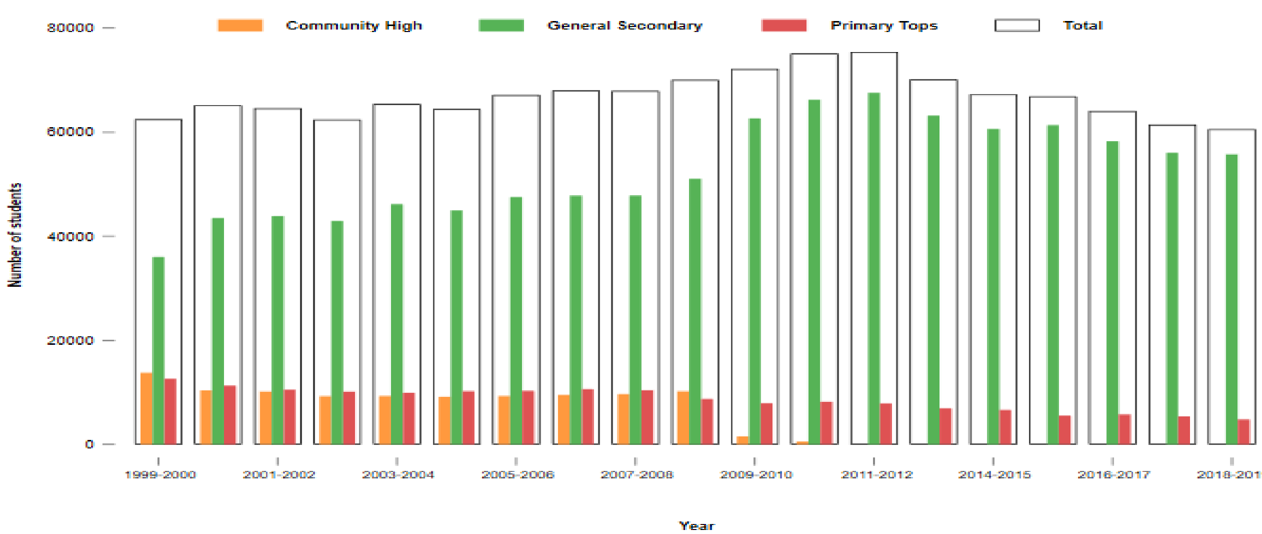


NB:/Missing data for the year (2012-2013) - Ministry of Education (MOE)
Figure 3.2: A comparison of the number of institutions and share of institutions for the period 1999-2019.
Source: Author's illustration based on Digest of Education Statistics (1999-2019).

Furthermore, the USE (2003-2007) policy reform resulted in a fall in the number of CHSs and Primary Tops between the pre-policy years (1999-2002) and the post-policy periods (2003 onwards. Furthermore, we examined the share of secondary institutions for the period (1999-2019) and find that the share of GSSs increased whilst the share of Primary Tops and CHSs declined over time (see Figure 3.2 above for the comparison of the number of institutions and the share of institutions between the pre-and-post-policy periods). This result is consistent with the goal of the USE (2003-2007) policy reform which sought to convert Primary Tops and CHSs from a vocational track to an academic track.

Moreover, as of 2018, there remain some Primary Tops to be converted to GSSs in Guyana. However, the Ministry of Education in collaboration with the World Bank conducted the 2008 Geoff Howse report which outlined what needed to be done to fully achieve Universal Secondary Education in Guyana.[3] This report was updated in 2021 and was accepted by Guyana's Minister of education. The Ministry of Education (MOE) has subsequently begun the implementation process (Chief Planning Officer, MOE, 2022).

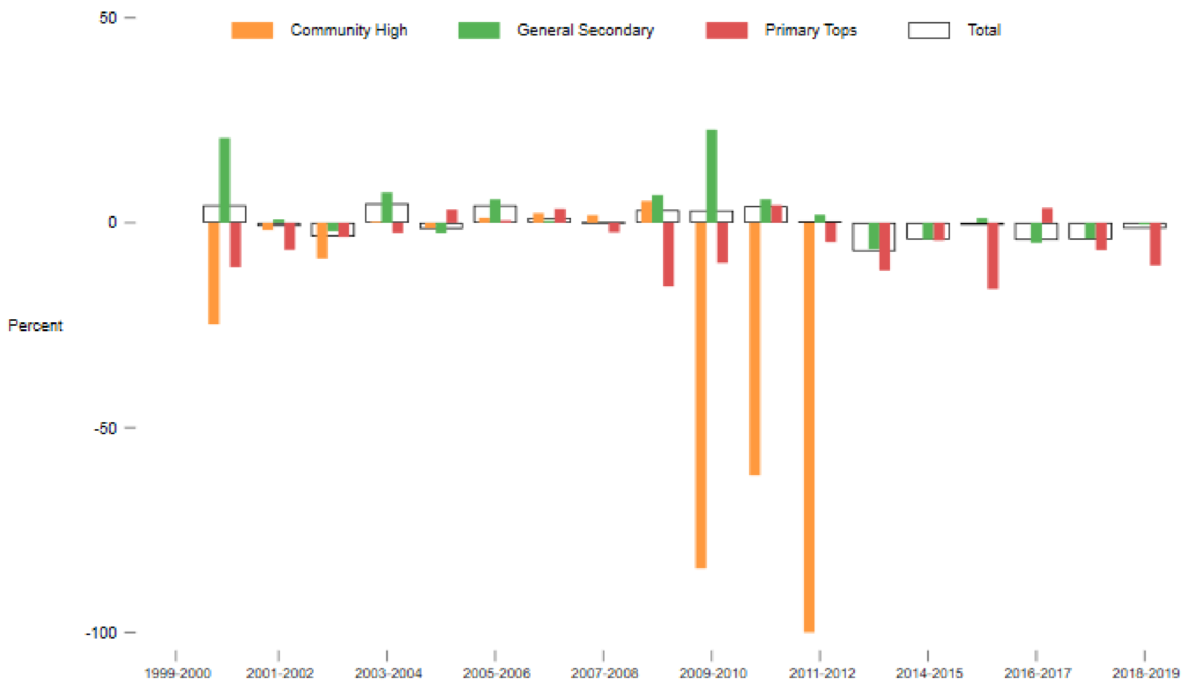
We can also see that the policy led to an increase in GSSs in the post-policy period, as expected. Furthermore, when looking at the number of students in secondary institutions for the period 1999-2019, we see a steady increase in GSSs students in the post policy period, a reduction of students in Primary Tops, as well as a complete phase out of CHSs in the year 2011 (see Figure 3.3 for the number of students between the pre-and-post-policy periods).



NB:/Missing data for the year (2012-2013) - Ministry of Education (MOE)
Figure 3.3: The number of students in secondary institutions between pre-and-post-policy periods.
Source: Digest of Education Statistics (1999-2019).

[3] See World Bank Document for the Geoff Howse Report, 2008.

When looking at the year-on-year percentage change in the total number of students in Primary Tops, CHSs and GSSs for the period 1999-2019 (see Figure 3.4 for the year-on-year percentage change of students in secondary institutions during pre-and-post-policy periods), we see decreases in year-on-year percentage change in the number of students in CHSs and Primary Tops. However, for GSSs, there is a general increase in the post-policy period compared to the pre-policy period.



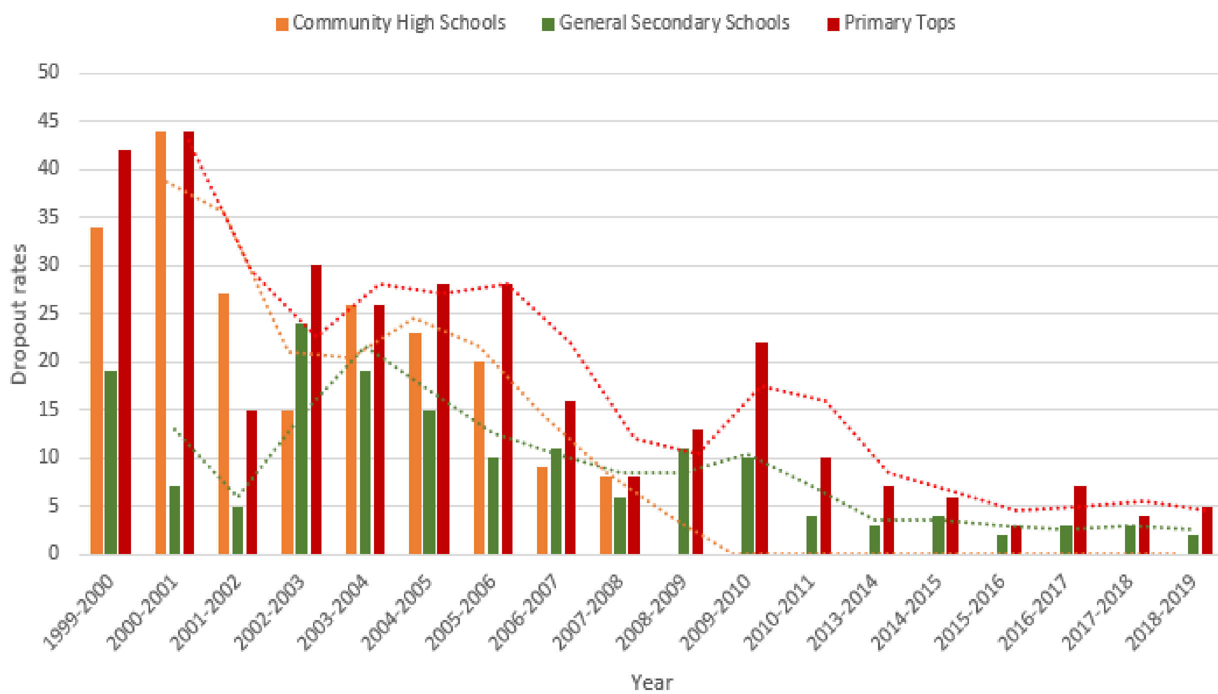
NB:/Missing data for the year (2012-2013) - Ministry of Education (MOE).
Figure 3.4: The year-on-year percentage change for students in secondary institutions for the period (1999-2019).
Source: Digest of Education Statistics (1999-2019).

Overall, the results from Figures 3.2 and 3.3 reveal that the USE (2003-2007) policy reform reduced the total number of secondary institutions and the year-on-year percentage change in the number of students in Primary Tops and CHSs but increased it for GSS institutions.

Moreover, we also examined the share of students across types of secondary institutions for the period (1999-2019) and find that the share of students in GSSs increased whilst it declined in Primary Tops and CHSs (see Figure 3.5 below for the share of students in secondary institution for the period (1999-2019)).

When examining the dropout rate over time, we find that the dropout rates were higher for Primary Tops and CHSs in both the post-and-pre policy periods. Furthermore, we find that as CHSs and

Primary Tops are converted to GSSs, the dropout rates for GSSs declined significantly (see Figure 3.6 below for the dropout rate in secondary institutions for the period (1999-2019)).



NB:/Missing data for the year (2012-2013) - Ministry of Education (MOE).
Figure 3.5: The dropout rates in secondary institutions over time (1999-2019).
Source: Digest of Education Statistics (1999-2019).

The USE policy also impacted the number of trained, untrained and unqualified teachers in secondary institutions in Guyana (see Appendix B.1 for further discussion).

3.2.3 Guyana's Labour Market

In this research, we examine the impact of the USE (2003-2007) policy reform on labour outcomes such as employment, wage employed, formal wage worker, work hours and log wage.

In Guyana, the statutory minimum age of employment is fifteen years old. An individual is therefore deemed employed if he/she is of working age and is engaged in any activity to produce or provide services for pay (or without pay). Consequently, majority of employees in Guyana are formally employed based on a permanent or fixed-term contract (ILO, 2022). However, there are many who are employed without written contract. In general, the work hours in Guyana are forty hours per week or 8 hours per day (ILO, 2022). In 2019, the public sector monthly minimum wage in Guyana was $70,000 Gyd/336.57 US$ per month, $3,230.27 Gyd/15.53 US$ per day and $403.79 Gyd/1.94 US$ per day (Bureau of Statistics, Guyana 2022).[4]

Guyana population over the last 20 years has been an average of 750,000. Guyana had a total population of 563,167 aged 15 and above in 2019. There were more women than men within the working-age population. The labour force participation rate was 49 percent, with men and women recording 61 and 38 percent respectively. Furthermore, the participation rates in rural and urban areas were 48 and 51 percent respectively. Guyana's unemployment rate was 13 percent, with youth unemployment being 30 percent (Guyana Labour Force Survey, 2019).[5]

In 1998, the total working-age population was 259,138 people with 62 percent having lower than or equal to primary education (National Employment Report Guyana, 2006). However, in 2019, 91.2 percent had higher than or equal to Primary education (Guyana Labour Force Survey, 2019). Moreover, in 2019, Guyana's percentage share of the working-age population by ethnicity stood at 45 percent East Indians, 26 percent Africans/Blacks, 20 percent Mixed, 9 percent Amerindians and 0 percent Other.

3.3 Data sources and descriptive statistics

3.3.1 The Guyana Labour Force Survey (GLFS)

This paper uses quarterly data from the Guyana Labour Force Survey (GLFS) and statistical tabulated data from the Digest of Education Statistics (DES 1999-2019). The GLFS is a continuous survey that uses a rotation scheme (or rotating panel) for 2017-2021. The GLFS samples approximately 4,000 households every quarter or a total of 11,000 individuals aged 15 years and above. The GLFS is based on a stratified two-stage probability design, each quarterly sample is spread over 12 consecutive weeks across 15 strata corresponding to urban, rural, coastal, and

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[4]At the time of this research, the conversion of Gyd to USD is $207.98 to 1 $USD (Bank of Guyana, September 2022).
[5]A person is deemed unemployed if they are actively looking for employment and are available to work within a short time span.

interior areas in the 10 administrative regions in Guyana. In the first sampling stage, there are 360 Primary Sampling Units (PSUs), which are groups of Census Enumeration Districts (EDs).

The GLFS used a rotating panel design to measure the change over time more accurately. All PSUs are kept the same from one quarter to the next. However, some households within each PSUs are kept in the sample while new households replace the rest. As a result, one part of the panel sample overlaps in both quarters (Guyana Bureau of statistics, IDB-GLFS, Methodological Report, 2018). The GLFS provides information on a wide range of outcomes related to education, employment, migration, wages and work-hours outcomes among others.

Given that the GLFS uses a rotating panel, we used one wave per block of respondents in this paper. To analyse a complete sample and use an individual-level dataset, we used a total of three blocks from survey quarters 3, 1 and 4 of 2018 and 2019 respectively. Furthermore, the sample consists of a total of 37,907 individuals that were selected from the three surveys. These surveys were used because there is no overlapping. In addition, as these samples are pre-2020, they are also unaffected by the COVID-19 pandemic.

In this research, Chapter 2 and 3 use different datasets. Chapter 2 uses MICS (2000-2014), and Chapter 3 uses GLFS (2018 and 2019). The samples in the Chapter 2 are female samples and Chapter 3 consist of both male and female samples. In Guyana, men are generally less educated than women (Digest of Education Statistics, 2018-2020; Guyana Chronicle, 2021). Moreover, based on the Human Development Report (2010), the percentage of female completing at least some secondary education in 2008 was 30 percent. Unfortunately, the figure for 2009 is unavailable. These results are close to the DHS 2009 Guyana data which recorded 43 percent (based on the new regression results) with completed secondary or tertiary education in 2009. Furthermore, the Human Development Report (2016) reported that female completing at least secondary education for the period 2005-2015 was 68.1 percent. Consequently, it is evident that the MICS (2000-2014) data over-represented the female completion of secondary or higher education, as it stood at 75 percent.

3.3.2 Digest of Education Statistics (DES)

The Digest of Education Statistics (DES) of Guyana is a collection of statistical tables compiled by the Ministry of Education (MOE), Guyana. It presents nationally aggregated yearly information on all the public educational institutions in the country, ranging from nursery to university. The DES also provides the education expenditure as a percentage of the national budget and gross domestic product (GDP). The DES (1999-2019) provides educational census data for Guyana for all the secondary institutions, i.e., Primary Tops, CHSs and GSSs. In addition, the DES contains variables such as: the number of schools at each level (i.e., nursery, primary, secondary, technical and university) by education district/region, grade and type of schools, enrolment by education district/region and type of schools, average enrolment, average attendance and percentage average attendance by education district/region and school type, admissions by education district/region and grade, class size by education district/region, number of classes by education district/region and the dropout rate by education district/region, grade and sex. Furthermore, the DES also provides information on the student/teacher ratio by education district/region by levels and type of schools, the number of teachers by education district/region, qualification and sex and teacher attrition by type of schools, education district/region, and sex.

Given that the DES provides detailed information on the school types. We have detailed information on all the secondary institutions (i.e., Primary Tops, CHSs and GSSs), which we have used for our analysis.

For this paper, we used the DES for the period 1999-2019 to effectively assess the impact of the USE (2003-2007) policy reform. Consequently, the DES (1999-2019) data was merged with the GLFS (2018 & 2019) data using the region in which the respondents were surveyed.

3.4 Empirical Strategy

To examine the relationship between the USE (2003-2007) policy reform and schooling, we employ a difference-in-differences estimation framework. The treatment is defined as those who were of secondary school-going age and thus exposed to the USE (2003-2007) policy reform while the control group were those who would have completed secondary school before the start of the policy reform period. Furthermore, the USE policy reform had a higher intensity in regions where there was a lower share of General secondary schools before the reform. Moreover, our empirical strategy is similar to that of Ajayi and Ross (2020) and Brudevold-Newman (2019). The estimating equation is as follows:

$$S_{ijrq} = \alpha_0 + \beta_1 \left(USE_j * I_r\right) + \beta_2 X_i + \delta_r + \gamma_j + \eta_q + \varepsilon_{ijrq} \qquad (1)$$

where S_{ijrq} are education outcomes, represented by schooling dummies (i.e., completion of secondary or tertiary education, the completion of tertiary education and the attendance of secondary or tertiary education) and labour market outcomes (i.e., dummies for employment, wage employed, formal wage worker, work hours and log wage) of individual i in cohort j in region r and survey quarter q, USE_j is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). The DES is used to construct the intensity variable of the USE program in the respondents' region of residence. Consequently, I_r is the intensity of the USE program in region *(r)* of residence (defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES). X_i represents a vector of individual characteristics, such as gender and ethnicity. δ_r, γ_j and η_q represent the region fixed effects, cohort fixed effects and survey quarter fixed effects, respectively. The interaction coefficient, β_1 is the estimate of the effect of the USE on educational attainment and labour market outcomes. Given that we are using a fixed effects model to analyse our difference-in-difference estimation, the region fixed effects absorb the intensity, and the cohort fixed effects are absorbed by the treated. Therefore, these two variables are collinear and are not included independently in our regression analysis. Moreover, ε_{ijrq} is the stochastic error term clustered at treatment levels. We used the reghdfe package by Sergio Correia's which allowed us to control for fixed effects and to cluster our standard errors at the treatment level.[6]

[6]Although we are using binary dependent variables, the argument that infers or supports the use of reghdfe being appropriate over logit and probit models is posited by an article by Cruz-Gonzalez et al, 2017. See Bias Corrections for Probit and Logit Models with Two-way Fixed Effects (sagepub.com).

In our baseline regressions, we assumed that the survey region was the region in which the respondents were educated. However, in our first robustness check we redefined the intensity variable intensity as the average share of non-GSS institutions in the region for the period 1999-2002 based on the DES.

3.5 Result

3.5.1 Summary Statistics

Table 3.1 below presents summary statistics of the key variables used in our analysis. Within the GLFS sample, we created a dummy variable equal to 1 if the highest education completed is secondary and 0 otherwise and find that 28 percent of the respondents completed secondary education. We also defined the completion of secondary or tertiary (i.e., including tertiary education) as a dummy equal 1 and 0 otherwise and find that 43 percent of the respondents completed secondary or tertiary education. In addition, we defined completed tertiary education as a dummy equal 1 if the highest education (i.e., technical/vocational certificate or Diploma, University Certificate or Diploma, Bachelor's degree, Postgraduate Certificate or Diploma, Masters, and Doctorate) and 0 otherwise. Moreover, we find that 15 percent of the respondents completed tertiary education.

With regards to the attendance of these institutions, we created a dummy equal to 1 of the highest education attended is secondary or tertiary (i.e., including tertiary education) and 0 otherwise and find that 85 percent of the respondents attended secondary or tertiary education. Moreover, when looking at the labour market outcomes, 66 percent of the respondents were employed with 69 percent earning an income. Furthermore, amongst the employed, 44 percent of the wage workers worked in the formal sector and the average work hours per week was 47 hours. Moreover, the mean of the log wage here is 11.15 (i.e., equivalent to a monthly income of $70,000 Guyanese dollars). This is due to missing wage data.

Table 3.1: Summary statistics

Variable	Mean	Standard deviation	Min	Max	N
Outcome variables					
Secondary education (Completed)	0.278	0.448	0	1	6326
Secondary or tertiary (Completed)	0.428	0.495	0	1	6326
Tertiary education (Completed)	0.148	0.355	0	1	6326
Secondary or tertiary (Attended)	0.879	0.326	0	1	6326
Employed	0.656	0.475	0	1	6326
Wage employed	0.689	0.463	0	1	3999
Formal wage worker	0.437	0.496	0	1	2759
Work hours	46.908	18.117	3	99	3999
Log wage	11.15	0.634	3.47	14.22	2312
USE & Intensity					
USE	0.526	0.499	0	1	6326
Intensity	0.727	0.109	0.60	0.95	6326
Individual characteristics					
Female	0.539	0.498	0	1	6326
East Indian	0.424	0.494	0	1	6326
African	0.287	0.453	0	1	6326
Mixed	0.196	0.397	0	1	6326
Amerindian	0.089	0.285	0	1	6326
Other	0.004	0.062	0	1	6751
Region 1	0.018	0.132	0	1	6326
Region 2	0.061	0.239	0	1	6326
Region 3	0.145	0.352	0	1	6326
Region 4	0.285	0.451	0	1	6326
Region 5	0.162	0.369	0	1	6326
Region 6	0.195	0.396	0	1	6326
Region 7	0.017	0.131	0	1	6326
Region 8	0.026	0.157	0	1	6326
Region 9	0.013	0.113	0	1	6326
Region 10	0.078	0.268	0	1	6326

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES).

In terms of individual characteristics, we find that 54 percent of the respondents are females, 33 percent of the respondents ranges between the ages of 26 and 40, 42 percent of the respondents were of East Indian descent, 29 percent were African, 20 percent were Mixed, 9 percent were

Amerindian.[7] When looking at the regions, we find that 29 percent of the respondents were from region 4, 20 percent from region 6, 16 percent from region 5 and 35 percent were from the remaining regions.

3.5.2 The effect of the USE (2003-2007) policy reform on schooling in Guyana

Table 3.2 below presents the main results where we regress our main outcome variables for schooling, (i.e., completed secondary education, completion of secondary or tertiary education, tertiary education and secondary or tertiary education attended). In columns 1 and 2, the coefficient of interest, β_1 is statistically significant at 1%, which means that greater exposure to the USE policy reform increases the completion of secondary education and secondary or tertiary education by 37.4 and 42.6 percentage points respectively. This finding is similar to that of Ajayi and Ross (2020), who find that greater exposure to Free Primary Education (FPE) program in Kenya increased the highest education level achieved. Consequently, the USE (2003-2007) resulted in an increased number of students completing and subsequently graduating from secondary or tertiary institutions in Guyana.

Furthermore, in column 3, we find that greater exposure to the USE policy reform does not have a statistically significant effect on the completion of tertiary education. In addition, when examining column 4, we find that greater exposure to the USE policy reform increases the attendance at secondary or tertiary education level by 16.1 percentage points. We also find that more females attended secondary or tertiary education as compared to their male counterparts.

[7]The East Indians are the most dominant ethnic group in Guyana, followed by the Africans, Mixed, Amerindians, Portuguese, Chinese, Whites and Other (i.e., those who did not identified with any of the listed race/ethnic groups. See: https://statisticsguyana.gov.gy/wp-content/uploads/2019/11/Final_2012_Census_Compendium2.pdf

Table 3.2: Effect of the USE on Educational Attainment

	(1) Secondary (Completed)	(2) Secondary/ tertiary education (Completed)	(3) Tertiary (Completed)	(4) Secondary/ tertiary (Attended)
USE x Intensity	0.374***	0.426***	0.032	0.161**
	(0.097)	(0.107)	(0.065)	(0.068)
Female	0.067***	0.070***	0.002	0.032***
	(0.011)	(0.011)	(0.008)	(0.007)
African	0.051***	0.189***	0.136***	0.121***
	(0.016)	(0.017)	(0.012)	(0.011)
Mixed	0.031*	0.101***	0.068***	0.077***
	(0.018)	(0.021)	(0.015)	(0.013)
Amerindian	-0.056**	-0.079***	-0.020	-0.045*
	(0.025)	(0.030)	(0.019)	(0.026)
Other	0.008	0.225**	0.219**	0.127***
	(0.089)	(0.101)	(0.109)	(0.040)
Constant	0.083**	0.160***	0.083***	0.754***
	(0.038)	(0.043)	(0.026)	(0.029)
Observations	6326	6326	6326	6326
Mean	0.278	0.428	0.148	0.879
Region fixed effects	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓
Survey quarter FE	✓	✓	✓	✓
R^2	0.039	0.078	0.068	0.069

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In Table 3.3, when restricting the regression to across the various ethnic groups in terms of educational outcomes, we find there was greater completion and attendance of secondary and tertiary education among the African ethnic group (see Columns 1-4). Although, the results for Amerindian students were not statistically significant, we find that the coefficients for the completion of secondary and attendance of secondary or higher were negative. There are many systematic, socioeconomic, and potential discriminatory factors can have a negative effect on the Amerindians. However, in Guyana, Amerindian communities were said to be at a disadvantage, as GSSs were mainly located on the outskirts of Amerindian villages which are situated in Guyana's hinterland, thus making access to secondary schools difficult, as many students either have to travel by boat or walk long distances to get to their schools (UNICEF, 2017).[8] In Table 3.4, column 5 and 6, we find that 65 percentage points of East Indian students were more likely to complete secondary education and 68 percentage point were more likely to complete secondary or higher education in Guyana.

Overall, we find that the USE (2003-2007) policy reform did not close the achievement gaps in education across ethnicities. However, the Africans and East Indians benefited more from the USE policy reform.

[8] The study of indigenous women and children in Guyana, 2017, pp 70 for factors influencing attendance and dropouts in Amerindian communities in Guyana, https://www.unicef.org/guyanasuriname/media/451/file/SitAn-Indigenous-women-children-in-Guyana.pdf)

Table 3.3: Educational Attainment - Restricted regressions (Ethnic groups: Africans, Mixed and Amerindians)

	(1) Secondary (Completed) (African)	(2) Secondary/ higher education (Completed - African)	(3) Tertiary (Completed- African)	(4) Secondary/ higher (Attended- African)	(5) Secondary (Completed) (Mixed)	(6) Secondary/ higher education (Completed - Mixed)	(7) Tertiary (Completed- Mixed)	(8) Secondary/ higher (Attended- Mixed)	(9) Secondary (Completed - Amerindian)	(10) Secondary/ higher education (Completed - Amerindian)	(11) Tertiary (Completed- Amerindian)	(12) Secondary/ higher (Attended- Amerindian)
USE x Intensity	0.807***	1.173***	0.339**	0.286**	0.226	0.152	-0.136	0.177	-0.387	-0.073	0.314	-0.285
	(0.154)	(0.174)	(0.170)	(0.077)	(0.192)	(0.178)	(0.143)	(0.127)	(0.335)	(0.374)	(0.192)	(0.317)
Female	0.766***	0.106***	0.028	0.022**	0.061**	0.090***	0.029	0.028**	-0.014	-0.033	-0.019	-0.023
	(0.026)	(0.022)	(0.022)	(0.009)	(0.027)	(0.028)	(0.021)	(0.014)	(0.035)	(0.039)	(0.015)	(0.034)
Constant	-0.008	0.099	0.114*	0.851***	0.166**	0.358***	0.211***	0.832***	0.364**	0.279	-0.006	0.906***
	(0.056)	(0.062)	(0.060)	(0.030)	(0.074)	(0.070)	(0.056)	(0.052)	(0.155)	(0.169)	(0.059)	(0.145)
Observations	1922	1922	1922	1922	1319	1319	1319	1319	596	596	596	596
R^2	0.055	0.054	0.036	0.045	0.042	0.073	0.058	0.047	0.071	0.083	0.091	0.108

Note: The omitted category for ethnicity is East Indian and Other consists of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.4: Educational Attainment - Restricted regressions (Ethnic groups: Other and East Indian – reference group)

	(1) Secondary (Completed - Other)	(2) Secondary/ higher education (Completed - Other)	(3) Tertiary (Completed- Other)	(4) Secondary (Completed – East Indians – ref group)	(5) Secondary/ higher education (Completed – East Indians)	(6) Tertiary (Completed- East Indian)	(7) Secondary/ higher (Attended- East Indian)
USE x Intensity	1.542	2.312	0.771	0.650***	0.684***	0.009	-0.043
	(2.861)	(2.229)	(2.044)	(0.182)	(0.195)	(0.115)	(0.147)
Female	-0.179	-0.768*	-0.589	0.072***	0.054***	-0.020*	0.045***
	(0.611)	(0.315)	(0.556)	(0.016)	(0.018)	(0.011)	(0.013)
Constant	-0.271	0.316	0.587	0.001	0.082	0.089**	0.810***
	(1.195)	(0.815)	(0.984)	(0.064)	(0.069)	(0.042)	(0.052)
Observations	18	18	18	2888	2888	2888	2888
R^2	0.662	0.899	0.842	0.048	0.057	0.034	0.034

Note: Results for Other **(secondary/higher attended)** were dropped due to zero observations for secondary or higher atteneded. The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.5.3 The effect of the USE (2003-2007) on labour market outcomes in Guyana

Based on the analysis of the impact of the USE policy reform on education attainment in Guyana, it is observed that the USE policy reform resulted in an increase in both the completion and attendance of secondary or tertiary education in Guyana. In this section, we examine the impact of the USE policy reform on labour market outcomes.

In Table 3.5, column 1, we find that the USE policy reform led to an increase in the employment, but the result is not statistically significant. In column 2, we find that the USE policy reform had a negative impact on wage employment, however the result is not statistically significant. Estimates in column 3 indicate a that the USE policy led to an increase in weekly work hours, however it is not statistically significant. Moreover, women tend to work 10.04 hours less when compared to men. We also find that there was an increase in work hours by 3.38, 2.51 and 10.18 among Africans, Mixed and the other ethnic groups respectively when compared to East Indians. However, we find a reduction in the work hours for the Amerindian workers by 2.87 hours. These results are consistent with the literature that shows that higher education affects work hours (Card, 1999; Heckman et al., 2006; Ye Chen, 2021).

When looking at wages in column 4, we find that an additional year of exposure to the USE policy is associated with an increase in wage by 52.5 percentage points. This finding supports the argument that better-educated individuals earn higher wages (Kampelmann et al., 2018).
We also find that females earned lower than their male counterparts. Consequently, we find that the USE policy led to an increase in the wage of people who were exposed to the policy. Furthermore, we find that log wage increases for Africans and Mixed ethnic groups but reduced for the Amerindians when compared to the East Indians.

Columns 5, Table 3.5 presents the effects of the USE policy reform on formal wage workers. We find that the policy has no significant effect on the probability of being a formal wage worker.

Table 3.5: Effect of the USE on the Labour Market in Guyana

	(1) Employed	(2) Wage employed	(3) Work hours	(4) Log wage	(5) Formal wage worker
USE x Intensity	0.039	-0.112	3.155	0.525**	0.210
	(0.076)	(0.118)	(3.803)	(0.257)	(0.135)
Female	-0.358***	0.034**	-10.041***	-0.214***	0.128***
	(0.015)	(0.015)	(0.592)	(0.029)	(0.020)
African	0.150***	0.142***	3.379***	0.115***	0.222***
	(0.014)	(0.021)	(0.732)	(0.030)	(0.025)
Mixed	0.062***	0.070***	2.509***	0.090**	0.074***
	(0.015)	(0.021)	(0.755)	(0.036)	(0.024)
Amerindian	-0.016	0.086*	-2.870*	-0.197**	-0.001
	(0.031)	(0.038)	(1.590)	(0.078)	(0.043)
Other	0.152**	-0.061	10.182**	-0.094	0.052
	(0.069)	(0.112)	(4.205)	(0.281)	(0.183)
Constant	0.780***	0.651***	48.353***	10.990***	0.201***
	(0.030)	(0.045)	(1.436)	(0.102)	(0.060)
Observations	6326	3999	3999	2312	2759
Mean	0.656	0.689	46.908	11.15	0.437
Region fixed effects	✓	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓	✓
Survey quarter FE	✓	✓	✓	✓	✓
R^2	0.176	0.055	0.100	0.081	0.171

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.6: Labour Market Outcomes - Restricted regressions (Ethnic groups: Africans and Mixed)

	(1) Employed (African)	(2) Wage employed (African)	(3) Work hours (African)	(4) Log wage (African)	(5) Formal wage worker (African)	(6) Employed (Mixed)	(7) Wage employed (Mixed)	(8) Work hours (Mixed)	(9) Log wage (Mixed)	(10) Formal wage worker (Mixed)
USE x Intensity	-0.049	0.257	8.616	0.299	0.595***	0.006	-0.388*	3.004	0.151	-0.308
	(0.166)	(0.220)	(8.305)	(0.379)	(0.223)	(0.182)	(0.231)	(8.677)	(0.428)	(0.280)
Female	-0.184***	0.091***	-10.954***	-0.214***	0.108***	-0.311***	0.004	-10.268***	-0.198***	0.205***
	(0.020)	(0.021)	(0.903)	(0.035)	(0.030)	(0.026)	(0.030)	(1.313)	(0.072)	(0.047)
Constant	0.870***	0.634***	50.741***	11.225***	0.310***	0.838***	0.825***	52.306***	11.244***	0.460***
	(0.058)	(0.077)	(2.866)	(0.135)	(0.084)	(0.071)	(0.085)	(3.200)	(0.170)	(0.119)
Observations	1922	1419	1419	887	1082	1319	864	864	496	591
R^2	0.066	0.053	0.119	0.061	0.144	0.126	0.079	0.129	0.073	0.154

Note: Results for Other was dropped due to zero observations for secondary or higher atteneded. The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.7: Labour Market Outcomes - Restricted regressions (Ethnic groups: Africans and Mixed)

	(1) Employed (Amerindian)	(2) Wage employed (Amerindian)	(3) Work hours (Amerindian)	(4) Log wage (Amerindian)	(5) Formal wage worker (Amerindian)	(6) Employed (Other)
USE x Intensity	0.357	0.071	51.368***	0.678	0.806**	3.775**
	(0.345)	(0.396)	(19.395)	(0.830)	(0.383)	(1.182)
Female	-0.260***	-0.010	-11.295***	-0.260**	0.214***	-0.307
	(0.041)	(0.063)	(2. 660)	(0.121)	(0.071)	(0.549)
Constant	0.623***	0.603***	27.009***	10.749***	-0.146	-0.374
	(0.159)	(0.179)	(8.533)	(0.376)	(0.183)	(0.593)
Observations	596	302	302	116	190	18
R^2	0.217	0.138	0.229	0.254	0.173	0.716

Note: Results for Other (**wage employed, work hours, log wage and formal wage worker)** were dropped due to small number of observations for secondary or higher atteneded. The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

When examining the labour market results in Tables 3.6 and 3.7, we find that the results were mixed, with Africans (in column 5) being more likely to be employed in the formal sector. While there is a negative impact on the wage employed for the mixed ethnic group (see column 7). Furthermore, in Table 3.7, column 3, we find that Amerindians work more hours.

3.5.4 Robustness Checks

We perform several robustness checks to examine whether the results are robust. Consequently, we check the robustness of our treatment intensity measure. Firstly, we check whether our results change if we redefine our intensity variable as: (I_r) - the intensity of the USE program in region (r) of residence is defined as the average share of non-GSS institutions in the region for the period 1999-2002 based on the DES rather than the share of non-GSS institutions in the immediate pre-policy year of 2002.

Table 3.8: Robustness Check - Effect of the USE on Educational Attainment in Guyana

	(1) Secondary (Completed)	(1) Secondary/tertiary education (Completed)	(2) Tertiary (Completed)	(3) Secondary/ tertiary (Attended)
USE x Intensity	0.411***	0.464***	0.032	0.155**
	(0.098)	(0.107)	(0.066)	(0.068)
Female	0.067***	0.070***	0.002	0.032***
	(0.011)	(0.011)	(0.008)	(0.007)
African	0.052***	0.189***	0.136***	0.121***
	(0.015)	(0.017)	(0.012)	(0.011)
Mixed	0.031**	0.101***	0.068***	0.077***
	(0.018)	(0.021)	(0.015)	(0.013)
Amerindian	-0.056**	-0.079**	-0.020	-0.045**
	(0.025)	(0.030)	(0.019)	(0.026)
Other	0.009	0.226***	0.219**	0.127***
	(0.088)	(0.101)	(0.109)	(0.040)
Constant	0.064	0.139***	0.083***	0.754***
	(0.039)	(0.044)	(0.027)	(0.030)
Observations	6326	6326	6326	6326
Mean	0.278	0.428	0.148	0.879
Region fixed effects	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓
Survey quarter FE	✓	✓	✓	✓
R^2	0.039	0.079	0.064	0.069

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level; there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.8 presents our robustness check where we regress our main outcome variables for schooling, (i.e., completion of secondary education, completion of secondary or tertiary education, tertiary education and secondary or tertiary education attended) on our explanatory variables. In columns 1 and 2, we find that the results are robust when compared to our main results. Furthermore, the result in column 1 shows that the coefficient for β_1 $(USE_j * I_r)$ is significant at the 1% level, which means that greater exposure the USE policy reform increased the completion of secondary and secondary or tertiary education by 41.10 and 46.40 percentage points respectively. These results are similar to our baseline result. This finding is similar to that of Ajayi and Ross (2020), who find that greater exposure to Free Primary Education (FPE) program in Kenya increased the highest education level achieved.

In Table 3.8, column 4, we find that the results were robust when looking at the effect of the USE policy reform on the attendance of secondary or tertiary education, i.e., exposure to the USE policy reform increased the attendance of secondary or tertiary education by 15.5 percentage points.

Table 3.9 below presents the results for the robustness check when looking at the effect of the USE on the labour market in Guyana using the average share of non-GSS institutions in the pre-policy period (1999-2002). Like our baseline results, we find that exposure to the USE policy reform increases log wage. Furthermore, we did not find any effect when examining the USE policy reform on the other outcome variables such as employment, wage employed work hours and formal wage workers.

Secondly, we redefined the intensity as the share of non-GSS students in secondary institutions in the region in 2002 who would have never completed general secondary schools, i.e., those who would have dropped out of non-GSSs in grade 9, based on the DES. This was done in order to determine whether the USE policy would have had a positive effect on students who would have dropped out of secondary education at grade 9 which is grade in which children in CHS would have normally dropped out at (Williams, 1993; Jennings, 2000; Gill-Marshall, 2000).

In column 1, Table 3.10, we find that the results are robust when compared to our main results. Furthermore, the result in column 1 shows that the coefficient for β_1 $(USE_j * I_r)$ is significant at the 1% level, which means that greater exposure the USE policy reform increased the completion of secondary education and secondary or tertiary education by 22 and 15.40 percentage points respectively. However, we find that tertiary education decline by 6.5 percentage points and increased secondary or tertiary education attended by 5.3 percentage points. These results are similar to our baseline results. In Table 3.11, columns 3 and 5, we also find that exposure to the USE policy reform increases work hours and formal wage worker.

Table 3.9: Robustness Check – Effect of the USE on the Labour Market in Guyana

	(1) Employed	(2) Wage employed	(3) Work hours	(4) Log wage	(5) Formal wage worker
USE x Intensity	0.035	-0.095	3.613	0.451*	0.204
	(0.076)	(0.117)	(3.747)	(0.255)	(0.136)
Female	-0.358***	0.034**	-10.040***	-0.214***	0.128***
	(0.015)	(0.015)	(0.592)	(0.029)	(0.020)
African	0.150***	0.142***	3.380***	0.116***	0.222***
	(0.014)	(0.021)	(0.733)	(0.030)	(0.025)
Mixed	0.062***	0.070***	2.510***	0.090**	0.074***
	(0.015)	(0.021)	(0.755)	(0.036)	(0.024)
Amerindian	-0.016	0.086*	-2.871*	-0.196**	-0.001
	(0.031)	(0.038)	(1.590)	(0.078)	(0.043)
Other	0.152**	-0.061	10.186**	-0.094	0.052
	(0.069)	(0.112)	(4.206)	(0.281)	(0.183)
Constant	0.781***	0.645***	48.136***	11.013***	0.201***
	(0.031)	(0.047)	(1.465)	(0.104)	(0.062)
Observations	6326	3999	3999	2312	2759
Mean	0.656	0.689	46.908	11.15	0.437
Region fixed effects	✓	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓	✓
Survey quarter FE	✓	✓	✓	✓	✓
R^2	0.176	0.055	0.100	0.080	0.171

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level; there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.10: Robustness Check- the effect of the USE on Educational Attainment

	(1) Secondary (Completed)	(1) Secondary/tertiary education (Completed)	(2) Tertiary (Completed)	(3) Secondary/ tertiary (Attended)
USE x Intensity	0.220***	0.154***	-0.065**	0.053**
	(0.028)	(0.038)	(0.027)	(0.023)
Female	0.067***	0.071***	0.002	0.032***
	(0.011)	(0.011)	(0.008)	(0.007)
African	0.053***	0.190***	0.136***	0.124***
	(0.016)	(0.017)	(0.012)	(0.011)
Mixed	0.032*	0.101***	0.067***	0.077***
	(0.016)	(0.021)	(0.015)	(0.012)
Amerindian	-0.050*	-0.075**	-0.021	-0.043*
	(0.026)	(0.030)	(0.019)	(0.025)
Other	0.009	0.225**	0.219**	0.127***
	(0.089)	(0.101)	(0.109)	(0.040)
Constant	0.155***	0.273***	0.116***	0.798***
	(0.016)	(0.018)	(0.013)	(0.012)
Observations	6326	6326	6326	6326
Mean	0.278	0.428	0.148	0.879
Region fixed effects	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓
Survey quarter FE	✓	✓	✓	✓
R^2	0.042	0.079	0.065	0.069

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level; there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.11: Robustness Check – Effect of the USE on the Labour Market in Guyana

	(1) Employed	(2) Wage employed	(3) Work hours	(4) Log wage	(5) Formal wage worker
USE x Intensity	-0.014	0.006	2.643**	-0.100	0.085*
	(0.029)	(0.043)	(1.274)	(0.085)	(0.047)
Female	-0.358***	0.034**	-10.041***	-0.215***	0.128***
	(0.015)	(0.015)	(0.593)	(0.029)	(0.020)
African	0.150***	0.142***	3.409***	0.116***	0.224***
	(0.014)	(0.021)	(0.736)	(0.029)	(0.025)
Mixed	0.062***	0.070**	2.522***	0.088**	0.075**
	(0.015)	(0.021)	(0.755)	(0.036)	(0.024)
Amerindian	-0.016	0.085**	-2.840**	-0.192**	0.000
	(0.031)	(0.038)	(1.593)	(0.078)	(0.043)
Other	0.151**	-0.060	10.172**	-0.103	0.052
	(0.069)	(0.112)	(4.215)	(0.284)	(0.183)
Constant	0.799***	0.607***	48.724***	11.231***	0.257***
	(0.013)	(0.020)	(0.585)	(0.033)	(0.026)
Observations	6326	3999	3999	2312	2759
Mean	0.658	0.653	46.559	11.12	0.422
Region fixed effects	✓	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓	✓
Survey quarter FE	✓	✓	✓	✓	✓
R^2	0.176	0.055	0.100	0.080	0.171

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level; there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.12: Summary statistics (respondents who have not migrated vs those who migrated)

Variable	Mean	SD	*Have not Migrated* N	Mean	SD	*Migrated* N
Outcome variables						
Secondary education (Completed)	0.276	0.447	5183	0.277	0.448	1030
Secondary or tertiary (Completed)	0.423	0.494	5183	0.442	0.497	1030
Tertiary education (Completed)	0.145	0.352	5183	0.163	0.369	1030
Secondary or tertiary (Attended)	0.878	0.327	5183	0.883	0.321	1030
Employed	0.666	0.472	5183	0.616	0.487	1030
Wage employed	0.688	0.463	3315	0.698	0.459	626
Formal wage worker	0.491	0.500	2282	0.556	0.497	437
Work hours	46.550	17.847	3315	48.562	19.134	626
Ln wage	11.17	0.631	2129	11.255	0.679	410
USE & Intensity						
USE	0.525	0.499	5183	0.513	0.500	1030
Intensity	0.725	0.109	5183	0.752	0.126	1030
Individual characteristics						
Female	0.524	0.499	5183	0.618	0.486	1030
East Indian	0.444	0.497	5183	0.318	0.466	1030
African	0.291	0.454	5183	0.290	0.454	1030
Mixed	0.178	0.383	5183	0.278	0.448	1030
Amerindian	0.085	0.279	5183	0.114	0.317	1030
Others	0.002	0.048	5183	0	0	1030
Region 1	0.020	0.140	5183	0.006	0.076	1030
Region 2	0.064	0.244	5183	0.046	0.209	1030
Region 3	0.119	0.324	5183	0.262	0.440	1030
Region 4	0.285	0.451	5183	0.284	0.451	1030
Region 5	0.165	0.371	5183	0.158	0.365	1030
Region 6	0.213	0.410	5183	0.106	0.309	1030
Region 7	0.017	0.123	5183	0.019	0.138	1030
Region 8	0.026	0.160	5183	0.021	0.145	1030
Region 9	0.015	0.121	5183	0.002	0.044	1030
Region 10	0.076	0.265	5183	0.094	0.292	1030

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES.

Table 3.13: Robustness Check: Effect of the USE on Educational Attainment in Guyana

	(1) Secondary (Completed)	(1) Secondary/tertiary education (Completed)	(2) Tertiary (Completed)	(3) Secondary/ tertiary (Attended)
USE x Intensity	0.450***	0.524***	0.056	0.163**
	(0.103)	(0.117)	(0.068)	(0.075)
Female	0.064***	0.077***	0.012	0.034***
	(0.012)	(0.012)	(0.008)	(0.008)
African	0.055**	0.191***	0.133***	0.120***
	(0.017)	(0.018)	(0.013)	(0.012)
Mixed	0.046**	0.118***	0.069***	0.096***
	(0.019)	(0.023)	(0.019)	(0.014)
Amerindian	-0.051*	-0.080**	-0.024	-0.010
	(0.030)	(0.036)	(0.024)	(0.031)
Other	0.099	0.306**	0.210	0.081
	(0.132)	(0.153)	(0.163)	(0.073)
Constant	0.051	0.113**	0.068**	0.746***
	(0.041)	(0.046)	(0.027)	(0.032)
Observations	5183	5183	5183	5183
Mean	0.276	0.423	0.145	0.878
Region fixed effects	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓
Survey quarter FE	✓	✓	✓	✓
R^2	0.045	0.086	0.069	0.072

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level; there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Thirdly, to reduce the influence of migration, we restricted the results to the persons who were still residing in the same regions of birth at the time of the GLFS survey. This was done to determine whether the results would still hold when considering the impact of migration. The assumption made in the baseline regression is that where the individual is currently residing is where they would have completed their education.

Based on the survey, a total of 5183 of the survey sample were still residing in their region of birth, which means that they did migrate to other regions; this accounts for 82 percent of the observation (see Table 3.12). Furthermore, in Tables 3.13-3.14, we restricted the results of the regressions to persons who were still residing in their same region of birth at the time of the survey and find that the results are robust. In Table 3.13, based on our baseline equation, we find that greater exposure to the USE policy reform led to an increase in the completion of secondary and secondary or tertiary education by 45.0 and 52.4 percentage points. In addition, when examining the effects of the USE policy reform on the attendance of secondary or tertiary education, we find that greater exposure to the USE policy reform led to an increase in the attendance of secondary or tertiary education by 16.3 percentage points. Furthermore, we find that the results were robust when looking at the labour market impacts in Table 3.14.

Table 3.14: Effect of the USE on the Labour Market in Guyana

	(1) Employed	(2) Wage employed	(3) Work hours	(4) Log wage	(5) Formal wage worker
USE x Intensity	0.024	-0.049	4.789	0.493*	0.289**
	(0.083)	(0.135)	(4.525)	(0.259)	(0.145)
Female	-0.340***	0.046**	-9.386***	-0.167***	0.187***
	(0.016)	(0.016)	(0.650)	(0.030)	(0.024)
African	0.138***	0.125***	2.874***	0.107***	0.211***
	(0.016)	(0.022)	(0.784)	(0.029)	(0.023)
Mixed	0.061***	0.072**	1.449*	0.066*	0.091**
	(0.017)	(0.023)	(0.842)	(0.035)	(0.034)
Amerindian	-0.005	0.058	-4.694**	-0.284**	-0.086
	(0.039)	(0.046)	(2.139)	(0.110)	(0.065)
Other	0.227**	0.058	1.916	-0.124	0.187
	(0.102)	(0.136)	(5.150)	(0.357)	(0.187)
Constant	0.784***	0.629***	47.619***	11.011**	0.206**
	(0.034)	(0.053)	(1.740)	(0.104)	(0.063)
Observations	5183	3315	3315	2129	2282
Mean	0.664	0.649	46.109	11.15	0.483
Region fixed effects	✓	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓	✓
Survey quarter FE	✓	✓	✓	✓	✓
R^2	0.162	0.050	0.090	0.072	0.141

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Fourthly, we performed additional robustness checks were done to ascertain whether the results still hold when dropping the regions one at a time (i.e., regions 1 to 10) from the survey data. These results are presented in Tables 3.15-3.16. When using the survey region as the region in which the respondents were educated in Table 3.15, we find that the results are robust for the completion of secondary, secondary or tertiary when dropping regions 1,2,3,5,6,7,8,9 and 10. Consequently, the results hold across nine of the ten administrative regions in Guyana. The results were also robust for the attendance of secondary or tertiary for regions 2,3,5,6,7,8,9 and 10. In addition, the results are also robust for wage when looking at the labour market outcomes in Table 3.16.

For our final robustness check, we applied multiple hypothesis testing using the Westfall-Young and use the Bonferroni Holm and Sidak-Holm adjusted p-value were used for comparison purposes. Here we compare the three-hypothesis tests by examining their adjusted p-value to a cut-off of 0.05 and 0.01 respectively; given that the nominal cut-off in our baseline specification is significant at the 0.01 and 0.05 levels respectively. When looking at the Westfall-Young adjusted p-values, we find that completion of secondary and secondary or tertiary education is significant at the 1% level, while secondary or tertiary education attended is significant at the 5% level after adjusting for Type 1 error (Jones and Reif, 2019).[9] Similarly, we find that log wage is also significant at the 5% level after adjusting for Type 1 error (see Table 3.17, below for the multiple hypothesis tests). Furthermore, when looking at the Bonferroni-Holm and Sidak-Holm adjusted p-values, we also find that the results were also significant for the completion of secondary or tertiary education and secondary or tertiary education attended. Consequently, we conclude that the real effect was observed for four outcome variables, i.e., the completion of secondary, secondary or tertiary education, secondary or tertiary education attended and log wage. Otherwise, the effects observed for work hours might be due to Type 1 error.

[9] Wyoung is a Stata command which applied free step-down resampling methodology of Westfall and Young (1993). It is used to calculate the adjusted *p*-values. The Stata command programmed by Julian Reif, is a precursor to the Romano-Wolf procedure, thus using bootstrap resampling to allow for dependence across outcomes. Furthermore, it also controls the Family Wise Error Rate (FWER) and allow for dependence amongst p-values. In addition, it also computes the Bonferroni-Holm and Sidak-Holm adjusted *p*-values (Jones and Reif, 2019).

Table 3.15: Robustness Check: Effect of the USE on Educational Attainment in Guyana (Share of non-GSS institutions)

Dropped Regions	Diff-in-Diff	Secondary (Completed)	Secondary/ tertiary education (Completed)	Tertiary (Completed)	Secondary/ tertiary (Attended)	Total Observations
Region 1	USE x Intensity	0.389*** (0.103)	0.460*** (0.114)	0.049 (0.071)	0.083 (0.067)	6214
Region 2	USE x Intensity	0.367*** (0.098)	0.406*** (0.108)	0.021 (0.068)	0.171** (0.068)	5941
Region 3	USE x Intensity	0.321*** (0.100)	0.369*** (0.112)	0.030 (0.070)	0.144** (0.072)	5408
Region 4	USE x Intensity	-0.096 (0.099)	0.029 (0.133)	0.122 (0.100)	0.168 (0.107)	4521
Region 5	USE x Intensity	0.285*** (0.098)	0.362*** (0.107)	0.046 (0.067)	0.171** (0.072)	5299
Region 6	USE x Intensity	0.472*** (0.092)	0.476*** (0.105)	-0.019 (0.061)	0.175** (0.069)	5092
Region 7	USE x Intensity	0.414*** (0.095)	0.470*** (0.106)	0.036 (0.068)	0.172** (0.070)	6216
Region 8	USE x Intensity	0.434*** (0.103)	0.525*** (0.110)	0.069 (0.072)	0.146** (0.072)	6166
Region 9	USE x Intensity	0.380*** (0.101)	0.449*** (0.111)	0.043 (0.066)	0.186*** (0.071)	6244
Region 10	USE x Intensity	0.465*** (0.098)	0.454*** (0.111)	-0.025 (0.057)	0.195*** (0.072)	5833

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.16: Robustness Check: Effect of the USE on the Labour Market in Guyana (Share of non-GSS institutions)

Dropped Regions	Diff-in-Diff	Employed	Wage Employed	Work hours	Log wage	Formal wage worker
		0.013	-0.127	-0.614	0.446*	0.226
Region 1	USE x Intensity	(0.079)	(0.121)	(3.824)	(0.265)	(0.141)
		0.031	-0.126	6.685*	0.460*	0.237*
Region 2	USE x Intensity	(0.078)	(0.122)	(3.804)	(0.242)	(0.138)
		0.074	-0.083	1.541	0.438	0.200
Region 3	USE x Intensity	(0.081)	(0.127)	(4.080)	(0.280)	(0.140)
		0.118	-0.293	-1.575	1.130***	0.368*
Region 4	USE x Intensity	(0.115)	(0.191)	(5.484)	(0.370)	(0.214)
		0.032	-0.162	2.450	0.755***	0.110
Region 5	USE x Intensity	(0.080)	(0.123)	(4.107)	(0.268)	(0.140)
		0.020	-0.080	4.237	0.378	0.163
Region 6	USE x Intensity	(0.076)	(0.119)	(3.660)	(0.253)	(0.143)
		0.057	-0.088	4.132	0.592**	0.273**
Region 7	USE x Intensity	(0.078)	(0.120)	(3.894)	(0.269)	(0.137)
		0.049	-0.100	2.647	0.438	0.154
Region 8	USE x Intensity	(0.081)	(0.124)	(4.183)	(0.273)	(0.138)
		0.037	-0.046	5.471	0.529**	0.205
Region 9	USE x Intensity	(0.077)	(0.120)	(3.875)	(0.267)	(0.141)
		0.011	-0.141	3.061	0.494*	0.250*
Region 10	USE x Intensity	(0.075)	(0.131)	(3.966)	(0.268)	(0.137)

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.17: Robustness Check (Baseline specification): Multiple Hypothesis Testing (Westfall-Young, Bonferroni and Sidak-Holm Corrections)

Outcome variable	Coeff (se)	(Diff-in-diff) Unadjusted p-value	(Diff-in-Diff) Westfall-Young (Adjusted p- value)	(Diff-in-Diff) Bonferroni-Holm (Adjusted p- value)	(Diff-in-Diff) Sidak-Holm (Adjusted p-value)	Westfall Young (sig)	Bonf (sig)	Sidak (sig)
Secondary education (Completed)	0.374*** (0.097)	0.000	0.00	0.000	0.000	yes	yes	yes
Secondary/tertiary education (Completed)	0.426*** (0.107)	0.000	0.00	0.000	0.000	yes	yes	yes
Tertiary (Completed)	0.032 (0.065)	0.620	0.46	0.620	0.620	no	no	no
Secondary/ tertiary (Attended)	0.161** (0.068)	0.020	0.00	0.041	0.040	yes	yes	yes
Employed	0.039 (0.076)	0.605	0.56	1.000	0.716	no	no	no
Wage Employed	-0.112 (0.118)	0.343	0.56	1.000	0.716	no	no	no
Work hours	3.155 (3.803)	0.408	0.56	1.000	0.716	no	no	no
Log wage	0.525** (0.257)	0.043	0.05	0.215	0.198	yes	no	no
Formal wage worker	0.209 (0.135)	0.123	0.28	0.492	0.408	no	no	no

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In addition, we also did a DID-IV results on the impact of education on labour market outcomes with USE * intensity as the instrumental variable. We use USE*intensity as an instrumental variable for education to conduct 2SLS estimates. We chose to focus mainly on log wage, as it was the only statistically significant variable among the other labour market outcome variables.

Table 3.18: Robustness Check (DID-IV: 2SLS Regressions)

	Log wage	Log wage	Log wage	Log wage
	2SLS	2SLS	2SLS	2SLS
	1	2	3	4
Secondary education (Completed)	1.330			
	(0.869)			
	[0.128]			
Secondary/Tertiary education (Completed)		0.997^{*}		
		(0.530)		
		[0.062]		
Tertiary education (Completed)			4.244	
			(4.546)	
			[0.352]	
Secondary/Tertiary (Attended)				2.324
				(1.455)
				[0.113]
Observations	2312	2312	2312	2312
Controls	✓	✓	✓	✓
Region fixed effects	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓
Survey quarter fixed effects	✓	✓	✓	✓
Kleibergen-Paap	6.626	8.812	0.775	6.269

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Where the brackets ( ) contains the standard errors and [ ] contains the p-values. Standard errors in parentheses are clustered at the treatment level; there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In Table 3.18 above, our coefficient for the completion of secondary/tertiary education when used as an instrumented variable with respect to the log wage is positive and statistically significant at the 10 percent level, suggesting that the USE policy increases wage income. Furthermore, although the other three coefficients are not statistically significant, the coefficients for the completion of secondary education and secondary/tertiary education attended are close to significant with p-values less than 0.15.

However, when synthesizing various pieces of evidence, the conclusion that USE policy resulted in higher wage is still valid.

In addition, we have also present placebo analysis to test that our main results are not driven by simultaneous impacts affecting both the region and the (treated group) 11-17 age groups, we conduct placebo tests.

Table 3.19: Placebo test - Effect of the USE on Educational Attainment

	(1) Secondary education (Completed)	(2) Secondary/ Tertiary education (Completed)	(3) Tertiary education (Completed)	(4) Secondary/ Tertiary education (Attended)
USE x Intensity	0.374***	0.426***	0.032	0.161**
	(0.097)	(0.106)	(0.065)	(0.68)
	[0.000]	[0.000]	[0.004]	[0.000]
Observations	6326	6326	6326	6326
Controls	✓	✓	✓	✓
Region fixed effects	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓
Survey quarter fixed effects	✓	✓	✓	✓
R^2	0.039	0.078	0.064	0.069

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Where the brackets ( ) contains the standard errors and [ ] contains the p-values. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.20: Placebo test - Effect of the USE on the Labour Market in Guyana

	(1) Employed	(2) Wage employed	(3) Work hours	(4) Log wage	(5) Formal wage worker
USE x Intensity	0.039	-0.112	3.155	0.525**	0.210
	(0.076)	(0.118)	(3.803)	(0.257)	(0.135)
	[0.011]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	6326	3999	3999	2312	2759
Controls	✓	✓	✓	✓	✓
Region fixed effects	✓	✓	✓	✓	✓
Age fixed effects	✓	✓	✓	✓	✓
Survey quarter fixed effects	✓	✓	✓	✓	✓
R^2	0.176	0.055	0.100	0.081	0.171

Note: The omitted category for ethnicity is East Indian and Other consist of Chinese, Portuguese, White and the Other (i.e., those who did not identified with any if the listed race/ethnic groups in Guyana). The USE is the treatment, i.e., a dummy variable equal to one for individuals born in cohort j if exposed to the policy (i.e., those aged 11-17 in 2003) and equal to zero (i.e., the control) if not (aged 18-24 in 2003 at the time of the reform). Intensity of the USE is defined as the share of non-GSS schools out of all secondary schools in the region in 2002, based on the DES. Standard errors in parentheses are clustered at the treatment level, there are 200 clusters * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

When performing randomization inference on the outcome variables. The results in Table 3.19 show that the coefficients for the completion of secondary education and secondary/tertiary education and the attendance of secondary/tertiary education are significant, with p=c/n being 0.000 in all cases.

Furthermore, when looking at the coefficient for log wage in Table 3.20, we find that the result was also statistically significant, with p=c/n being 0.000. However, when examining the other labour market variables, the results was not significant.

3.6 Conclusion

This study uses the DES (1999-2018) and the GLFS (2018-2019) to analyse the effects of the USE (2003 -2007) school conversion policy on educational attainment and labour market outcomes in Guyana. The study contributes to the body of literature on supply-side policies aimed at increasing the supply of academic schooling based on the conversion of vocational or technical education into an academic track. Studies have shown that educational reform policies that convert vocational education to general education are likely to result in higher educational achievements and better-paying jobs (e.g., Malamud and Pop-Eleches, 2010; Brunello and Rocco, 2017).

We use a difference-in-difference estimation strategy exploiting variation across birth cohorts and Guyana's ten administrative regions where the conversion of CHSs and Primary Tops into GSSs occurred. We combine this with nationally representative data from the GLFS (2018-2019) that contains information on a wide range of outcomes related to education, migration, wages and work-hours outcomes. We find that greater exposure to the USE policy increases the completion of secondary and secondary or tertiary education by 37.4 and 42.6 percentage points respectively. Therefore, the USE policy reform resulted in an increase in the completion and graduation rates in secondary or tertiary education in Guyana.

We find that greater exposure to the USE policy increases the attendance of secondary or tertiary education. When examining the labour market outcomes, we find that an additional year of exposure to the USE policy reform is associated with an increase in wage by 52.5 percentage points. This finding supports the argument that better-educated individuals earn higher wages. We also find that the USE (2003-2007) policy reform did not close the achievement gaps in education across ethnicities. Moreover, our results are robust when redefining the intensity of the USE program as the average share of non-GSS institutions in the period 1999-2002 based on the DES; when restricting the results to the persons who were still residing in the same regions of birth at the time of the survey, i.e., examining the results without the impact of migration and when dropping the regions individually (i.e., regions 1 to 10) from the survey data.

Effectively, our paper provides a comprehensive analysis of the effects of school conversion policy on educational attainment and labour market outcomes in Guyana. To date, this is the first study to analyse the effects of this policy on Guyana's educational system and labour markets. Consequently, this study provides evidence to support the ongoing conversion of Primary Tops to GSSs. Moreover, this study can be used by the Ministry of Education to speed up the process of their ongoing conversion, since the implementation of the USE (2003-2007) has thus far achieved some positive results in increasing the supply and improving access to secondary education in Guyana. Furthermore, this has reduced the dropout rates which was a phenomenon (in CHSs and Primary Tops) under the old system.

Although the USE (2003-2007) policy reform did not show much impact on the labour market outcomes in Guyana, we noticed that it has led to an increase in the wages that were reported in the GLFS. Consequently, this supports the literature on better-educated individuals who earn higher wages, experience less unemployment and work in more prestigious occupations than their less-educated counterparts.

It is evident that Guyana's Ministry of Education has made strides in increasing and improving the access to secondary education, however, more can be done to increase the speed of the conversion of the remaining Primary Tops to GSSs. In addition, the MoE should evaluate the USE policy impact across ethnicities and employ measures to help close the current achievement gaps. Furthermore, we find that the policy also led to the completion of secondary or tertiary education when dropping eight out of the ten administrative regions; this highlights the realised benefits of Guyana's USE (2003-2007) policy reform. However, the broader societal impacts and intergenerational effects are topics that warrant further exploration in future studies.

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CHAPTER 4

Birth Order Effects and Early Childhood Health in Guyana

4.1 Introduction

Literature has shown that first-born children have lower birth weight and other gestational problems, however ,first-born children also tend to have higher cognitive and non-cognitive skills, acquire more education, and receive higher earnings than their later-born siblings.[1] Consequently, the negative health impacts of first-born children might be mitigated by the differences in parental behaviour (such as postnatal investments), in order to reverse the negative health outcomes at birth and in early childhood (Saldarriaga, 2015).

In this study, we analyse the effects of birth order on early childhood health in Guyana. This is the first study to examine this question in the context of Guyana. We use a rich set of anthropometric data for children aged 0-59 months from the 2009 Guyana Demographic and Health Survey (GDHS) to examine whether first born children are at a disadvantage at birth when compared to their later-born siblings. Previous literature on child health and birth order effects reveals that the health for first born children is considerably disadvantaged and they also tend to have lower birth weight when compared to later born children (Björkegren and Svaleryd 2016; Brenøe and Molitor, 2017; Pruckner et al., 2019). This study is important for Guyana because the weight at birth, in particular, 'low birth weight' often leads to neonatal deaths and poor adult health which can negatively impact the human capital formation of the country. Consequently, according to UNICEF-WHO (2019), low birthweight new-borns have a higher risk of dying in the first 28 days of life. Moreover, studies have also shown that there is a negative correlation between birth weight and academic achievements measured using standardised test scores (Kohara and Ohtake, 2009).
Consequently, we focus on several measures of early childhood health, i.e., birth weight, low birth weight, height for age z score (HAZ), stunting and child height indicators.[2] Low-birth

[1] See Björkegren and Svaleryd (2016), Brenøe and Molitor (2017), Pruckner, Schneeweis, Schober and Zweimüller (2019) for evidence from developed countries. In contrast, De Haan, Plug and Rosero (2014), Saldarriaga (2015) provide evidence for birth order and birth weight in developing countries.

[2] According to literature, child height is predictive of adult height (Healy et al., 1956) and taller adults have greater cognitive skills (Glewwe and Miguel 2008; Guven and Lee 2015), fewer functional impairments (Barker and Osmond 1986; Barker et al. 1993; Gould 1989), and higher earnings (Strauss and Thomas 1998; Case and Paxson 2008; Hoddinott et al. 2013).

weight is the leading indicator of poor health among infants, which may lead to negative health impacts, such as delay brain and somatic development that affects a wide range of subsequent health outcomes later in life (Nakamuro et al., 2013). A child's height for age z score is an important measure since it captures lingering effects of growth disturbance that may have occurred early in life (Leroy et al., 2015). Stunted is defined as height for age z scores below -2 standard deviation. We also examine the height of the child (in cm) at the time of the 2009 GDHS. Moreover, we also examined parental postnatal investment to determine which group of children it favours more.

Overall, we find that birth outcomes improve with birth order. Consequently, birth order is positively correlated with birth weight and negatively correlated with low birth weight for children born between 2005-2009 from the 2009 GDHS. These findings contribute to the broader body of literature such as Björkegren and Svaleryd 2017; Brenøe and Molitor, 2017; Pruckner et al., 2019 whom all found that health at birth improves with increasing birth orders. In addition, we find that compared to first born children, second and third born children tend to grow taller in Guyana. These results are analogous to Sahn and Stifel (2002) who found that compared to first born children, second and third-borns had higher-for-age z scores in fourteen African countries. Moreover, we find similar results when we examined the height of the children at the time of the survey, i.e., we find that when compared to first born children, height increases for the second and third-borns.

We also examine postnatal intervention such as indicators for exclusive breastfeeding and completed vaccination for children between the ages of 0-59 months and found that mother's both breastfed extensively and invested more in vaccinations. It is argued that extensive breastfeeding (i.e., 6 months or more) and postnatal investments can both offset the negative health impacts at birth for first-born children. Moreover, we see that given that parents tend to invest more in pentavalent and polio vaccinations, such actions may offset the negative health outcome at birth for first-borns and possibly leads to a reversal effect (Elliot, 1992; Saldarriaga, 2015). When examining the heterogeneous effects, we find that the height for age z score increases more for second and third born male children when compared to first born children. We also find that compared to firstborn, third born and fourth born or higher Muslim children tend to have higher birthweight.[3] Moreover, the results are robust when clustering the standard errors at the 2009 GDHS Primary Sampling Units (PSUs) level. Consequently, we find that birth outcomes improve with birth order.

The rest of the paper unfolds as follows. Section 4.2 present the literature review. Section 4.3 describes the data sources and Section 4.4 introduces the empirical strategy. Section 4.5 presents the results and Section 4.6 concludes.

4.2 Literature Review

There are several studies that focused on birth order effects on child health since health status during childhood is important for outcomes in later life. Childhood health is an important determinant for later life outcomes such as educational attainment, labour market outcomes and adult health (Case et al., 2005; Currie et al., 2010).

Birth order refers to the order in which children are born into a family setting. Children are defined as firstborn, second born, third born and so on. Moreover, birth order categories have also been used to describe the order of birth, i.e., firstborn children, only or singleton children, middle children, early and later-born children, and last-born children (Elliot, 1992).

There are several studies that posited that firstborn children generally do better academically than later-born children. Consequently, studies have shown that first-born children have higher IQs and higher educational attainment, and earnings and are more likely to live a healthier life than later-born children (Kantarevic and Mechoulan, 2006; Kristensen and Bjerkedal, 2007; Booth and Kee, 2008; Bu, 2014; Black et al.,2005,2011,2016). Furthermore, a study has shown that firstborn children are more likely to have more cognitive ability (due to greater parental human capital investments) and acquire more prestigious jobs, such as managers, while later-born children are more likely to be self-employed (Black et al., 2017). Esposito et al., 2020 find that firstborns' advantage in educational outcomes is amplified for males when their other siblings are females in Mexico. Isungest et al., 2022, studied birth order differences in education and found that it originates in postnatal environments because although early-born

[3] In Guyana during the month of Ramadan, women who are pregnant or nursing, the sick, or elderly people and children, are all exempted from fasting. See Guyana Times Newspaper, April 2020: https://guyanatimesgy.com/islams-holy-month-of-ramadan-commences-on-saturday-ciog/

children had lower birth weights, they had higher educational outcomes, which made them conclude that birth order differences arise postnatally.

However, as it relates to health outcomes at birth, several studies have shown that first-born children have worst health outcomes than later-born children. Previous literature on child health and birth order effects reveals that the health of firstborn children is considerably disadvantaged, and they also tend to have lower birth weight when compared to later-born children (Elliot, 1992; Björkegren and Svaleryd 2017; Brenøe and Molitor, 2017; Pruckner et al., 2019). Brenøe and Molitor (2018) examine birth order differences in the health of newborns using data from Denmark (1981-2010) and find that firstborn children are less healthy at birth compared to later-born children. They posited that later-born children had better health due to a biological mechanism which improves nutrient supply to the foetus with each pregnancy (Khong et al., 2003; Gluckman and Hanson, 2004). Moreover, according to Black et al., (2016), there is higher prevalence of obesity in first- born adult. However, Wells et al., (2017) concluded that this might be due to lower nutrient supply to first-borns in-utero.

Furthermore, Pruckner et al., 2019 found that later-born siblings exhibit greater health than firstborns. Consequently, childhood health increases with birth order. They also find differences in parental health investment by birth order. First-born children are more likely to receive greater postnatal care and immunisation against measles, mumps, and rubella. Moreover, when comparing first-born with later-born siblings, it was found that later-born children had higher birth weights and were less likely to be born with low birth weights (i.e., below 2.5 kg) and less likely to be born premature. It is argued that mothers are more likely to attend prenatal care in their first pregnancy and to breastfeed the first-born child (Buckles and Kolka, 2014; Black et al*.,* 2016; Brenøe and Molitor, 2018; Lehmann et al., 2018). Mmopelwa (2019) studied the household size, birth order and child health in Botswana and found that later-born children were more likely to be nutritionally deprived compared to firstborns.

Several studies have shown that birth order is correlated with height-for-age z scores, stunting and child height. As such, Sahn and Stifel (2002) use the Demographic and Health Survey from fourteen African countries and find that birth order was positively correlated with the children's height-for-age z score, i.e., the height-for-age z scores were higher for second and third born children when compared to first-born children. In a study, De Keyser and Van Rossem (2017), also find that compared to first-borns, the height-for-age z score for second and third-born children increases. However, it declines systematically with higher birth order.

Black et al., (2011) argue that endowments at birth increase the birth order effects on outcomes later in adulthood. Myrskyla et al., (2013) use military enlistment data from Sweden to examine the relationship between birth order and height. They find the negative effects of birth order on height and argue that parental postnatal investments are important in helping young children (especially those under the age of 2) achieve their childhood health milestones, as height is often used as a proxy for health in early life. Rahman (2016), in his study on birth order and chronic malnutrition of children in Bangladesh, finds that stunted growth increases with higher birth order. Björkegren and Svaleryd (2017), examine birth order effects on child health in Sweden and find that firstborns have worsened health at birth until age six. However, their study reveals that such disadvantaged at birth are reversed in later life since higher-born siblings are more likely to be hospitalised for injuries, avoidable conditions, alcohol-related problems, or mental health issues. Jayachandran and Pande (2017) in a comparative study on Indian and Sub-Saharan African children, find that Indian children tend to be taller at birth. However, the differences decrease for children with higher birth order.

In the literature, there is a common trend that is observed for developing countries, i.e., later-born children tend to receive less maternal and health care in developing nations when compared with developed countries. On the contrary, De Haan et al. (2014), in an Ecuadorian study found mothers spent more time with their male children than with female children. Moreover, they find that firstborns are breastfed for less time when compared to later borns. Furthermore, De Hann et al. (2014) argue that disadvantages between firstborns and later-borns are likely to reverse in adulthood in children from rich and highly educated families due to parental investments.

4.3 Data sources and descriptive statistics

4.3.1 The 2009 Guyana Demographic and Health Survey (GDHS)

This study analysed data from the 2009 Guyana Demographic and Health Survey (GDHS) provided by the DHS Programs. The 2009 GDHS is a cross-sectional, nationally-representative dataset which samples women of childbearing age that uses the 2002 Population and Housing Census as the master sample for the survey. The survey used a stratified two-stage cluster sample of 330 primary sampling units/clusters (equivalent to very small regions); that sampled 5,632 households.

Guyana is divided administratively into ten regions. As such, the regions were then divided into enumeration districts (EDs) and in the first stage units (primary sampling units of PSUs) are the enumeration districts utilised in the 2002 Population and Housing Census. In the second stage, 25 households were selected by systematic random sampling from the updated household listing of the selected EDs (2009 GDHS). A total of 4,996 face-to-face interviews were successfully completed for women aged 15-49. The survey gathers information on socioeconomic and demographic characteristics of households and their members. Consequently, mothers provided data on their entire birth history and outcomes (such as birth weight), anthropometric z scores (such as height -for-age z scores, weight-for-age z scores, etc), health service utilisation (for prenatal care and immunisation), and nutritional status of mothers and young children under 5 years old.

We use the children's data from the Kid Record (KR) file in the 2009 GDHS data files, since it relates the child's outcomes to characteristic of the mother. Furthermore, the KR file includes all the children aged 0-59 months whose mothers were samples. Information for 2,178 children were recorded, however when excluding the only/singleton children, we have a total of 1,730 observations. As such, our regressions were restricted to 1,328 children aged 0-59 months year old whose birth weight was recorded in the KR file. Moreover, to measure the child health indicators, we use the haz06 Stata package to compute the standardised child nutritional indicators through the World Health Organisation (WHO) software for growth and development of the world's children (WHO, 2011). The software uses information on child sex, height, weight, and age in months and transforms it to height-for-age, weight-for-age and weight-for-height into z scores, as standardised measures of their deviation from the median of the reference population.[4] This method takes the difference between a child's observation and median reference value and divides it by the standard deviation of the reference population (i.e., children of the same age).

Following standard practice, we use anthropometric measures for height and weight of children aged 0-59 months collected from the DHS Guyana 2009 dataset. Moreover, we compute z-scores for height-for-age z-scores using the haz06 Stata package. Binary outcome variables are

[4]The composition of the reference population changed over time, from the US National Centre for Health Statistics (NCHS) data to the current reference population, which is an outcome of a WHO Multi Growth Reference study (MGRS) of a pooled sample of six participating countries: Brazil, Ghana Indian, Norway, Oman, and the USA, which consist of around 8,500 children (WHO, 2006).

constructed for stunted based on the z-score for HAZ. As such children who are more than two standard deviations (SDs) below the HAZ median for their age group are classified as stunted. Low birth weight is computed based on the birth weight data, i.e., birth weight below 2.5 kg based on the WHO's standard is deemed as "low birthweight."

The measure above is widely used to assess children's health and nutrition status, as they capture different aspects of childhood undernutrition. For instance, stunted reflects the cumulative effect of undernutrition and possible infections from a child's birth and even in utero. Moreover, it often indicates poor environmental conditions or other long-term restrictions or lingering health problem to a child's physical development.

In addition, we control for mother's characteristics such as mother's age at current birth and ethnicity. These data are all taken from the Kid Record (KR) file in the DHS Guyana 2009 dataset.

4.3.2 Summary Statistics

Below, we present the descriptive statistics of the key variables used in our analysis in Table 4.1. The average birth weight for children born between 2005-2009 is 3.3 kg with a minimum and maximum of 0.8 kg and 8 kg respectively. Of the 1328 children in the sample, approximately 12 percent had a birth weight below 2.5 kg and are thus underweight. Birth order 1 accounts for 33 percent, followed by Birth order 4 or higher, Birth Order second, third with shares of 28, 22 and 17 percent respectively. The height-for-age z score (HAZ) for children ranges from -5.99 and 5.53 with a mean of -1.077, thus suggesting that the children in the 2009 GDHS sample are 1 standard deviation below the median of the reference population. On average 25 percent of the children had stunted growth.[5]

[5] Stunted is defined as z scores below -2 standard deviation.

Table 4.1: Summary statistics

Variables	Mean	Standard deviation	Min	Max	N
Demographic Characteristics					
Birth order 1	0.325	0.469	0	1	1730
Birth order 2	0.239	0.427	0	1	1730
Birth order 3	0.158	0.366	0	1	1730
Birth order 4 or higher	0.277	0.447	0	1	1730
Child is Male	0.499	0.500	0	1	1730
Urban	0.169	0.375	0	1	1730
Health at birth					
Birth weight (in kilograms)	3.275	0.842	0.8	8	1328
Low birth weight (<2.5 kg)	0.117	0.321	0	1	1328
Childhood Health					
Height for age z score*	-1.077	1.544	-5.99	5.53	1328
Stunted	0.244	0.430	0	1	1328
Child height (cm)*	86.468	13.864	42	123.3	1328
Mother's Characteristics					
Mother's age at first birth	19.009	3.722	11	38	1730
Nursery or no education	0.039	0.194	0	1	1730
Primary education	0.278	0.448	0	1	1730
Secondary education	0.631	0.483	0	1	1730
Higher education	0.051	0.221	0	1	1730
Ethnicity					
African	0.172	0.378	0	1	1730
Indian	0.225	0.418	0	1	1730
Mixed	0.228	0.420	0	1	1730
Amerindian	0.373	0.484	0	1	1730
Portuguese	0.012	0.034	0	1	1730
Religion					
Christian	0.827	0.378	0	1	1730
Hindu	0.127	0.333	0	1	1730
Muslim	0.033	0.179	0	1	1730
Rastafarian	0.001	0.034	0	1	1730
Not Religious	0.009	0.096	0	1	1730
Other	0.001	0.339	0	1	1730
Postnatal Investments					
Breastfeed (Months)	0.944	0.230	0	1	1211
All vaccinations	0.506	0.500	0	1	1290
No vaccination	0.054	0.227	0	1	1290
BCG	0.932	0.252	0	1	1290
Polio 1	0.739	0.439	0	1	1290
Pentavalent 3	0.771	0.421	0	1	1290
Measles	0.678	0.468	0	1	1290

Note: * Height-for-age z score and child health reflect the height and weight for the child at the time of the survey interview. The postnatal investments are restricted to children whose birth weight were recorded.

Literature has shown that maternal age and birth order of an infant are highly correlated. Consequently, as maternal age increases, the influence of birth order gets increasingly stronger and is associated with increased birth weight in infants (Selvin and Janerich, 1971; Jarry et al., 2013; Brenøe and Molitor, 2018). The average age of a first-time mother is 19 years old, however the minimum and maximum age at first time mothers between 11 and 38 years old respectively. Approximately 50 percent of children are males. On average, 2.3 percent of the mothers had no education, 0.4 percent had primary education, 64 percent had secondary education and 6 percent had higher education. About 19 percent of the children resided in urban locations. Approximately 51 percent of the children in the survey received all their vaccinations. 93 percent of the children received their BCG vaccinations, 73 percent received Polio, 77 percent received Pentavalent, and 68 percent received Measles vaccination.[6]

4.4 Empirical Strategy

To measure the relationship between birth order and child health at birth, we employ methods used by Pruckner et al. (2019) and Brenøe and Molitor (2018) by estimating an ordinary least square (OLS) regression of the following type:

$$Y_{ifym} = \alpha + \beta_j \sum_{j=2}^{4} 1(\text{Birth order}_i = j) + \gamma \text{Boy}_i + \lambda_t + \varphi_m + \delta_f + X_i + \varepsilon_{ifym} \qquad (1)$$

Where Y_{ifym} is health outcome of child i, born in family f, born in year y and month m. The health outcome variables are birth weight, dummy for low birth weight (birth weight < 2.5 kg), height for age z score, a dummy for being stunted (i.e., HAZ < -2 SD) and child health (in cm). The sum represents a set of birth order dummies, $1(\text{Birth order}_i = j)$ for j = 2, 3, and 4 where 1(.) is the indicator function. As such children of birth order, one represent the omitted category therefore β_j, the vector of the coefficient of interest, captures differences with respect to birth order one. Furthermore, we include Boy_i is a dummy=1 if the child is male and 0 otherwise, year of birth fixed effects (λ_t), month of birth fixed effects (φ_m), cluster fixed effects (δ_f) and (X_i) a vector of mother characteristics (i.e., mother's education and mother's age at first birth). Boy_i is a dummy that denotes the child being male, and ε_{ifym} is the stochastic error term. We cluster standard errors at the mother-level.

The estimation approach in equation (1) exploits only within-family variations in birth order and accounts for time-constant family-level confounding factors, such as maternal age at first birth. Conditionally on the mother fixed effects, controlling for child's birth cohort implies

[6] Based on the 2009 GDHS, Pentavalent is a multi-dose/combination vaccination which comprises of DPT, it is given in weeks 8, 16 and 24 respectively.

controlling for mother's age at birth, since the two variables are perfectly collinear. Therefore, our estimation model accounts for the maternal age at birth increasing with the child's birth order.

The estimation approach is based on comparing the health outcomes of children born within the same family, in the birth order categories of second, third and fourth born or higher using the firstborns as the reference category, across different years and months. We also include cluster fixed effects to control for common unobserved influences at the cluster level that affect all units within the cluster.

Moreover, we performed robustness check by clustering the standard errors at the Primary Sampling Units (PSUs) or enumeration district (clusters level). Therefore, in these regressions, we did not include cluster fixed effects. These regressions also used svyset or the command for survey setting.

4.5 Results and Discussions

Our OLS regression results in Table 4.2 below shows that compared to firstborns (reference category) birth order is positively correlated with birth weight and negatively correlated with low birth weight. These results are also comparable to Björkegren and Svaleryd 2017; Brenøe and Molitor, 2018; Pruckner et al., 2019 who all found that health at birth improves with increasing birth orders. Column 1 demonstrates that health at birth improves with increasing birth order. Consequently, we see that birth weight increases by 0.14kg and 0.31kg for birth order two, three compared to firstborns for mothers within the same cluster, however it decreases to 0.25kg for fourth born or higher when compared to first born. Based on column 2, we see that third born and fourth born children are less likely to born with low birth weight. Furthermore, the magnitudes of the increase in the coefficient for second-borns are comparable to Pruckner et al., (2019), who found that second-born siblings are 158 grams (5 percent) heavier than their firstborn counterparts in Austria.

Table 4.2: DHS Guyana 2009 Birth Order Effects on Child Health - Clustered at Mother's level (OLS Regressions)

	(1) Birth weight (kg)	(2) Low birth weight (<2.5 kg)	(3) Height-for-age z score	(4) Stunted	(5) Child height (cm)
2nd born	0.146*	-0.024	0.299**	-0.002	1.043*
	(0.078)	(0.034)	(0.150)	(0.041)	(0.558)
3rd born	0.313***	-0.075**	0.318*	-0.065	1.287**
	(0.090)	(0.038)	(0.165)	(0.045)	(0.607)
4th born or higher	0.247**	-0.073**	-0.060	0.052	0.053
	(0.099)	(0.037)	(0.148)	(0.045)	(0.555)
Male	0.135**	-0.025	-0.092	0.003	0.881**
	(0.053)	(0.019)	(0.097)	(0.027)	(0.333)
Urban	-0.347	0.022	0.294	0.050	-1.090
	(0.307)	(0.049)	(0.562)	(0.253)	(1.540)
Mother's age at 1st birth	0.006	-0.001	0.002	0.002	0.034
	(0.008)	(0.003)	(0.015)	(0.097)	(0.054)
Primary education	0.166	-0.039	0.369	-0.074	1.626
	(0.218)	(0.083)	(0.341)	(0.093)	(1.174)
Secondary education	0.161	-0.084	0.552*	-0.142	2.436**
	(0.214)	(0.079)	(0.325)	(0.108)	(1.130)
Higher education	0.246	-0.083	0.965**	-0.000	3.646**
	(0.247)	(0.093)	(0.398)	(0.004)	(1.402)
Constant	2.983***	0.119	-1.896**	0.162	106.246***
	(0.413)	(0.115)	(0.578)	(0.218)	(1.731)
Observations	1328	1328	1328	1328	1328
R^2	0.350	0.294	0.347	0.329	0.904

Note: All regressions include month and year (2005-2009) of birth fixed effects, cluster fixed effects and a male dummy variable. Standard errors are clustered at the Mother level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Moreover, in column 3, we examine the height-for-age z scores which were taken at the time of the survey. Consequently, we see that second and third born children tend to grow taller when compared to firstborn children. As such, height-for-age z score of second and third borns are 0.299 SD and 0.318 SD higher than that of firstborns. These results are comparable to Sahn and Stifel (2002) and De Keyser and Van Rossem (2017), who find that compared to first born children, second and third-borns have higher height-for-age z scores. Moreover, we also find that in general the height-for-age z scores increases for children whose mother had completed their secondary or higher education. Column 4, in Table 4.2, we see that stunting declines from second and third born children compared to first born children, although the results are not significant.

When examining the height of the children at the time of the survey, we find that when compared to first born children, height increases for the second and third-borns by 1.04 cm and 1.29 cm respectively. We also find that child height increases for children whose mother had completed their secondary and higher education.

It is important to note here that that the proportion of births that are multiple birth increases with age, up to 30-34, and then declines thereafter.

4.5.1 Postnatal Investments

A large body of literature reveals that there is a positive effect of breastfeeding on child health in developing countries (Betran et al., 2001, Sanauer and Kassouf 2000; Victora et al., 1987). Moreover, postnatal investments, such as breastfeeding, vaccination, and early stimulation, are important in determining children's physical development and, subsequently, their socioeconomic outcomes later in life. Postnatal health investments are often viewed as a method of correcting the growth profiles of disadvantaged children, such as those born with low birth weights (Saldarriaga, 2015). Consequently, we use indicators of exclusive breastfeeding and completed vaccination for children between the ages of 0-59 months year old. According to Saldarriaga (2015), postnatal investments in child health can mitigate stunting caused by low birth weight in newborns. As such, we examine the effects of postnatal investments on childhood health given their birth order.

Table 4.3 reveals postnatal investments by the parents in the form of vaccinations and months of breastfeeding (see Table C.1 in the Appendix C for the recommended vaccination schedule in Guyana). Studies have shown that mothers are less likely to breastfeed later born children (Lehmann et al., 2018, Black et al., 2016; Buckles and Kolka, 2014). Contrary to the literature, in Table 4.3, column 1 we find that when compared to their firstborns' mothers tend to spend more months breastfeeding their second, third and fourth born or higher. Consequently, we find that birth order gaps are reinforced, as later-borns do better at birth and are breastfed more. These finding are comparable to De Haan et al., (2014), who found in their Ecuadorian study that firstborns are breastfed for less time when compared with later borns.

Table 4.3: DHS Guyana 2009 Birth Order Effects on Child Health - Clustered at Mother's level (OLS Regressions)

	(1) Breastfed (Months)	(2) All vaccination (either)	(3) No vaccination (either)	(4) Polio 1st dose (either)	(5) Polio 2nd dose (either)	(6) Polio 3rd dose (either)	(7) Measles (either)	(8) Pentavalent 1st dose (either)	(9) Pentavalent 2nd dose (either)	(10) Pentavalent 3rd dose (either)	(11) BCG (either)
2nd born	0.097**	0.052	-0.015	0.017	0.008	0.024	0.055	0.030	0.029	0.064*	0.031
	(0.034)	(0.047)	(0.021)	(0.040)	(0.040)	(0.043)	(0.038)	(0.025)	(0.028)	(0.033)	(0.025)
3rd born	0.099**	0.033	0.005	0.034	0.022	0.018	0.046	0.027	0.032	0.042	0.005
	(0.035)	(0.053)	(0.026)	(0.045)	(0.046)	(0.050)	(0.040)	(0.030)	(0.033)	(0.039)	(0.029)
4th born or higher	0.102**	0.047	-0.030	0.066	0.045	0.054	0.067	0.060**	0.062*	0.063*	0.027
	(0.034)	(0.052)	(0.026)	(0.047)	(0.048)	(0.050)	(0.041)	(0.030)	(0.033)	(0.038)	(0.030)
Male	-0.016	0.009	-0.003	-0.006	-0.001	-0.014	0.000	-0.001	0.008	-0.027	0.011
	(0.015)	(0.025)	(0.014)	(0.023)	(0.023)	(0.025)	(0.021)	(0.016)	(0.017)	(0.021)	(0.016)
Urban	0.014	-0.123	-0.339*	0.413*	0.392	0.548**	-0.096	0.360**	0.344*	0.510**	0.334*
	(0.037)	(0.183)	(0.177)	(0.231)	(0.244)	(0.239)	(0.184)	(0.172)	(0.186)	(0.201)	(0.178)
Mother's age 1st first	0.003	0.004	0.003	0.001	0.006	0.007	-0.002	-0.005	-0.002	0.002	-0.003
	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.005)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
Primary education	-0.083**	0.071	-0.043	0.064	-0.001	0.088	0.030	0.010	-0.046	0.012	0.072
	(0.042)	(0.112)	(0.043)	(0.091)	(0.099)	(0.103)	(0.085)	(0.055)	(0.070)	(0.081)	(0.053)
Secondary education	-0.064	0.054	-0.022	0.003	-0.043	0.035	0.043	-0.017	-0.037	-0.009	0.054
	(0.043)	(0.111)	(0.040)	(0.090)	(0.098)	(0.102)	(0.083)	(0.052)	(0.067)	(0.077)	(0.050)
Higher education	-0.113*	0.035	-0.016	-0.004	-0.055	0.031	0.020	0.008	-0.047	-0.028	0.028
	(0.058)	(0.125)	(0.046)	(0.108)	(0.116)	(0.121)	(0.095)	(0.060)	(0.076)	(0.088)	(0.057)
Constant	0.943***	0.543**	0.265	0.643**	0.590**	0.503*	0.828***	0.839***	0.788***	0.751**	0.709***
	(0.087)	(0.234)	(0.198)	(0.265)	(0.278)	(0.275)	(0.219)	(0.197)	(0.213)	(0.231)	(0.203)
Observations	1211	1290	1290	1290	1290	1290	1290	1290	1290	1290	1290
R^2	0.311	0.542	0.350	0.494	0.532	0.520	0.647	0.474	0.573	0.575	0.340

Note: All regressions include month and year (2005-2009) of birth fixed effects, cluster fixed effects and a male dummy variable. The results show the three doses of vaccination for Polio and Pentavalent. Pentavalent is a multi-dose/combination vaccination which comprises of DPT given in weeks 8, 16 and 24 respectively. Polio vaccination is given in weeks 8, 16 and 24 respectively. Standard errors are clustered at the PSUs level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

According to the 2009 GDHS, the coverage for Polio, Pentavalent and DPT declined with subsequent doses, thereby leading to higher dropout rates for the full course of the vaccines (GDHS 2009). The vaccinations were reported based on both the mother's records, as well as what was recorded on the children's immunisation cards. Columns 10 in Table 4.3 above shows that compared to their firstborn children, mothers tend to vaccinate their second and fourth-born or higher more against pentavalent.

The results also provide evidence on the relationship between health investments during pregnancy and early childhood. We see that postnatal investments may have mitigated the incident of stunting caused by low birthweight in new-borns, since we do not find any impact of stunting (see Table 4.2, column 4) on childhood health as parents tend to employ postnatal interventions such as breastfeeding and immunisation.

4.5.2 Robustness Check

For robustness check we used an alternative specification of clustering using the primary sampling units (PSUs) levels. Moreover, these results do not include cluster fixed effects. In 2000, the Guyana Bureau of Statistics (GBOS), in collaboration with the U.S. Census Bureau, designed a sampling frame from the census master sample. In the same year, GBOS updated the geographical location and household listing each primary sampling units or (PSUs) included in the master sample; this work was supported in part by USAID. Consequently, we present Table 4.4 by clustering at the PSUs (level 3) or using 330 cluster ids. Column 1, in Table 4.4 show that (based on the point estimates) birthweight increases for second, third and fourth born or higher by 0.18kg, 0.24kg and 0.26kg respectively, when compared to firstborn children. These results are similar to our main results in Table 4.2. However, based on column 2, third born are less likely to born with low birthweight when compared to first-borns.

In column 3, we find that when compared to firstborn children, second and third born children tend to grow taller. This is reflected in the height for age z score being 0.48 SD and 0.58 SD higher than that of firstborns. Analogous to our main results, when examining the height of children at the time of the survey, we find that when compared to first born children height (in cm) increases for second and third-borns by 1.773 cm and 2.223 cm respectively when compared with first borns.

Table 4.4: DHS Guyana 2009 Birth Order Effects on Child Health - Clustered at PSUs level (OLS Regressions)

	(1) Birth weight (kg)	(2) Low birth weight (<2.5 kg)	(3) Height-for-age z score	(4) Stunted	(5) Child height (cm)
2nd born	0.184^{**}	0.001	0.478^{**}	-0.066	1.773^{**}
	(0.074)	(0.035)	(0.187)	(0.061)	(0.789)
3rd born	0.241^{**}	-0.062^{*}	0.576^{**}	-0.126^{*}	2.223^{**}
	(0.079)	(0.038)	(0.228)	(0.073)	(0.958)
4th born or higher	0.260^{**}	-0.035	0.176	0.007	1.257
	(0.093)	(0.036)	(0.209)	(0.067)	(0.905)
Male	0.103^{**}	-0.014	-0.109	0.008	0.663^{*}
	(0.051)	(0.020)	(0.100)	(0.027)	(0.369)
Urban	-0.074	0.023	0.229^{*}	-0.042	0.116
	(0.068)	(0.025)	(0.120)	(0.029)	(0.447)
Mother's age at 1st birth	0.013	-0.002	0.034^{**}	-0.008^{**}	0.138^{**}
	(0.008)	(0.003)	(0.013)	(0.004)	(0.048)
Primary education	0.120	-0.009	-0.008	0.049	0.398
	(0.231)	(0.078)	(0.283)	(0.084)	(0.958)
Secondary education	0.107	-0.039	0.372	-0.079	1.540^{*}
	(0.219)	(0.078)	(0.251)	(0.073)	(0.856)
Higher education	0.099	-0.022	0.487	-0.123	2.318^{**}
	(0.229)	(0.086)	(0.325)	(0.088)	(1.136)
Constant	2.878^{***}	0.222^{**}	-2.181^{***}	0.429^{**}	104.144^{***}
	(0.316)	(0.110)	(0.454)	(0.133)	(1.704)
Observations	1328	1328	1328	1328	1328
R^2	0.028	0.021	0.091	0.090	0.880

Note: All regressions include month and year (2005-2009) of birth fixed effects, and a male dummy variable. Standard errors are clustered at the PSUs level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.5: DHS Guyana 2009 Birth Order Effects on Child Health (Postnatal Investments) - Clustered at PSUs level (OLS Regressions)

	(1) Breastfed (Months)	(2) All vaccination (either)	(3) No vaccination (either)	(4) Polio 1st dose (either)	(5) Polio 2nd dose (either)	(6) Polio 3rd dose (either)	(7) Measles (either)	(8) Pentavalent 1st dose (either)	(9) Pentavalent 2nd dose (either)	(10) Pentavalent 3rd dose (either)	(11) BCG (either)
2nd born	0.076*	0.077	-0.019	0.099**	0.089*	0.088*	0.066	0.067**	0.073**	0.100**	0.026
	(0.040)	(0.051)	(0.025)	(0.045)	(0.046)	(0.051)	(0.045)	(0.033)	(0.034)	(0.037)	(0.026)
3rd born	0.106**	0.085	-0.016	0.086*	0.087*	0.063	0.096**	0.061*	0.074**	0.077*	0.024
	(0.043)	(0.053)	(0.033)	(0.049)	(0.051)	(0.053)	(0.041)	(0.032)	(0.035)	(0.041)	(0.035)
4th born or higher	0.099**	0.077	-0.023	0.121**	0.091*	0.064	0.091**	0.066**	0.047	0.029	0.020
	(0.047)	(0.050)	(0.028)	(0.050)	(0.050)	(0.050)	(0.039)	(0.030)	(0.031)	(0.037)	(0.029)
Male	-0.013	-0.007	0.002	0.010	0.018	-0.045*	-0.004	-0.007	0.004	-0.052**	-0.005
	(0.017)	(0.026)	(0.015)	(0.026)	(0.027)	(0.025)	(0.020)	(0.018)	(0.020)	(0.020)	(0.017)
Urban	0.020	-0.093*	-0.034*	-0.118*	-0.132*	-0.120*	-0.007	0.030	0.004	-0.009	0.034*
	(0.018)	(0.056)	(0.018)	(0.068)	(0.068)	(0.064)	(0.029)	(0.020)	(0.023)	(0.032)	(0.020)
Mother's age 1st birth	0.002	0.009**	0.000	0.006*	0.009**	0.011**	0.003	0.000	0.002	0.005*	-0.000
	(0.003)	(0.003)	(0.002)	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
Primary education	-0.055**	0.217*	-0.114	0.166	0.125	0.237*	0.091	0.122	0.074	0.152	0.169
	(0.025)	(0.123)	(0.105)	(0.162)	(0.173)	(0.128)	(0.116)	(0.121)	(0.135)	(0.107)	(0.112)
Secondary education	-0.063***	0.188	-0.096	0.086	0.057	0.194	0.128	0.082	0.074	0.171	0.146
	(0.016)	(0.120)	(0.113)	(0.154)	(0.157)	(0.128)	(0.121)	(0.117)	(0.120)	(0.115)	(0.117)
Higher education	-0.093*	0.118	-0.088	0.033	0.038	0.144	0.077	0.089	0.062	0.177	0.144
	(0.048)	(0.135)	(0.117)	(0.172)	(0.174)	(0.146)	(0.129)	(0.122)	(0.128)	(0.119)	(0.121)
Constant	0.845***	0.513***	0.120	0.595**	0.555**	0.461**	0.883***	0.894***	0.824***	0.726***	0.821***
	(0.088)	(0.153)	(0.109)	(0.189)	(0.185)	(0.168)	(0.155)	(0.148)	(0.145)	(0.151)	(0.120)
Observations	1211	1290	1290	1290	1290	1290	1290	1290	1290	1290	1290
R^2	0.038	0.307	0.110	0.142	0.184	0.217	0.523	0.353	0.415	0.407	0.095

Note: All regressions include month and year (2005-2009) of birth fixed effects, and a male dummy variable. The results show the three doses of vaccination for Polio and Pentavalent. Pentavalent is a multi-dose/combination vaccination which comprises of DPT given in weeks 8, 16 and 24 respectively. Polio vaccination is given in weeks 8, 16 and 24 respectively. Standard errors are clustered at the PSUs level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

When looking at postnatal investments, we find that overall parents tend to invest more in vaccinations when clustering the standard errors at the Primary Sampling Units (PSUs) or enumeration district (clusters level). compared to our main equation (1). In column 1 of Table 4.5 above, we find that when compared to firstborn children, mothers tend to spend more months breastfeeding their second, third and fourth or higher. As it relates to investments in inoculations, we find that on average mothers tend to invest in Polio vaccinations for the second born, third born and fourth born or higher children when compared to their firstborns. Compared to first-born children mothers tend to invest more in Pentavalent vaccines for their second, third and fourth born or higher. In a similar manner, mothers tend to invest more in Measles vaccines for their third and fourth born or higher.

4.5.3 Heterogeneous effects

So far, we have shown results that suggest that first-born children are at a disadvantage both at birth and in early childhood than their younger siblings. However, there are other factors that can influence the relationship between birth order and childhood health. Differences in birth order effects also can vary by ethnicity and gender etc. Consequently, we examine the heterogenous effects with respect to ethnicity, religion, maternal education, and gender on the effect of birth order and childhood health. In addition, we have also examined the heterogenous effect by the mother's age at each birth (or current age of the mother) and the mother's age at first birth.

We have included heterogeneous effects by religion and ethnicity because Guyana is an ethnically diverse country with a strong religious background. According to the 2002 Guyana census, 57 percent of the Guyanese population are Christians, 28 percent are Hindus, 7 percent are Muslims, and the remainder are non-religious (Guyana Bureau of Statistics, 2023). These variables are relevant to birth order effects because religion and ethnicity can influence birth order. For instance, Buber-Ennser and Berghammer (2021), in their study revealed that Christians who regularly attend church services generally have more children than non-affiliated persons in Europe. Religious belief can also influence how parents raise their firstborns. For instance, there are specific rituals or expectations for the firstborn child that may affect investment decisions. Furthermore, there can be a son-bias in some religious culture which can cause investment decisions to be skewed towards boys and impact birth order

(Barcellos, 2014; Jayachandran and Pande, 2017). Moreover, ethnicity can have influences on birth order and vary across different ethnic groups (Su et al., 2014; Marjoribanks, 1999). As such, based on ethnicity and religion children are treated differently based on birth order.

Guyana is an ethnically diverse nation with persons who are descendants from their African, Indian, Amerindian/Indigenous, Chinese, Portuguese, and other European ancestors (mainly French, Dutch, and English). There is also a subgroup of persons who are of Mixed ethnic backgrounds via a combination of any of the above-mentioned groups.

According to the 2002 Guyana Population and Housing Census, the Indo-Guyanese or Indians were the largest ethnic group and accounted for 43.4 percent of the total population. The Afro-Guyanese or African were the second largest group and accounted for 30.2 percent of the population while the Mixed race accounted for 16.7 percentage of the population. For this research, we focused on these three main ethnic subgroups, i.e., Africans, Indian and Mixed, as the observations for these groups. Therefore, our omitted categories are the Amerindian and Portuguese subgroups.

Table 4.6: DHS Guyana 2009 Birth Order Effects on Child Health - Clustered at Mother's level (OLS Regressions) – Heterogeneous Effects (ETHNICITY)

	(1) Birth weight (kg)	(2) Low birth weight (<2.5 kg)	(3) Height for age z score	(4) Child height (cm)
2nd born	0.267**	-0.062	0.546**	2.497**
	(0.126)	(0.059)	(0.275)	(0.940)
3rd born	0.301*	-0.059	0.455*	2.567**
	(0.163)	(0.071)	(0.264)	(0.972)
4th born or higher	0.284*	-0.103*	0.067	1.081
	(0.154)	(0.059)	(0.235)	(0.883)
Male	0.135**	-0.026	-0.111	0.808**
	(0.053)	(0.019)	(0.097)	(0.332)
Urban	-0.413	0.001	0.462	-0.447
	(0.341)	(0.069)	(0.550)	(1.571)
African	0.085	0.067	0.514	3.107**
	(0.238)	(0.098)	(0.406)	(1.467)
Indian	-0.452**	0.122	0.578	3.131**
	(0.183)	(0.089)	(0.361)	(1.356)
Mixed	0.247	-0.067	0.073	1.163
	(0.201)	(0.066)	(0.323)	(1.198)
2nd born x African	-0.140	0.048	-0.532	-3.048**
	(0.241)	(0.103)	(0.433)	(1.543)
2nd born x Indian	-0.150	0.042	-0.585	-2.855*
	(0.170)	(0.093)	(0.400)	(1.470)
2nd born x Mixed	-0.232	0.075	-0.038	-0.961
	(0.220)	(0.075)	(0.404)	(1.375)
3rd born x African	0.034	-0.042	-0.504	-3.125*
	(0.274)	(0.116)	(0.468)	(1.706)
3rd born x Indian	0.254	-0.114	-0.188	-2.275
	(0.212)	(0.104)	(0.395)	(1.488)
3rd born x Mixed	-0.305	0.112	0.026	-0.702
	(0.253)	(0.091)	(0.422)	(1.535)
4th born or higher x African	-0.197	0.026	-0.513	-2.778*
	(0.300)	(0.113)	(0.429)	(1.553)
4th born or higher x Indian	0.248	-0.059	-0.553	-3.171**
	(0.218)	(0.097)	(0.384)	(1.450)
4th born or higher x Mixed	-0.267	0.172**	0.329	0.486
	(0.233)	(0.080)	(0.372)	(1.327)
Mother's age at 1st first	0.011	-0.003	0.001	0.031
	(0.009)	(0.003)	(0.015)	(0.056)
Constant	2.809***	0.164	-2.267***	104.163***
	(0.432)	(0.124)	(0.588)	(1.951)
Observations	1328	1328	1328	1328
R^2	0.369	0.307	0.353	0.905

Note: All regressions include month and year (2005-2009) of birth fixed effects and clustered fixed effects, and a male dummy variable. We also control for the mother's education (primary, secondary, and higher education) with the omitted category being no and nursery education. Standard errors are clustered at the Mother level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.7: DHS Guyana 2009 Birth Order Effects on Child Health - Clustered at Mother's level (OLS Regressions) – Heterogeneous Effects (RELIGION)

	(1) Birth weight (kg)	(2) Low birth weight (<2.5 kg)	(3) Height for age z score	(4) Child height (cm)
2nd born	0.197	-0.115	1.049**	7.004***
	(0.366)	(0.143)	(0.459)	(1.784)
3rd born	-0.502	-0.049	-0.793	-1.643
	(0.332)	(0.174)	(1.427)	(5.548)
4th born or higher	-0.568*	0.093	0.471	3.575
	(0.326)	(0.138)	(0.744)	(2.385)
Male	0.125**	-0.023	-0.097	0.877**
	(0.054)	(0.019)	(0.099)	(0.338)
Urban	-0.308	0.008	0.263	-1.198
	(0.314)	(0.050)	(0.569)	(1.544)
Christian	-0.253	0.080	0.803	4.063**
	(0.218)	(0.067)	(0.667)	(1.968)
Hindu	-0.645**	0.214**	0.922	5.182**
	(0.281)	(0.106)	(0.699)	(2.099)
Muslim	-0.633**	0.202	1.559	6.107
	(0.285)	(0.159)	(1.005)	(3.919)
2nd born x Christian	-0.062	0.114	-0.696	-5.806**
	(0.373)	(0.144)	(0.497)	(1.912)
2nd born x Hindu	0.021	-0.012	-0.984*	-6.865***
	(0.387)	(0.166)	(0.518)	(1.974)
2nd born x Muslim	0.016	0.103	-1.360	-7.434*
	(0.437)	(0.203)	(1.006)	(4.252)
3rd born x Christian	0.738**	0.018	1.063	2.933
	(0.341)	(0.176)	(1.441)	(5.583)
3rd born x Hindu	1.105**	-0.195	1.381	2.915
	(0.374)	(0.197)	(1.468)	(5.701)
3rd born x Muslim	1.388**	-0.260	0.913	2.600
	(0.427)	(0.238)	(1.621)	(6.519)
4th born or higher x Christian	0.759**	-0.132	-0.540	-3.478
	(0.349)	(0.142)	(0.774)	(2.499)
4th born or higher x Hindu	1.067**	-0.298*	-0.429	-3.767
	(0.395)	(0.171)	(0.812)	(2.632)
4th born or higher x Muslim	1.733***	-0.501**	-1.052	-5.126
	(0.495)	(0.223)	(1.275)	(4.752)
Mother's age at 1st birth	0.005	-0.001	0.004	0.041
	(0.009)	(0.003)	(0.015)	(0.054)
Constant	3.277***	0.004	-2.717**	102.046***
	(0.466)	(0.134)	(0.885)	(2.639)
Observations	1328	1328	1328	1328
R^2	0.363	0.305	0.352	0.905

Note: All regressions include month and year (2005-2009) of birth fixed effects and clustered fixed effects, and a male dummy variable. We also control for the mother's education (primary, secondary, and higher education) with the omitted category being no and nursery education. Standard errors are clustered at the Mother level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.6 above presents the heterogenous effect of birth order and ethnicity. We did not find any heterogeneity as it relates to birth weight, although we do find 3rd and 4th born or higher, however we find that in general Indian children tends to have lower birth weights when compared to other subgroups (see column 1). Moreover, we find that the low birthweight increases for fourth born or higher Mixed-race children. In general, we find that African and Indian children tend to grow taller when compared to Mixed race. However, when looking at the heterogenous effect of child height (in Column 4), we find that second and fourth born or higher African and Indian children tend to grow taller.

Table 4.7 above displays the heterogeneous effects with respect to religion. In Guyana, Christianity is the dominant religion. According to the 2002 Guyana Population and Housing Census, approximately 57 percent of the population were Christians, 28 percent were Hindus, 7 percent Muslims, 4 percent Rastafarian and other and 4 percent of the population did not conform to any religious belief. In Table 4.7, we restrict our regressions primarily to the three main religions (i.e., Christian, Hindu, and Muslim). We find that when compared to firstborns (in column 1), third and fourth born or higher children from all religious groups had higher birthweight. Consequently, fourth born or higher children born to Christians, Hindu and Muslims weighed 0.76kg, 1.06kg and 1.73kg more respectively when compared to firstborns. We also find that for fourth born or higher low birth weight reduces (see column 2) for Hindu and Muslim families when compared to firstborns. When examining the height-for-age z score (column 3), we find that second born children of the Hindu religion tend to be shorter. When examining the child height at the time of the survey, we see that 2nd born Muslim children tends to be shorter across all the religious groups when compared to first-borns.

Table 4.8, (column 1) below shows that mothers who had secondary and higher education had children with higher birth weight when compared to those mothers with only nursery and primary education. However, when looking at the heterogenous effects, we see that birthweight for third and fourth born or higher children reduces for mothers with secondary and higher education. Table 4.9 displays the gender heterogeneity, and we find that the height-for-age z score increases more for second and third born male children when compared to first born children.

Table 4.8: Birth Order Effects on Child Health - Clustered at Mother's level (OLS Regressions) – Heterogeneous Effects (EDUCATION)

	(1) Birth weight (kg)	(2) Low birth weight (<2.5 kg)	(3) Height for age z score	(4) Child height (cm)
2nd born	0.946	0.261	1.364*	5.396**
	(0.665)	(0.240)	(0.818)	(2.203)
3rd born	2.690***	-0.002	1.208	4.502
	(0.798)	(0.128)	(1.133)	(4.990)
4th born or higher	2.579***	-0.061	0.348	1.801
	(0.744)	(0.148)	(0.612)	(1.849)
Male	0.149**	-0.027	-0.090	0.871**
	(0.053)	(0.019)	(0.099)	(0.339)
Urban	-0.347	0.026	0.317	-1.014
	(0.312)	(0.048)	(0.524)	(1.463)
Nursery or Primary education	2.183**	0.013	0.413	2.006
	(0.722)	(0.132)	(0.627)	(1.964)
Secondary or Higher education	2.227**	-0.033	1.053*	4.586**
	(0.714)	(0.120)	(0.582)	(1.714)
2nd born x Nursery or Primary educ	-0.736	-0.243	-0.642	-2.626
	(0.683)	(0.251)	(0.894)	(2.572)
2nd born x Secondary or Higher educ	-0.822	-0.299	-1.246	-5.077**
	(0.674)	(0.243)	(0.824)	(2.245)
3rd born x Nursery or Primary educ	-2.323**	-0.074	-0.426	-1.815
	(0.816)	(0.153)	(1.177)	(5.143)
3rd born x Secondary or Higher educ	-2.419**	-0.075	-1.081	-3.796
	(0.802)	(0.136)	(1.156)	(5.052)
4th born or higher x Nursery or Primary educ	-2.349**	-0.033	-0.185	-0.724
	(0.761)	(0.160)	(0.682)	(2.209)
4th born or higher x Secondary or Higher educ	-2.356**	0.005	-0.484	-2.141
	(0.747)	(0.154)	(0.632)	(1.937)
Mother's age at 1st birth	0.006	-0.001	0.005	0.043
	(0.008)	(0.003)	(0.015)	(0.055)
Constant	0.954	0.071	-2.230**	104.725***
	(0.795)	(0.138)	(0.782)	(2.215)
Observations	1328	1328	1328	1328
R^2	0.360	0.297	0.348	0.904

Note: All regressions include month and year (2005-2009) of birth fixed effects and clustered fixed effects, and a male dummy variable. The omitted category is no education. Standard errors are clustered at the Mother level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4.9: Birth Order Effects on Child Health - Clustered at Mother's level (OLS Regressions) – Heterogeneous Effects (GENDER)

	(1) Birth weight (kg)	(2) Low birth weight (<2.5 kg)	(3) Height for age z score	(4) Child height (cm)
2nd born	0.112	-0.053	0.017	-0.148
	(0.115)	(0.050)	(0.199)	(0.752)
3rd born	0.272**	-0.127**	0.037	0.081
	(0.124)	(0.053)	(0.217)	(0.814)
4th born or higher	0.182	-0.056	-0.268	-0.686
	(0.135)	(0.051)	(0.197)	(0.714)
Male	0.046	-0.051	-0.575**	-1.044
	(0.136)	(0.059)	(0.258)	(1.001)
Urban	-0.337	-0.014	0.283	-1.166
	(0.313)	(0.053)	(0.580)	(1.668)
2nd born x Male	0.072	0.059	0.619*	2.602**
	(0.159)	(0.077)	(0.318)	(1.218)
3rd born x Male	0.089	0.097	0.612*	2.596**
	(0.171)	(0.073)	(0.317)	(1.230)
4th born or higher x Male	0.133	-0.031	0.478	1.735
	(0.161)	(0.066)	(0.310)	(1.136)
Primary education	0.158	-0.026	0.382	1.698
	(0.219)	(0.082)	(0.340)	(1.168)
Secondary education	0.153	-0.073	0.565*	2.505**
	(0.216)	(0.079)	(0.326)	(1.126)
Higher education	0.240	-0.075	0.972**	3.679**
	(0.250)	(0.093)	(0.400)	(1.407)
Mother's age 1st first	0.006	-0.001	0.002	0.035
	(0.009)	(0.003)	(0.015)	(0.054)
Constant	3.029***	0.112	-1.685**	107.047***
	(0.421)	(0.117)	(0.582)	(1.732)
Observations	1328	1328	1328	1328
R^2	0.351	0.298	0.350	0.904

Note: All regressions include month and year (2005-2009) of birth fixed effects and clustered fixed effects, and a male dummy variable. The omitted category is no education. Standard errors are clustered at the Mother level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Furthermore, we have done heterogenous effect by the mother's age at each birth (see Table 4.10 below), i.e.., the current age of the mother at each birth. However, we did not find any birth order effects when looking at these sub-groups.

Table 4.10 DHS Guyana 2009 Birth Order Effects on Child Health – Heterogeneous effects (Mother's age at each birth subgroups).

	(1) Birth weight (kg)	(2) Low birth weight (<2.5 kg)	(3) Height for age z score	(4) Child height (cm)
2nd born	-0.676	0.676	-5.976	-30.762
	(2.779)	(1.667)	(6.733)	(25.110)
3rd born	-0.126	1.028	-4.197	-23.196
	(2.535)	(1.340)	(6.069)	(21.226)
4th born or higher	-0.763	0.473	-3.975	-22.570
	(2.404)	(1.159)	(6.021)	(20.576)
Male	0.169^{**}	-0.022	0.007	0.838
	(0.078)	(0.035)	(0.178)	(0.581)
Urban	0.490	-0.019	0.857	-3.157
	(0.447)	(0.094)	(1.675)	(2.686)
Mother's age at 2nd birth	0.037	-0.021	-0.038	-0.113
	(0.033)	(0.014)	(0.066)	(0.215)
Mother's age at 3rd birth	-0.006	0.010	-0.080	-0.330
	(0.042)	(0.019)	(0.081)	(0.269)
Mother's age at 4th birth	-0.001	0.013	-0.032	-0.324
	(0.110)	(0.053)	(0.271)	(0.914)
2nd born x Mother's age at 2nd birth	-0.028	-0.014	0.220	1.150
	(0.139)	(0.080)	(0.345)	(1.258)
3rd born x Mother's age at 3rd birth	-0.055	-0.025	0.118	0.691
	(0.122)	(0.063)	(0.297)	(1.011)
4th born or higher x Mother's age at 4th birth	-0.021	-0.006	0.098	0.602
	(0.108)	(0.052)	(0.273)	(0.916)
Primary education	0.072	-0.074	0.515	2.108
	(0.176)	(0.110)	(0.454)	(1.622)
Secondary education	0.080	-0.090	0.955^{**}	3.664^{**}
	(0.193)	(0.109)	(0.457)	(1.625)
Higher education	0.053	-0.070	2.223^{**}	7.474^{**}
	(0.281)	(0.189)	(0.696)	(2.671)
Constant	3.595	-0.225	3.236	131.897^{***}
	(2.489)	(1.202)	(6.196)	(21.237)
Observations	542	542	602	602
R^2	0.603	0.490	0.435	0.918

Note: All regressions include month and year (2005-2009) of birth fixed effects and a male dummy variable. Standard errors are clustered at the Mother level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Furthermore, when looking at the heterogenous effect by mother age at first birth (see Table 4.11, column 1), we find that birthweight increases for the interaction for 2 and 3rd born x age at first birth, however the results were not statistically significant. However, we find that the coefficient for 4th born x age at first birth was statistically significant at the 10 percent level, i.e., we find that birth weight increases. Furthermore, we find that height and height-for-age z-score decreases and are significant at the 5 percent and 10 percent level respectively.

Table 4.11 DHS Guyana 2009 Birth Order Effects on Child Health – Heterogeneous effects (Mother's age at first birth).

	(1) Birth weight (kg)	(2) Low birth weight (<2.5 kg)	(3) Height for age z score	(4) Child height (cm)
2nd born	-0.027	-0.226^{*}	1.576^{**}	5.997^{**}
	(0.365)	(0.136)	(0.770)	(2.992)
3rd born	-0.151	-0.056	1.253	5.913^{*}
	(0.416)	(0.159)	(0.878)	(3.462)
4th born or higher	-0.645	-0.189	1.582^{*}	7.055^{**}
	(0.483)	(0.159)	(0.887)	(3.444)
Male	0.129^{**}	-0.023	-0.087	0.904^{**}
	(0.053)	(0.020)	(0.097)	(0.331)
Urban	-0.335	0.020	0.275	-1.175
	(0.305)	(0.049)	(0.567)	(1.545)
Mother's age at 1st birth	-0.014	-0.007	0.062^{*}	0.287^{*}
	(0.016)	(0.006)	(0.036)	(0.150)
2nd born x Mother's age at 1st birth	0.009	0.010	-0.065^{*}	-0.253^{*}
	(0.017)	(0.007)	(0.038)	(0.150)
3rd born x Mother's age at 1st birth	0.024	-0.001	-0.047	-0.236
	(0.020)	(0.008)	(0.044)	(0.176)
4th born x Mother's age at 1st birth	0.047^{*}	0.006	-0.086^{*}	-0.367^{**}
	(0.025)	(0.008)	(0.046)	(0.178)
Primary education	0.130	-0.045	0.415	1.819
	(0.217)	(0.085)	(0.346)	(1.194)
Secondary education	0.114	-0.092	0.610^{*}	2.688^{**}
	(0.213)	(0.082)	(0.333)	(1.156)
Higher education	0.212	-0.089	0.992^{**}	3.774^{**}
	(0.243)	(0.095)	(0.401)	(1.411)
Constant	3.440^{***}	0.232	-3.114^{***}	101.081^{***}
	(0.486)	(0.162)	(0.864)	(3.177)
Observations	1328	1328	1328	1328
R^2	0.354	0.296	0.350	0.904

Note: All regressions include month and year (2005-2009) of birth fixed effects and a male dummy variable. Standard errors are clustered at the Mother level in the Guyana Demographic and Health Survey (GDHS), noted in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.5.4 Policy Implications

A child's birth order cannot be predetermined, but knowledge of its impact can be used to formulate policies to alleviate the pressures that parents feel with their newborns and to promote the development of later-born children.

Policy implications of birth order are not very straightforward because it is not in the hands of policymakers, thus making it difficult to alter. At conception, each sibling inherits the same genes from both parents, but the genes expressed by each individual after birth vary depending on prenatal and postnatal factors (Björkegren and Svaleryd, 2016). Essentially, this means that differences by birth order are likely to be dependent on pre-and postnatal influences rather than pre-determined conditions, which opens discussions for policy inventions. According to Björkegren and Svaleryd (2016), policy implications depend on findings.

Our findings reveal that mothers are more likely to invest more months in breastfeeding their later-born children, and these children are more likely to receive important vaccinations, such as Polio, Measles and Pentavalent. Consequently, alone time with parents is crucial to newborn infants, thus indicating that day care for older children would be important so that parents can better tend to their newborns while on parental leave. One possible policy implication would be free childcare for working parents with 2-3 children aged five and under. This would help parents to boost the development of later-born children. Currently, Guyana's Childcare and Development Service Act Number 12 of 2011 (Part 1b), states that pre-school, day care, home care, playgroup etc, must be provided for a fee or reward (Part 1b (i)).[7] As such, there is no free provision to assist working parents with childcare services. Furthermore, given the statistics taken from the 2009 GDHS vaccine coverage rate for Polio, Pentavalent and DPT, we see that the dropout rates for the full vaccine course are extremely high. Another policy implication would be the creation of programmes by the Ministry of Health Guyana to better educate first-time mothers on the impact of low birth weight on firstborn children and the importance of postnatal inventions such as exclusive breastfeeding and being fully vaccinated to mitigate such negative impacts.

[7] See: GUY99448.pdf (ilo.org)

4.6 Conclusion

This study uses the 2009 Guyana Demographic and Health Survey to analyse the effects of birth order on early childhood health in Guyana. This study contributes to the body of literature that postulates that birth order positively affects health at birth and in early childhood. Consequently, we provide new evidence for Guyana that supports the hypothesis that compared to first-born children, birth order is positively correlated with birth weight and negatively correlated with low birth weight. Our finding also shows that the height for age z score taken for the children at the time of the survey increases for second and third born children when compared to firstborns. Moreover, our findings reveal that the height (in cm) of the child at the time of the survey, increases for more for second and third born children when compared to first-borns.

This study also examines the use of postnatal intervention which may offset the disadvantages health that first-born faces at birth (Saldarriaga, 2015; Brenøe and Molitor, 2017; Pruckner, 2019). Differential parental behaviour as it relates to postnatal investments can be capture through our findings from postnatal investments. Our findings show that compared to first-borns mothers tend to extensively breastfeed their later-born babies and they also tend to invest in postnatal inoculations (viz Pentavalent and Polio vaccinations) in Guyana.

Effectively, our paper provides a comprehensive analysis of the relationship between birth order and childhood health using the 2009 DHS from Guyana. Consequently, we also examined the heterogeneity by ethnicity, religion, maternal education, and child gender. Overall, we find that in general Indian children tends to have lower birth weights when compared to other subgroups. In addition, we find that second born children of Hindu religion tend to be shorter when compared to firstborns. We also find that third and fourth born or higher Muslim children across the various religious groups had higher birth weight compared to firstborns. While birth order is not quite a policy intervention debatable subject; given the statistics taken from the 2009 GDHS vaccine coverage rate for Polio, Pentavalent and DPT, we see that the dropout rates for the full vaccine course are extremely high. As such, the Ministry of Health Guyana should create programmes to better educate first time mothers on the impact of low birth weight on first born children and the importance of postnatal invention such as exclusive breastfeeding and full vaccination doses in mitigating such negative impacts.

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Chapter 5: - Conclusion

5.1 Introduction

This final chapter summarises the overall findings and contribution of the thesis, which focuses on the research questions that were answered concerning the effects of weather shocks, educational reform and birth order on health and education-related outcomes in Guyana. The chapter presents significant findings on how weather shocks and birth order can impact early childhood health in Guyana, as well as the impact of educational policy reforms on the completion of secondary and higher education in Guyana. In addition, the chapter highlights the negative impacts of in-utero exposure to weather shocks (i.e., positive and negative rainfall shocks) and early gestation, as well as the benefits of being later-born siblings and the positive impacts of secondary school reform policy on the completion of secondary and the completion of secondary or tertiary education. The chapter then presents some of the policy implications for local mitigation of weather shocks on early childhood health and possible policy implications for birth order effects. Furthermore, this chapter also provides empirical evidence of the impact of the USE (2003-2007) policy reform on educational and labour market outcomes in Guyana and supports the need for the swift conversion of secondary schools with vocational curriculums into academic curriculums (i.e., Primary Tops into General Secondary Schools). There is a need to contextualise early childhood vulnerabilities to climate change and its impact on childhood health, understand how birth order effects can influence policy changes and how secondary educational policy reform can influence secondary or tertiary completion and, ultimately, the human capital of Guyana.

5.2 Research Highlights

Climate change has led to an increase in the phenomenon of natural disasters, which has catastrophic impacts on economies at large. Chapter Two, based on weather shocks' effects on Guyana's childhood health, highlights how vulnerability to floods and climate variability in flood-prone regions can lead to negative childhood health impacts on outcomes such as height-for-age z-scores, and stunted and severely stunted growth in Guyana. Le and Nguyen (2021) reveal that exposure to excess rainfall in the first trimester in 55 low and middle-income countries resulted in reduced children's HAZ and increased stunting. My research demonstrated similar findings in the context of middle-income Guyana, which is susceptible to flooding and sea levels rises. Chapter Two reveals that exposure to rainfall shocks, primarily in the first trimester, results in lower height-for-age z-scores and an increase in the incidence of stunted and severely stunted growth. My research also found that positive rainfall shocks in the first trimester increases the likelihood of stunted and severely stunted growth. Similarly, positive rainfall shock in the second trimester increases the likely of stunted growth. Therefore, the research provides many insights into the effects of in-utero exposure to weather shocks and its impact on early childhood health in Guyana. The research also provides some plausible policy implications which can be used by the Government of Guyana to combat the incidence of positive and negative rainfall shocks due to climate change.

Chapter Three of this thesis examined the impact of a secondary school policy reform on the completion of secondary and the completion of secondary or tertiary education in Guyana. Furthermore, the research is the first-ever study to analyse a USE (2003-2007) policy reform that converts secondary schools with a vocational curriculum into academic curriculums. It is also the first study to provide an empirical evaluation of the impact of the USE (2003-2007) policy reform on Guyana's educational sector.

The findings of this research show that greater exposure to USE (2003-2007) had positive impacts on the completion of secondary and the completion of secondary or tertiary education and the potential to earn higher wages in Guyana. Research from Germany, Denmark, Austria and Switzerland shows that some developed countries operate under a dual-educational system where schools with vocational education and training curriculums are encouraged alongside schools with academic curriculums to suit the various students' abilities (Eichhorst, 2015; Baethge and Wolter, 2015). However, my research findings revealed that the conversion of pre-vocational secondary schools with vocational curriculums into academic curriculums led to the completion of secondary or tertiary education and an increase in wages of the people exposed to the policy. On the other hand, the finding also revealed that the USE (2003-2007) policy reform did not close the achievement gaps in education across all ethnic groups. As such, the USE policy only benefitted the two larger ethnic groups, i.e., East Indians and Africans.

Chapter Four is based on birth order effects and early childhood health in Guyana. My research revealed that health at birth improves with increasing birth orders. Furthermore, we find that third- and fourth-born children are less likely to be born with low birth weight. It also revealed that second and third-born children had higher height-for-age z-scores when compared to firstborn children. Furthermore, when looking at postnatal investments in the form of breastfeeding, we also find that when compared to their firstborn, mothers spend more months breastfeeding their later borns. Overall, when looking at postnatal investments in inoculations, we also find that mothers tend to vaccinate their later borns against Pentavalent and Polio compared to their firstborns.

This thesis presents several policy implications that can be used by the Government of Guyana. For Chapter Two, one potential policy recommendation is for the Ministry of Health, Guyana, to collaborate with a multidisciplinary research team to specifically assess the medium-and long-term effects of adverse weather shocks on child and maternal health. Furthermore, the Ministry of Health should consider the nutrition, and medical outreach programmes for pregnant mothers, in regions that are more susceptible to flooding. It is also proposed that a climatologist should be added to this team to effectively monitor and predict the onset of these shocks, which would better put provisions in place to improve maternal and early childhood health in weather shocks aftermath.

As it relates to Chapter Three, it was recognised that the USE (2003-2007) reform policy introduced by Guyana's Ministry of Education had made strides in increasing and improving access to secondary education. Although it was found that the policy led to the completion of secondary and the completion of secondary or higher education, thus realising the benefits of Guyana's USE (2003-2007) policy reform. Overall, I find that the USE (2003-2007) policy reform did not close the achievement gaps in education across ethnicities. It is also recommended that the MoE evaluate the USE (2003-2007) policy reform and assess whether it is fulfilling its equity goal and employ measures to ensure that the achievement gaps are closed across all ethnic groups. It is also recommended that more should be done to increase the speed of the conversion of the remaining Primary Tops to GSSs. With the greater conversion of Primary Tops to GSSs, it is likely that this will lead to greater completion of secondary and the completion of secondary or tertiary education in Guyana. As such, it is imperative that Guyana's Ministry of Education works towards making this a reality.

Chapter Four examined the birth order effects and early childhood health in Guyana. My finding revealed that mothers are more likely to invest in postnatal investments such as breastfeeding practices and inoculations for their later-born children. Consequently, one possible policy implication is the provision of free childcare for working parents with 2-3 children aged five and under by the Government of Guyana to help parents boost the development of later-born children.

In addition, the statistics taken from the 2009 GDHS revealed that the dropout rates for the full vaccine coverage for Polio, Pentavalent and DPT are extremely high. Therefore, another policy implication would be the creation of programmes by Guyana's Ministry of Health to better educate first-time mothers on the impact of low birth weight on firstborn children and the importance of postnatal investments such as exclusive breastfeeding and being fully vaccinated to mitigate such negative impacts.

The policy implications proposed by this research can be used by the Government of Guyana to better deal with the negative effects of climate change on early childhood health. Moreover, the provision of childcare services for parents with 2-3 children five years old and under should be a top priority for the Government of Guyana. This research also analysed the effectiveness of the USE (2003-2007) policy reform and found that the policy reform was beneficial for the students who were exposed to the USE. It is also recommended that the conversion of the remaining Primary Tops into GSSs by Guyana's Ministry of Education should be done in a swift manner to encourage greater completion of secondary or tertiary education.

5.3 Needs for Further Research

This thesis presents findings from research that took place in several different periods, i.e., during in-utero periods of weather shocks for children born in 1995-2014, using MICS 2000, 2006-07 and 2014; using the GLFS for the period 2018 and 2019 to analyse the USE (2003-2007) policy reform and using Guyana 2009 DHS to analyse birth order effects. Consequently, there is a need for similar studies in the same areas with extended data, for instance, including the MICS 2018 dataset for Guyana, in order to find out if there will be significant changes in terms of childhood health outcomes and also to ascertain how mothers are coping with weather shocks given the current policy changes in response to flooding made by the Government of Guyana. In addition, with the conversion of the remaining Primary Tops to GSSs, there will be a need for an extension of Chapter Three, which can provide empirical evidence for the benefits of the USE (2003-2007) reform policy as it relates to educational attainment and labour market outcomes. Finally, I recommend more research examining, understanding, and exploring birth order effects and childhood health in Guyana. It is evident that ‘good’ childhood health is very important in strengthening the human capital of Guyana and, ultimately, the economic wealth of Guyana. As health and education are two important human capital investments essential to any society, the Government of Guyana must continue to invest in these sectors at the national and community level to improve its human capital.

5.4 Summary

Chapter Two of this study provides evidence that weather shocks can lead to negative childhood outcomes, potentially impacting the labour market and the economy as a whole. The study provides evidence that children who were in-utero during weather shocks are likely to have lower height-for-age z-scores and an increase in the incidence of stunted and severely stunted growth in Guyana. Furthermore, it was found that mothers exposed to positive rainfall shocks were more likely to breastfeed for longer periods of time and invest in some postnatal vaccinations when looking at the trimester-specific effect. Furthermore, the study recommends that in an effort to reduce vulnerability to climate variability, Guyana’s Ministry of Health, in collaboration with climatologists, should better monitor the onsets of floods and other climatic disasters to provide the necessary health for mothers affected by these natural disasters.

The empirical evidence provided in Chapter Three is beneficial to both the Ministry of Education and the wider society, as there are no empirical studies, nor no known studies done by the MoE to effectively analyse the USE (2003-2007) policy reform in Guyana. Consequently, this study provides knowledge to both the Government of Guyana and the economy at large. The education sector accounts for approximately 5 percent of Guyana’s yearly GDP, and it is one of the country’s most important sectors as it provides the country’s human capital (World Bank Data, 2022). This study recommends that the MoE speed up the conversion of Primary Tops into GSSs to encourage greater completion of secondary or tertiary education in Guyana. It is also recommended that the MoE assess the impact of the policy across the ethnic groups and use the appropriate measures to address achievement gaps. Based on the findings of this study, it is evident that the students exposed to the USE (2003-2007) policy reform were more encouraged to complete their secondary education in their new General Secondary Schools.

Chapter Four provided evidence that later-born children have better birthweight and mothers tend to invest in postnatal vaccinations for later-born siblings. As such, it was recommended that the Government of Guyana provide free childcare services for parents with 2-3 children five years old and under.

Overall, this dissertation provides empirical evidence supporting the need for policy changes to improve Guyana's Health and Education sectors to strengthen the country's human capital and thereby encourage greater economic growth.

Appendix A

CHAPTER 2 - The effects of weather shock on childhood health

Appendix 1 Further details on data and variable description

Individual Characteristics

Height-for-age z scores (HAZ) – Defined as height-for-age z-score between -9.62 SD and 6.58 SD. NB:// The variable was defined using the variables (HAZ2 - MICS 2000, 2006/07 and 2014).

Stunted – Defined as a dummy variable equal to 1 if the HAZ is less than -2 SD and 0 otherwise.

Severely stunted – Defined as a dummy variable equal to 1 if the HAZ less than -3 SD and 0 otherwise.

Male – Defined as a dummy variable equal to 1 if the male and 0 otherwise.

Postnatal investments

Child ever breastfed – Defined as a dummy, equal to 1 if the child has ever been breastfed and 0 otherwise. The variable was defined using the variables (bf1 (MICS 2000), BF1 (MICS 2006/07) and BD2 (MICS 2014) in the MICS survey– the month of BCG immunization.

Measles vaccination – Defined as a dummy, equal to 1 if the child has received their measles vaccination within their first year of birth and 0 otherwise. In Guyana, measles vaccinations are distributed at 9-11 months after birth. NB:// The variable was defined using the variables (im5m (MICS 2000), im6m (MICS 2006/07) and im3mm (MICS 2014) in the MICS survey – the month of BCG immunization.

DPT Vaccination – Defined as a dummy equal to 1 if the child had received their DPT vaccinations within their first year of birth and 0 otherwise. NB:// The variable was defined using the variables (im4cm (MICS 2000), im5cm (MICS 2006/07) and im3d3m (MICS 2014) in the MICS survey – the month of BCG immunization.

BCG Vaccination - Defined as a dummy equal to 1 if the child had received their BCG vaccinations within their first year of birth and 0 otherwise. NB:// The variable was defined using the variables (im2m (MICS 2000), im2m (MICS 2006/07) and im3bm (MICS 2014) in the MICS survey – the month of BCG immunization.

Mother Characteristics

No education – Defined as a dummy equal to 1 if the mother has no education (i.e., variable melevel=1) and 0 otherwise.

Primary education – Defined as a dummy equal to 1 if the mother has primary education (melevel =3) and 0 otherwise.

Higher education – Defined as a dummy equal to 1 if the mother had secondary or higher education (i.e., variable melevel=4 and 5) and 0 otherwise.

Urban – Defined as a dummy equal to 1 if the mother lived in an urban area and 0 otherwise.

Ethnicity

African – Defined as a dummy equal to 1 if the child is of African descent and 0 otherwise.

East Indian - Defined as a dummy equal to 1 if the child is of East Indian descent and 0 otherwise.

Mixed - Defined as a dummy equal to 1 if the child is of Mixed descent and 0 otherwise.

Amerindian - Defined as a dummy equal to 1 if the child is of Amerindian descent and 0 otherwise.

Portuguese - Defined as a dummy equal to 1 if the child is of Portuguese descent and 0 otherwise.

Chinese – Defined as a dummy equal to 1 if the child is of Chinese descent and 0 otherwise.

Appendix B

CHAPTER 3 - Effects of a School Conversion Policy on Educational Attainment and Labour Market Outcomes in Guyana

Appendix 1 Further details on data and variable description

Educational Attainment outcomes

Secondary or higher education (Completed) – Defined as a dummy equal to 1 if the highest education completed is Secondary or higher (including tertiary education) and 0 otherwise. *NB//:* This variable was constructed by combining the response to questions q1_14 and q1_15 in the GLFS questionnaires.
Q1_14 = What class did you Complete?
Q1_15 = What is the highest post-secondary level/degree that you have completed?

Tertiary (Completed) – Defined as a dummy equal to 1 if the highest education (i.e., technical/vocational certificate or Diploma, University Certificate or Diploma, Bachelor's degree, Postgraduate Certificate or Diploma, Master's and Doctorate) and 0 otherwise. NB:// This variable was constructed based on the combined variable above (using q1_14 and q1_15).

Secondary or higher education (Attended) – Defined as a dummy equal to 1 if the highest education attended is Secondary & higher and 0 otherwise. *NB:// This variable was constructed using question Q1_13, i.e., What is the highest level of education that you have attended*?

Labour Market Outcomes

Employed – Defined as a dummy equal to 1 if in the last seven days the respondent worked for a wage salary or tips (q2_04), or if in the last seven days the respondent did any kind of business or farming (q2_05), or if in the last seven days the respondent did even one hour of cooking for sale or other food processing activities for sale, making baskets, mats or other handicrafts for sale (q2_06), or if in the last seven days, the respondent helped in an unpaid business or farm owned by a household (q2_07), or if in the last seven days, the respondent was absent from a paid job or business including a household business, cook for sale or other food processing activities for sale or making handicrafts for sale (q2_10), given that the age of the respondent, i.e., age 15 and above (q1_04) and 0 otherwise. *NB:// This variable used to construct this variable are q1_04>=15, q2_04, q2_05, q2_06, q2_07, and q2_10.*

Wage employers – Defined as a dummy equal to 1 if the individual reported working as an employee for a company and 0 if the self-employed or unpaid family worker, conditional on employed. *NB:// This variable was constructed using question Q3_16, i.e., What is your employment status in your main job?*

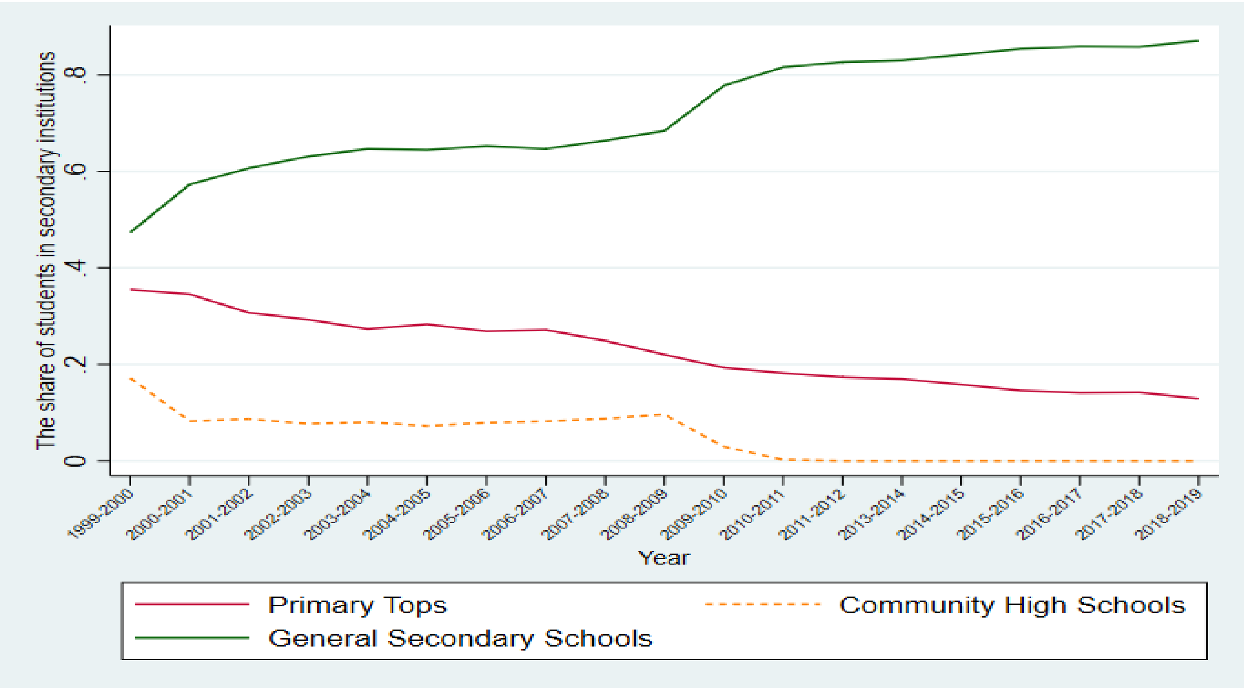
Work hours – Hours worked in the past week conditional on employed, i.e., missing for non-working individuals. *NB:// This variable was constructed using question Q3_03, i.e., How many hours do you usually work per week in your main job (the one that takes more hours)?*

Log wage – The logarithm of the monthly wage variable. *NB:// This variable was constructed using question Q6_01, i.e., What was your income in the last month in terms of net salary (in numbers)?*

Formal wage worker – Defined as a dummy equal to 1 if the individual was provided with a written contract, as opposed to a verbal agreement (informal workers). *NB:// This variable was constructed using question Q3_18, i.e., Are you working on the basis of a written contract or is it on the basis of a verbal agreement?*

Appendix B.1: The USE policy reform and teacher's qualification

The section below provides some descriptive statistics analysed using the DES (1999-2018) which explains changes as it relates to trained, untrained and unqualified teachers.

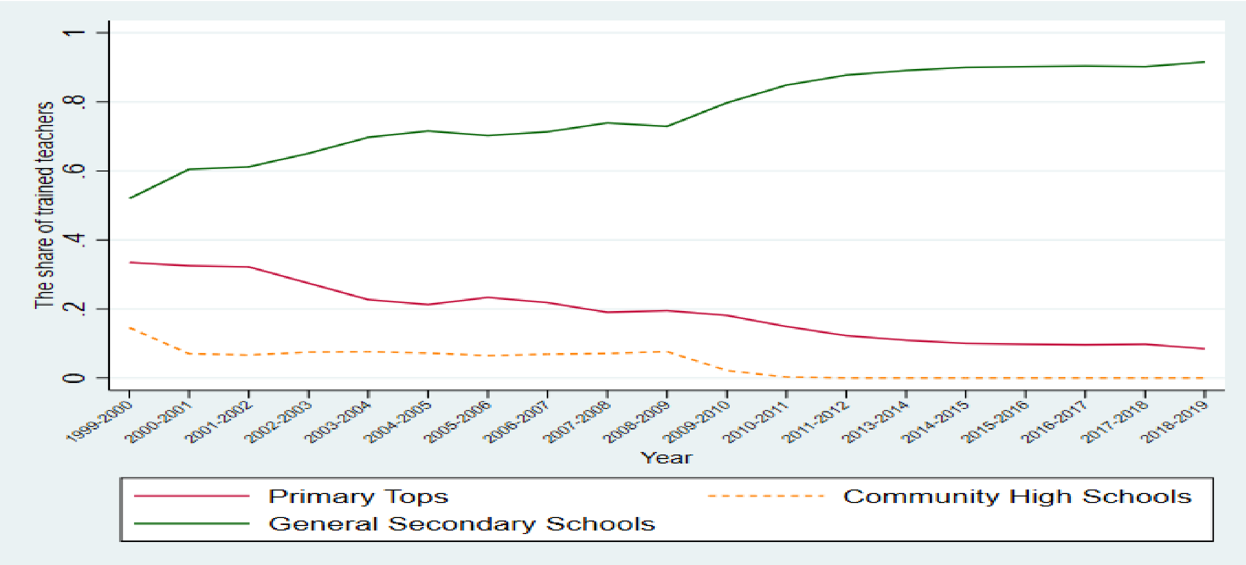


NB:/Missing data for the year (2012-2013) - Ministry of Education (MOE).
Figure B1: The share of students in secondary educational institutions by type during (1999-2019).
Source: Digest of Education Statistics (1999-2019).

The DES (1999-2019) provides us with data on the number of trained and untrained teachers in the secondary institutions. Trained teachers are defined as teachers with the necessary professional qualifications, i.e., a minimum of five subjects inclusive of Mathematics and English at CSEC level coupled with an educational certification from the Cyril Potter College of Education (CPCE). Untrained teachers are teachers who do not have the professional qualification to teach, for instance, those without any educational certification from the CPCE. On the other hand, unqualified teachers do not have the requisite qualification to enter the CPCE to become certified to teach (Chief Planning Officer, MOE, 2022).

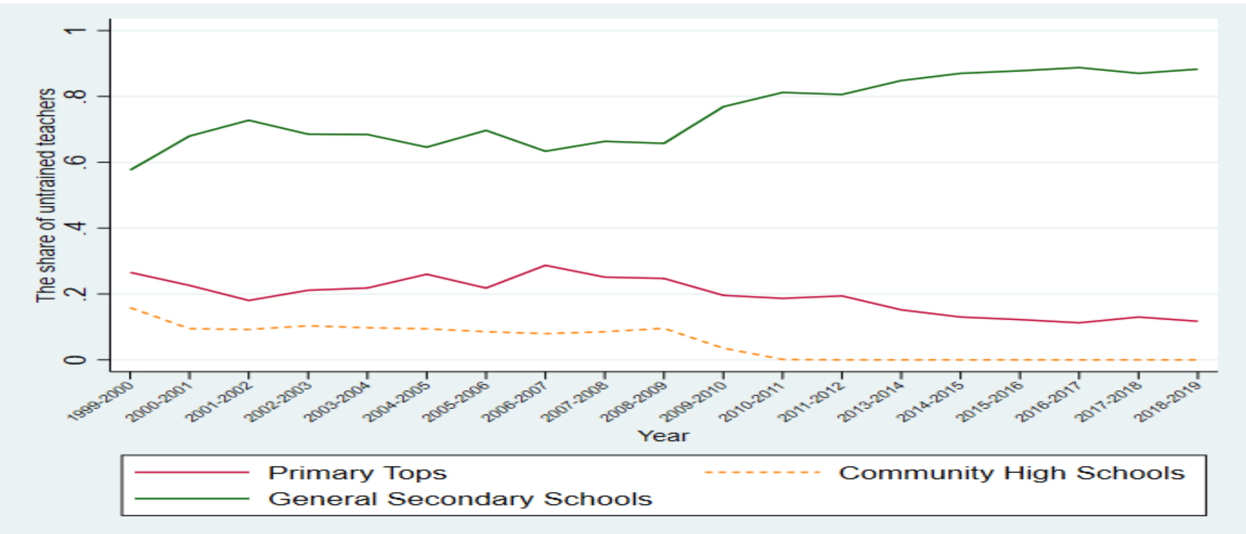
In addition, during the post-and-pre policy periods, we find that GSSs had a greater share of trained teachers when compared to CHSs and Primary Tops who both had lower share of trained teachers before the policy change. During the pre-policy period, we can see a steady increase in trained teachers in the GSSs, but on average a slight decline in trained teachers in

Primary Tops and CHSs (see Figure B2 below for the share of trained teachers in the secondary institutions for the period (1999-2019)).



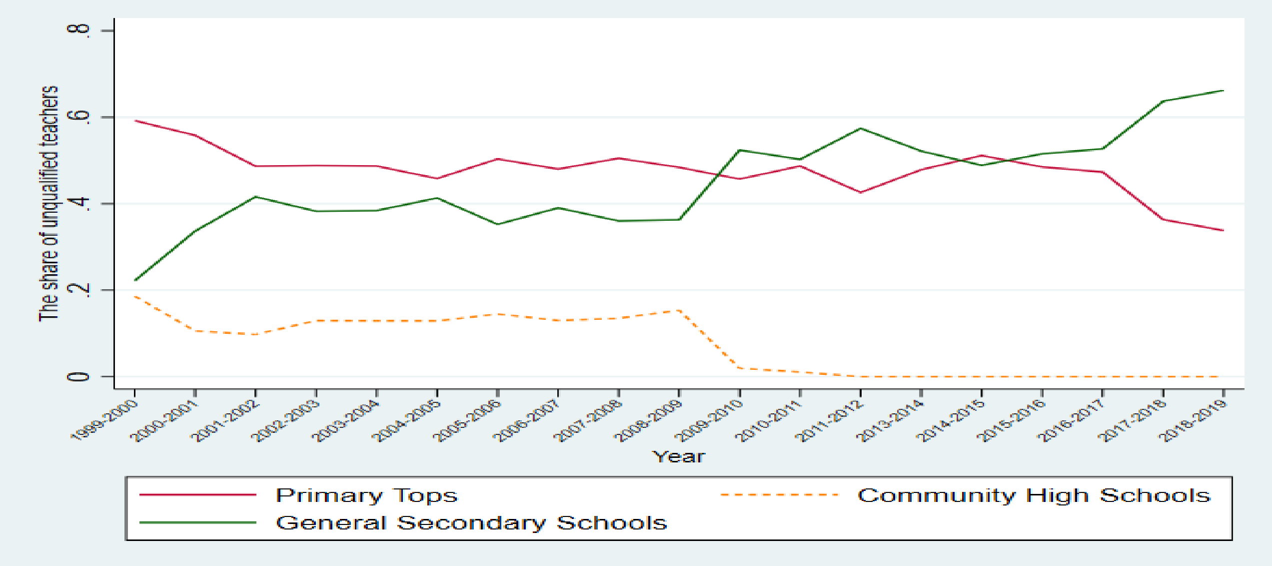
NB:/Missing data for the year (2012-2013) - Ministry of Education (MOE).
Figure B2: The share of trained teachers for types of secondary educational institutions during (1999-2019).
Source: Digest of Education Statistics (1999-2019)

Furthermore, GSSs saw successive increase in the number of trained teachers over the years. When looking at the share of untrained teachers for the period, we find that there were higher shares of untrained teachers for GSSs but lower shares in Primary Tops and CHSs overtime (see Figure B3 below for the share of untrained teachers for the period (1999-2019).



NB:/Missing data for the year (2012-2013) - Ministry of Education (MOE).
Figure B3: The share of untrained teachers for the period (1999-2019).
Source: Digest of Education Statistics (1999-2019).

However, when looking at the share of unqualified teachers, we find that in the years (1999-2009) the Primary Tops had a greater proportion of unqualified teachers when compared to the CHSs and GSSs (see Figure B4 below for the share of unqualified teachers for the period (1999-2019)).



NB:/Missing data for the year (2012-2013) - Ministry of Education (MOE).
Figure B4: The share of unqualified teachers in the secondary institutions for the period (1999-2019).
Source: Digest of Education Statistics (1999-2019).

Appendix C

CHAPTER 4 - Birth Order Effects on Early Childhood Health in Guyana

Appendix 1 Further details on data and variable description

Demographic Characteristics

Birth order 1 – Defined as a dummy equal to 1 if the child was the first born and 0 otherwise.

Birth order 2- Defined as a dummy equal to 1 if the child was the second born and 0 otherwise.

Birth order 3 – Defined as a dummy equal to 1 if the child was the third born and 0 otherwise.

Birth order 4 or higher – Defined as a dummy equal to 1 if the child was a fourth born or higher and 0 otherwise.

Child is male – Defined as a dummy equal to 1 if the child is male and 0 otherwise.

Urban – Defined as a dummy equal to 1 if the child resided in Urban areas and 0 otherwise**.**

Health at birth

Birth weight (kg) – Defined as the birth weight in kilogram ranging between 0.8 kg – 8kg.

Low birth weight (<2.5 kg) – Defined as a dummy if the childbirth weight is 2.5 kg or lower.

Childhood Health

Height-for-age z-score - Defined as height-for-age z-score that lies between -5.99 SD and 5.53 SD.

Stunted - Defined as a dummy variable equal to 1 if the HAZ is less than -2 SD and 0 otherwise.

Child height (cm) – Defined as the height of children ranging between 42 cm to 123.3 cm.

Mother's Characteristics

Mother's age at first birth – Defined as the mother's age (continuous variable) ranging from 11 to 38 years old.

Nursery or no education – Defined as a dummy equal to 1 if the mother has a nursery or no education and 0 otherwise.

Primary education – Defined as a dummy equal to 1 if the mother has primary education and 0 otherwise.

Secondary education – Defined as a dummy equal to 1 if the mother has secondary education and 0 otherwise.

Higher education – Defined as a dummy equal to 1 if the mother has higher education and 0 otherwise.

Ethnicity

African – Defined as a dummy equal to 1 if the child is of African descent and 0 otherwise.

East Indian - Defined as a dummy equal to 1 if the child is of East Indian descent and 0 otherwise.

Mixed - Defined as a dummy equal to 1 if the child is of Mixed descent and 0 otherwise.

Amerindian - Defined as a dummy equal to 1 if the child is of Amerindian descent and 0 otherwise.

Portuguese - Defined as a dummy equal to 1 if the child is of Portuguese descent and 0 otherwise.

Religion

Christian – Defined as a dummy equal to 1 if the child is from a Christian family and 0 otherwise.

Hindu – Defined as a dummy equal to 1 if the child is from a Hindu family and 0 otherwise.

Muslim – Defined as a dummy equal to 1 if the child is from a Muslim family and 0 otherwise.

Rastafarian – Defined as a dummy equal to 1 if the child is from a Rastafarian family and 0 otherwise.

Not Religious – Defined as a dummy equal to 1 if the child is from a family without a religious background and 0 otherwise.

Other - Defined as a dummy equal to 1 if the child is from a family who has "other" religious belief that was not listed and 0 otherwise.

Postnatal Investments

Breastfed – Defined as a dummy equal to 1 if the child has ever been breastfed and 0 otherwise.

All vaccination (either) – Defined as a dummy equal to 1 if the child has received all their vaccinations 'either' declared by the mother or on their vaccination card and 0 otherwise.

No vaccination (either) - Defined as a dummy equal to 1 if the child has not received any vaccination 'either' declared by the mother or on their vaccination card and 0 otherwise.

Polio 1st dose (either) - Defined as a dummy equal to 1 if the child has received their first dose of polio vaccine 'either' declared by the mother or on their vaccination card and 0 otherwise.

Polio 2nd dose (either) - Defined as a dummy equal to 1 if the child has received their second dose of polio vaccine 'either' declared by the mother or on their vaccination card and 0 otherwise.

Polio 3rd dose (either) - Defined as a dummy equal to 1 if the child has received their third dose of polio vaccine 'either' declared by the mother or on their vaccination card and 0 otherwise.

Measles (either) - Defined as a dummy equal to 1 if the child has received their measles vaccine 'either' declared by the mother or on their vaccination card and 0 otherwise.

Pentavalent 1st dose (either) - Defined as a dummy equal to 1 if the child has received their first dose of pentavalent vaccine 'either' declared by the mother or on their vaccination card and 0 otherwise.

Pentavalent 2nd dose (either) - Defined as a dummy equal to 1 if the child has received their second dose of pentavalent vaccine 'either' declared by the mother or on their vaccination card and 0 otherwise.

Pentavalent 3rd dose (either) - Defined as a dummy equal to 1 if the child has received their third dose of pentavalent vaccine 'either' declared by the mother or on their vaccination card and 0 otherwise.

Appendix 2: Recommended vaccination schedule in Guyana

Table C.1: Recommended Vaccination Schedule in Guyana

VACCINE	NO. of DOSES	AGE at administration
BCG	1	Birth
OPV	3 1st booster 2nd booster 3rd booster	8, 16, 24 weeks 18 months 3-5 years 11+ years every 10 years thereafter
IPV	3	8, 16, 24 weeks
Pentavalent (DPT, Hib, Hepatitis B)	3	8, 16, 24 weeks
PCV 13	3	8, 16, 24 weeks
DPT	1st Dose after Pentavalent series 2nd Dose	18 months 3 years 9 months
DT (Paediatric)		Given to children in whom DPT is contraindicated
DT (adult)	1st Dose 2nd Dose 1st Booster	Pregnant women at contact 4 weeks after 6 months after 2nd dose Repeat every 10 years if necessary
MMR	2 doses	12 months 3 years 9 months and over
Yellow fever	1	12 months Repeat every 10 years if necessary
Hepatitis B	1st dose 2nd dose 3rd dose	Health workers at risk At any age 4 weeks later 5 months later

Source: Ministry of Health, Guyana, Jan 20th, 2020

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