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The Impact of Consanguineous Marriages on Child Health in Egypt: Cultural Practice or Health Risk?

by

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Declaration

I, Sayed Sameed Hussain, hereby declare that the thesis "The Impact of Consanguineous Marriages on Child Health in Egypt: Cultural Practice or Health Risk?" submitted to GLODEP Consortium has been written and composed entirely by myself. I have properly acknowledged and attributed all the materials and sources utilized in its preparation.

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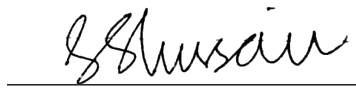
Signature: 

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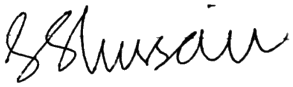

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Abstract

This study investigates the impact of consanguinity on child wellbeing by measuring a key indicator, the Height for Age Z scores, which account for chronic malnutrition. Utilizing nationally representative data from the Egypt Demographic and Health Survey, the study employs an OLS regression model to analyze the relationship between different types of paternal and maternal consanguinities on HAZ scores. The study controls for region fixed effects to examine the effects of household dynamics in consanguineous unions. The study also performs heterogeneity analysis to examine how maternal education and wealth status interact with different types of consanguinities and how their effect on HAZ scores changes. The findings reveal a statistically significant negative association between consanguineous unions, particularly paternal first cousin marriages, and child HAZ scores, highlighting the increased risk of stunting in the offspring. Moreover, higher maternal age and institutional delivery are found to mitigate these adverse effects. The study underscores the importance of integrating genetic counselling and targeted maternal educational programs within the realm of public health. Importantly, the study advances the understanding of household and kinship dynamics in Egypt, which provides valuable insights to policymakers aiming to improve child outcomes in culturally sensitive contexts.

Keywords*: Consanguinity, child wellbeing, HAZ scores, DHS, OLS, household dynamics.

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List of Abbreviations

ANC: Antenatal Care

CAPMAS: Central Agency for Public Mobilization and Statistics

CHWs: Community Health Workers

DHS: Demographic and Health Survey

EAs: Enumeration Areas

EDHS: Egypt Demographic and Health Survey

HAZ: Height for Age Z-scores

LBW: Low Birth Weight

MICAs: Multiple Indicator Cluster Surveys

NGOs: Non-Governmental Organizations

OECD: Organization for Economic Co-operation and Development

OLS: Ordinary Least Squares

PPS: Probability Proportional to Size

SD: Standard Deviation

SDH: Social Determinants of Health

UNDP: United Nations Development Programme

UNICEF: United Nations Children's Fund

VIF: Variance Inflation Factor

WHO: World Health Organization

Chapter 1

1. Introduction:

Child health is an essential aspect of public health and development, and early years of life play a substantial role in children's overall well-being and quality of life. Children's health not only affects their chances of survival but also has long-lasting implications for educational attainment and future economic productivity. Healthy children contribute positively towards the development and growth of their countries, whereas poor health can have severe negative consequences. According to the Economic Research Forum, every 1 out of 5 children in Egypt is stunted. The percentage of stunted children for the year 2014 stood at 21 per cent (Hashad, 2020). Stunting is a chronic undernutrition and is influenced by a range of interrelated factors, one such factor being consanguinity (Vishwarkarma, 2021).

Consanguinity is defined as a union between individuals who are related as second cousins or closer, sharing a common ancestor and proportion of their genetic material (Bittles A. H., 2001). Biologically, consanguineous unions increase the likelihood of autosomal recessive disorders and congenital anomalies, which can impair growth and development (Bittles A. H., 2001). However, this genetic risk is compounded by socioeconomic factors often associated with consanguineous unions. Consanguinity is common in Africa, particularly in North and West Africa, where cultural practices and socio-economic factors often favor consanguineous unions. Consanguinity rates in Morocco are reported to be around 20-30 per cent with significant regional variation, as rural areas exhibit higher rates (Jaouad ic, 2009). In Tunisia, the prevalence of consanguinity is estimated to be around 25-30 per cent, with a growing concern over the potential impact on public health, including child health outcomes such as stunting (Ben Halim, 2013). For Africa, the highest rates of consanguinity can be seen for Sudan, where consanguineous unions are reported to be 40-50 per cent, with a higher percentage of first-cousin marriages. This high percentage is associated with both cultural practices and the geographic isolation of the communities (lhadi, 2023). Studies in Egypt indicate that such marriages are more prevalent among poorer, less educated, and rural households; these are the groups that are vulnerable to several economic and social shocks (Rabah M. Shawky., 2011). According to the latest round of the Demographic Health Survey, 31 per cent of the ever-married women in Egypt were in a consanguineous union, whereas a high prevalence was seen for the younger population, where almost 27 percent of the youth aged 13-35 years were

in a consanguineous union (DHS, 2014). Thus, such a high prevalence of stunting and consanguinity in Egypt makes this study relevant.

1.1. Background

As explained earlier, unions between blood relatives are common in Egypt. The percentage of women marrying a blood relative range from 37 per cent for women with no education to 26 per cent for women with secondary or higher education. More than half of the consanguineous unions involve marrying first cousins. However, in a consanguineous union, the husband is more likely to be a blood relative from the father's side than the mother's side. (DHS, 2014).

Another important aspect of the consanguineous unions in Egypt is that the highest percentage of consanguineous unions can be seen for the age group 15-19 years old, where 13 per cent of the women marry their paternal first cousins and almost 7 per cent marry their maternal first cousins. For all the other age groups, the percentage persists at around 10 per cent. (DHS, 2014).

Children born to women who marry at a young age are more likely to experience adverse health outcomes. Early maternal age at marriage is associated with low birth weight, undernutrition, and reduced access to skilled birth attendants, all of which contribute to poorer child health outcomes. (Fan, 2022) .

In addition to these socioeconomic determinants of consanguinity, household dynamics such as maternal autonomy of wealth, bargaining power among household members and the distribution of resources play an important role in how consanguinity affects child wellbeing. Since consanguineous unions are more common among extended households, where many members of the family live together, the distribution of resources may be more tilted towards the elderly or male members. It is therefore necessary to examine how consanguinity affects child health, after controlling for factors such as maternal education, wealth status, etc. (Mohamed Elaabsi., 2022).

Even though the rates of consanguinity are high, a very small percentage of the population is aware of its negative consequences for child health. A recent study in Egypt reported that children born to consanguineous unions had a higher percentage of pregnancy wastage, where 24 per cent were stillbirths and 61.7 per cent with congenital malformations (Esraa A. Mofied., 2024).

Given the high prevalence of consanguineous marriages in Egypt and their documented association with adverse child health outcomes, it is critical to further investigate their effects. This study aims to study the impact of consanguinity on children's Height for Age Z scores.

1.1.1. Implications of Consanguinity

Even though consanguinity has implications beyond child health, this study will have its focus on its impact on child health. Sufficient literature is available in which the different effects of consanguinity are studied. One of the most well-documented consequences of consanguinity is the increased risk of autosomal recessive genetic disorders in offspring. Because consanguineous unions share a great proportion of their genes, there is a higher likelihood that both parents carry the same deleterious recessive allele, thereby increasing the risk of genetic conditions in children (Bittles & Black, 2012). Another study of the Arab population found that consanguinity is associated with significantly higher rates of congenital malformations, perinatal mortality, and morbidity (Tadmouri, 2009).

Like many other countries, in Egypt, the effects of consanguinity are not limited to genetic risks. They often intersect with socioeconomic disadvantages, such as poverty, lower levels of education, and reduced access to health care services, which can further worsen child health outcomes. The intersection of the genetic disorders and social vulnerabilities makes the issue of consanguinity particularly pressing in the Egyptian context (RM Shawky MY El-Awady., 2011).

Given these biological and socioeconomic risks, it is important to explore the broader implications of consanguineous marriages using a nationally representative dataset. In Egypt, where both consanguinity and child undernutrition remain prevalent, understanding this relationship is not only relevant for academic inquiry but also for informing public health interventions.

1.1.2. Cultural roots of consanguineous unions in Egypt

Like all other Muslim majority countries, Egypt has a very high percentage of consanguineous unions. Before we delve deeper into the analysis and impacts of consanguinity, it is important to answer the question that why Egypt sees such an inflated number of consanguineous unions. The answer to this question lies in the culture, traditions and the dominant religion of Egypt. Consanguinity, in Egypt, is closely linked to the preservation of the family structure, property and social stability. Marrying within close or extended family, especially among first cousins, has been

a longstanding tradition aimed at maintaining familial bonds and ensuring the continuity of family assets. Empirical literature finds several reasons for kin marriages, such as avoiding fragmentation of the patrilineal property and protecting the bride's interest (Hendy, 2024). Similarly, the collectivist nature of Egyptian societies places a strong emphasis on family loyalty and cohesion, making consanguineous marriages a reason to strengthen family values (Scroope, 2017).

The religious view on consanguinity in Egypt is nuanced. In Egypt, where 90 per cent of the population identifies as Muslims, the role of Islamic teachings is very important. While Islam allows for cousin marriages, it does not explicitly encourage them. However, the percentage of such unions is very high amongst the Muslims (Hendy, 2024). On the other hand, the Coptic Orthodox Church has initiated efforts to discourage consanguineous marriages due to health concerns. The church has also launched awareness campaigns highlighting the genetic risk of marrying close relatives (Egypt Today, 2014).

Thus, we can conclude that consanguineous unions in Egypt can be primarily attributed to deep-rooted cultural traditions and religious acceptance. These practices are often reinforced by societal norms that emphasize family cohesion.

1.2. Research Problem and Objective

1.2.1. Research Problem

This study seeks to improve the understanding of the association between consanguinity and child health. In particular, the study uses a nationally representative data set to explain the relationship between different kinds of consanguinity and child Height for Age Z score. Previous literature on the topic of consanguinity in case of Egypt is limited to certain parts of the country, and no study has been conducted prior to this one that investigates this relationship using a nationally representative dataset. Furthermore, this study also controls for different maternal and socio-economic factors that can have an impact on children HAZ scores, but also helps isolate the effect of household dynamics.

1.2.2. Research Objectives

The objective of this study is to investigate the relationship between consanguinity and HAZ scores. By controlling for region fixed effects the study analyzes the exogenous effects of household dynamics on children HAZ scores in consanguineous unions. It also seeks to understand

the differential effects of various types of consanguineous unions on HAZ scores among children. The study conducts a descriptive analysis of the prevalence of stunting and consanguinity across different socioeconomic factors. This study should also provide evidence-based policy prescriptions for public health and social policy targeting childhood malnutrition in consanguineous family settings.

1.2.3. Research Gap

An ample amount of literature can be found where the relationship between consanguinity and child health has been investigated in Egypt (Bittles A. H., 2002). However, most of the existing studies have focused on specific regions or subpopulations (Rabah M. Shawky, 2011). These studies often lack national representativeness and do not differentiate between types of consanguineous unions. This study addresses this research gap by leveraging nationally representative data from the latest available Demographic and Health Survey in Egypt. This study also controls for key maternal and socioeconomic factors, which allows it to provide a comprehensive understanding of how consanguinity affects child nutritional outcomes across Egypt. A study by Mokhtar & Fattah (2001) Conducted a case-control study in Alexandria focusing on advanced maternal age and risk factors for reproductive losses. They found a significant relationship between consanguinity and prenatal loss and infant deaths. However, their analysis did not specifically control for the place of delivery. Therefore, this study, utilizing data from DHS Egypt and controlling for various socioeconomic factors, amongst which one is a place of delivery, addresses a notable gap in the existing literature. By using a nationally representative dataset and incorporating various child, socioeconomic, and mother-specific variables, this study provides a more nuanced understanding of how consanguinity affects child HAZ scores in Egypt.

1.3. Organization of the Study

The remainder of the study is divided into five chapters. Chapter 2 contains a comprehensive review of the literature. Chapter 3 explains the structure of the data and describes the key variables. Chapter 4 provides a detailed descriptive study of the prevalence of stunting and consanguinity across different socioeconomic categories. The econometric model and the methodology that this study undertakes are explained in Chapter 5. Results and Discussions are provided in chapter 6, while the last chapter, chapter 7, includes conclusions, policy recommendations, and limitations of the study.

Chapter 2

2. Literature Review

The literature review provides a very comprehensive understanding and analysis of the existing literature on the subject of consanguinity and child health, particularly in Egypt. This analysis of the existing literature ranges from the explanation of the methodologies that different studies have undertaken to the scope of the data the studies have exploited. Consanguinity has long been investigated for its different negative impacts, but these studies are limited to certain geographical localities. By reviewing this gap in the literature, it will establish how important it is to exploit a larger and nationally representative dataset to have a more elaborate understanding of the subject.

This chapter will explain the prevalence and patterns of consanguinity in Egypt and what are the regional and socioeconomic variations (Bildirici, 2010). It will then provide empirical evidence of the health consequences of consanguinity, both global and regional, by analyzing studies linking consanguinity to low birth weight, infant and child mortality, and relevance to stunting.

In the last part of the literature review, the methodological approach of all cited literature will be discussed and analyzed. It will explain how this study advanced the methodology by using OLS and a multivariate approach, controlling for important confounders. This will also help us understand the gaps in the literature and the contribution of this study to knowledge.

2.1. Types of Consanguinity

As mentioned earlier, consanguinity refers to the union between two individuals who are related as second cousins or closer and typically share one common ancestor (Bittles A. H., 2001). Consanguinity is then divided into different types based on the blood relation with the partner. The Egyptian Journal of Medical Human Genetics discusses these types, including unions between first cousins (paternal or maternal), unions between second cousins, or unions between individuals related by blood for reasons other than the previously mentioned ones. It is also reported that these consanguineous unions amongst first and second cousins are more prevalent in the context of Egypt (RM Shawky MY El-Awady., 2011). This classification of consanguinity is also explained in a study that demonstrates that consanguineous marriages are categorized on the genetic proximity of partners, with first cousin marriages being more common in Egypt (Hamamy, 2012).

This study also uses the same classification of consanguineous unions for its analysis, exploring the effects of different types of consanguinity on child HAZ scores.

2.2. Prevalence and Patterns of Consanguinity

Consanguinity remains a widespread phenomenon in Egypt, rooted in cultural traditions, family ties, and social norms. The overall prevalence of consanguinity in Egypt is different for different regions and socio-economic backgrounds, but the percentage varies from 20% to 40% (Temtamy & Aglan, 2012).

There are apparent regional and socio-economic variations in the prevalence of consanguinity across Egypt. In Egypt, consanguinity is found to be more prevalent in Upper Egypt and Rural Governorates compared to Cairo and other urbanized areas. Socio-economic factors such as lower female education levels, greater family cohesion, and rural traditions are found to be major contributors to the persistence of consanguineous unions (Mokhtar & Fattah, 2001). Similarly, women from poorer households, as defined by the DHS quintiles, are more likely to end up in a consanguineous union. This is partly due to economic issues, such as reducing the cost of dowry and the belief that marriage within the family provides the necessary security that might be absent in non-consanguineous unions. Consanguinity is also believed to ensure compatibility amongst the partners as they belong to the same family and have similar values (Khayat & Saxena, 2007). In poorer households, lower maternal education and limited access to reproductive healthcare are correlated with higher rates of consanguinity (Hamamy, 2012). Over time, the rates of consanguineous unions have only declined slightly, which reflects the strong resilience of these practices even in the face of modernization and urbanization (Temtamy & Aglan, 2012).

Thus, empirical literature suggests that in Egypt, consanguinity varies significantly with certain factors, such as women's education, age, place of residence, and the cultural and traditional norms followed by the family. One aetiology of consanguinity among the Egyptian population is intergenerational consanguinity. Rabah M. Shawky et al (2011) found that consanguinity between parents increases the likelihood of consanguinity among their offspring.

Higher rates of divorce among Egyptians can also be argued as another important reason that motivates the choice of consanguineous unions. A divorce rate of 37.8 per cent among youth aged between 18 and 29 years means that many marriages become weak and fragile, and families believe

that there will be less probability of divorce between partners of the same family (CAPMAS, 2023).

The Egypt Demographic and Health Survey provides a unique platform to analyze the patterns of consanguinity across different regions and socio-economic factors using a nationally representative dataset. This analysis will also help us identify the at-risk populations for targeted health interventions. Having established the regional and socioeconomic patterns of consanguinity in Egypt, the following section examines how such unions affect child health outcomes both globally and locally.

2.3. Health Consequences of Consanguinity (Global and Regional)

The increased risk of adverse health outcomes in consanguineous unions arises primarily from the expression of autosomal recessive disorders, where both parents may carry the same allele. Offspring of first-cousin unions have a doubling of the risk of congenital disabilities compared to non-consanguineous unions. These may then lead to genetic anomalies, heart defects, and metabolic conditions (Bittles A. H., 2001).

Many studies have also emphasized the socioeconomic and maternal factors that compound the effects of consanguinity on child health. Studies have shown that consanguineous unions in poorer households and lower socioeconomic status may have less access to genetic counselling, prenatal care, and maternal health services, leading to a higher percentage of children with Low Birth Weight (LBW), preterm birth, and congenital anomalies (Modell, 2002).

The age of the mother at first birth or maternal age in general is another critical factor determining the health outcomes of a child. Older maternal age is often linked to **delayed pregnancies** in consanguineous unions, which can increase the risk of birth complications and developmental delays (Temtamy & Aglan, 2012). Like most of the Arab countries where consanguineous unions are common, in Egypt, consanguineous unions are associated with a younger marital age of mothers. This association then leads to maternal anemia, malnutrition, and poorer pregnancy outcomes, which in turn lead to increased risk of stunting and LBW (Nasrullah, 2014).

In the specific case of Egypt, rural women who tend to marry within their extended families are more likely to have LBW infants and stunted children, primarily due to poor nutritional status. A study conducted in Arab countries shows that poor reproductive outcomes are not only due to

genetic factors, but also low maternal education, young maternal age, and limited health services (Tadmouri, 2009). In Norway, which is a non-constrained setting, consanguinity was associated with risks, but these risks were significantly lower when maternal care and socioeconomic status were favorable (Camilla Stoltenberg, 1999).

This evidence from empirical literature makes it evident that the adverse effects of consanguinity on both child and maternal health are not limited to one specific region or the status of the development of the country. We have seen that for most of the Arab population, consanguinity has adverse effects on Child health, not just for genetic reasons, but also because of the culture, traditions, family values, and the overall socioeconomic status. One example from the developed world supports our argument that, despite having fewer constraints on health resources, certain variations in child health can be seen for consanguineous unions with different levels of healthcare access in Norway.

2.4. Other Determinants of Child Nutritional Outcomes

This section of the literature review elaborates key determinants influencing child health in Egypt, drawing upon previous studies. Height for Age Z scores, which are lower than -2.0 Standard Deviations, reflect chronic malnutrition and have long-term impacts on cognitive development and economic productivity (Sharaf, 2019). HAZ scores are widely regarded as a long-term indicator for child health and development because they capture the cumulative effect of chronic undernutrition and adverse health conditions during the early years of life. HAZ scores help reflect sustained nutritional deprivation and socioeconomic disadvantages. Low HAZ scores, indicating stunting, are associated with delayed cognitive development, reduced school performance, and lower productivity (Case, 2005). These factors make studying HAZ scores more interesting in the case of Egypt, where long-term structural inequalities can shape a child's growth trajectory. In this context, HAZ scores offer a meaningful lens through which to assess the lasting impact of factors like consanguineous unions on child wellbeing.

In the previous sections, we have discussed how maternal education and other socioeconomic factors are associated with consanguinity and how it affects child health. Certain other factors, such as place of delivery, dietary diversity and feeding practices, are also significant determinants of child nutritional status. Due to limited data, this study only focuses on the association between a child's place of delivery and HAZ scores. Births occurring in health facilities are more likely to

involve skilled birth attendants who can monitor and manage complications, ensure proper newborn feeding practices and administer early interventions. On the other hand, home deliveries, which are still very prevalent in remote regions of Egypt, are associated with a lack of postnatal support, which increases the risk of malnutrition and infant mortality (WHO, 2020).

Household access to sanitation and clean water also significantly affects child nutritional outcomes, often resulting in higher levels of stunting (El-Zanaty F. a., 2009). In addition, regional disparities in nutritional outcomes also play a significant role. Rural Upper Egypt and Frontier governorates consistently show higher rates of stunting, largely due to poorer infrastructure, lower maternal education and reduced access to health services (UNICEF, 2023).

2.5. Methodological Review of Literature

Existing literature on the topic of consanguinity and its effects on child well-being uses several data sources, such as hospital records and localized community-based surveys. While hospital-based surveys provide detailed clinical records and genetic data, they tend to suffer from selection bias as the population represented is typically urban, relatively affluent and seeking care at tertiary facilities. One such study explores the effects of consanguinity on congenital disorders from data drawn from hospital records, which limits the validity of the study and lacks generalizability to the broader Egyptian Population (RM Shawky MY El-Awady., 2011)

Moreover, studies that do examine consanguinity are often treated as a binary variable (related vs non-related), without distinguishing among the different types of consanguineous unions. This oversimplification obscures potential variations in health outcomes arising from different degrees of genetic relatedness and social practices associated with kinship ties. For Example, one paper on consanguineous marriages and preconception consultation discusses how insufficient classification of consanguinity types limits the understanding of genetic, socioeconomic and policy design in high consanguinity regions such as the Middle East and North Africa (Hamamy, 2012). Another study on consanguinity and its relevance to clinical genetics argues that many epidemiological studies use overly simplistic binary classification of consanguinity and stresses the importance of distinguishing between degrees and types of relatedness when assessing health outcomes (Bittles A. H., 2001).

The existing body of literature underscores the complex interplay between consanguinity, socioeconomic determinants, and child health outcomes in Egypt. While many studies have addressed the adverse effects of consanguinity on child well-being, most of them lack in distinguishing between the types of consanguinity (Hamed, 2020). Moreover, most of the literature on this subject in Egypt uses localized and limited data from hospitals and clinics, which limits the external validity and generalizability of the study. In addition to this, there are also gaps in the literature for the use of key confounders and control variables, such as the place of delivery, as most of the data is taken from hospitals. By building on these gaps in the literature, the study provides a more nuanced and statistically robust analysis of the literature. In doing so, it helps the policy discussions surrounding familial structures, child nutrition and regional health inequalities in Egypt.

2.6. Theoretical Framework

Understanding the determinants of child health, particularly HAZ scores, requires a comprehensive theoretical framework that includes economic, sociocultural and public health perspectives. This section provides the theoretical framework that guides this study, focusing on how different types of consanguinity, maternal education, and other socioeconomic factors influence child health outcomes in Egypt.

2.6.1. Household Bargaining Models and Intra-household Dynamics

The foundational perspective that this study follows is derived from household bargaining models (McElroy & Horney, 1981) This argues that household decisions are based on bargains between different members of the household. This model is particularly of interest in the case of consanguineous unions where traditional kinship ties may influence women's autonomy, resource allocation and healthcare seeking behaviors.

In male-dominated societies like that of Egypt, consanguineous unions often reinforce male-dominated family structures and reduce mothers' decisions. Such norms have direct implications for children's health by affecting the timing and quality of investment in child nutrition. Several studies have shown that women's autonomy in decision making is positively associated with child nutritional outcomes, independent of income (Carlson GJ, 2015).

This theoretical framework will also help us to do our heterogeneity analysis for the interaction between consanguinity and maternal education. Literature suggests that when even mothers are educated, the restrictive nature of highly endogamous families may limit their autonomy and their ability to translate knowledge into positive outcomes for children and themselves (Hobcraft, 1993).

2.6.2. Kinship and Social Structure Theories

The anthropological theories of kinship (Ortner, 1984) Inform the study's focus on consanguinity. These theories provide insight into how family structures and marriage norms are embedded in larger social systems. In our country of analysis, Egypt, consanguineous marriages not only serve reproductive purposes, but also maintain lineage, property and social cohesion. By viewing consanguinity not simply as a biological factor but as a social institution, this study provides a richer, multidimensional understanding of its effects on child growth and development.

2.6.3. Theoretical Framework for the Heterogeneity Analysis

This study is based on the combination of Human Capital Theory and Household Bargaining Theory, and literature from the medical and social epidemiology, to explain the mechanisms behind how consanguinity interacts with maternal education and household wealth status to influence child health outcomes, particularly HAZ scores.

The Human Capital Theory explains that individuals invest in health and education to improve productivity and long-term outcomes (Becker, 1964). Maternal education has been proven to enhance child health outcomes because of better awareness of childbearing practices, breastfeeding and effective nutrition. However, in settings where cultural traditions such as consanguineous marriages prevail, the effect of education may be mediated by intra-household power dynamics or limited autonomy. In consanguineous unions, the returns to maternal education may be constrained. Thus, maternal education may not uniformly translate to better child health outcomes across all marital types (Cleland J, 2010).

2.6.4. Social Determinants of Health Framework

This study is also grounded in the SDH framework popularized by the WHO (2008), which argues that health outcomes are primarily affected by the conditions in which people are born, grow, live, work and age. These determinants are economic status, education, social norms and the healthcare

system. In the context of Egypt, where structural inequalities persist, this framework helps contextualize how factors like maternal education, regional disparities, and healthcare access mediate the effects of consanguineous union on child health. Empirical literature indicates disparities among child health and education in Sub-Saharan and North African contexts which can also be true in the case of Egypt.

In short, this study is theoretically anchored in multiple frameworks i.e. Human Capital Theory, Household Bargaining Models, Social Determinants of Health and Kinship Theory. These frameworks collectively explain the complex relationships observed between consanguinity, maternal education and regional background, and child HAZ scores in Egypt. The study also offers nuanced understanding of why certain children are more vulnerable to stunting and how these vulnerabilities intersect with social norms and household structures.

Chapter 3

3. Data

3.1. Data Source and Sampling

The study uses the latest available Demographic and Health Survey for Egypt. It is a nationally representative dataset which includes all the urban and rural regions, e.g. Upper Rural, Lower Rural, Frontier and Urban Governorates of Egypt. Several rounds of DHS have been conducted in Egypt, but for our analysis, we are using data from the survey conducted in 2014, which is the latest available nationally representative dataset from DHS. The 2014 DHS survey of Egypt sampled 29,471 households, where 21,762 women were interviewed. The response rate was over 99 per cent for both the households and eligible women. It included all the 27 governorates of Egypt, making it nationally representative. The key modules that are included in this survey are on Fertility, family planning, maternal and child health, domestic violence and consanguinity. In addition, it also includes children's anthropometric data such as Height for Age Z scores, Weight for Age Z scores collected from children under 5 years (DHS, 2014).

3.1.1. Sampling Strategy and Weights

The 2014 Egypt DHS employed a stratified two-stage cluster sampling to ensure national representativeness across all 27 governorates. In the first stage of sampling, a sample of enumeration areas (EAs) was selected from the national census using probability proportional to size (PPS). In the second stage of the sampling, households were systematically selected within the EAs. This approach ensured balanced representation across urban and rural strata, as well as different socioeconomic and geographic contexts. The use of such a stratified sample design helps minimize sampling bias and enhances the reliability of regional and subgroup analyses.

3.2. Data Composition and Structure

The Egypt Demographic and Health Survey is a cross-sectional dataset collected at a single point in time. This dataset provides a snapshot of Egypt's Population, health and socioeconomic conditions. The primary respondents are women aged 15-49 years for the children's questionnaire. The children dataset includes information on children's date of birth, sex, survival status, and breastfeeding. In addition, it also contains information on Anthropometry, Vaccination Status and Nutritional Intake, etc.

Estimations for this study are performed using the DHS survey conducted in 2014. The key variables used in the study are children's HAZ scores, mother's education, geographical location, place of delivery, sex of the child, age of the mother at birth and the dependent variable, which explains the relationship between the parents of the child.

In preparing the final dataset for analysis, biologically implausible anthropometric values were excluded following WHO guidelines (e.g. HAZ scores below -6 or above +6 SDs). Observations with missing values on key variables were excluded through listwise deletion. The study was then conducted for all the children whose HAZ scores were reported, allowing the total observations to be around 13000 children.

3.3. Variables

3.3.1. Specification of the Variables

The sample includes data on children aged 0 to 59 months and their mothers. The dependent variable of interest is height for age z-scores, which were available for children who were selected for measurement. Moreover, this variable had to be divided by 100 in order to correct the scale. According to the World Health Organization, children with a HAZ score lower than -2.0 standard deviations are considered to be suffering from stunted growth (Vishwarkarma, 2021) . On the other hand, the main independent variable is consanguinity, which is a categorical variable taking five values, 0 for no blood relation between the parents of the child, 1 for paternal first cousin unions, 2 for maternal first cousin unions, 3 for other relation with paternal relatives, and 4 for any other relation with maternal relatives.

3.3.2. Explanation of Predictor Variables

The other set of variables includes both mother-specific and child-specific covariates. The first predictor variable is the sex of the child; this is a binary variable coded as 0 for females and 1 for males. The variable of region is categorized into four categories, i.e. Urban Egypt, Lower Egypt Rural, Upper Egypt Rural and Frontier. A detailed explanation of this variable will be given in a later section. The model also accounts for the wealth status, which is categorized into the poorest, poorer, middle, richer and richest. This categorization of households is not solely based on the income level but also on the overall ownership of assets such as refrigerators, TV, radio, etc. Another significant determinant of child well-being is maternal education. This factor in our study

has been categorized into three categories, i.e. mothers with a maximum of primary education coded as 0, mothers with education level as high as secondary, coded as 1, and the last category with mothers' education level higher than secondary coded as 2. We have used this categorization for our OLS model (Gakidou, 2010). However, for our descriptive analysis we have used two variables i.e. mothers with at least primary education or higher and the second variable is mothers with at least secondary education or higher. This has been done to adjust for higher number of observations for mothers with secondary education which could cause observation bias. Unlike previous studies, this study also accounts for the place of delivery of the child. This variable that explains the place of delivery is coded as a binary variable that takes the value 0 if a child is born at home and takes the value 1 if the child is born at a private or public health facility that can at least provide prenatal and postnatal care (Vishwarkarma, 2021).

The last variable that the model controls for is the age of the mother at birth. The significance of this variable has been explained in the literature review. The variable that controls for the age of the mother at the time of the birth of the child is a continuous variable that ranges from 14 years old to 49 years old. Extreme values of maternal age at birth, such as 14-18 or 38 plus, can result in significant health adversities for the child. The inclusion of this variable controls all the effects that may be caused by the age of the mother on Child HAZ scores.

Table 1 Descriptive Statistics of Socioeconomic Characteristics

Variable	Observations	Mean	Standard Deviation	Min	Max
Wealth Status	13,519	3.07	1.41	1	5
Male	13,519	0.514	0.500	0	1
Mothers with at least Primary Education	13,519	0.83	0.38	0	1
Mothers with Secondary or Higher Education	13,519	0.74	0.44	0	1
Institutional Delivery	13,519	0.875	0.330	0	1
Mother's Age at Birth	13,519	26.78	5.50	14	48

Note: *This table presents descriptive statis for the key variables used in the analysis. "Wealth Status is based on DHS household wealth quintiles ranging from 1 (Poorest) to 5 (Richest). "Male" is a binary variable equal to 1 if child is Male and 0 if female. Mothers with Primary Education and Mothers with Secondary or Higher Education are binary outcomes equal to 1 if mother has attained at least primary or secondary schooling, respectively. "Institutional Delivery" equals 1 if the child was delivered in a health facility. "Mother's Age at Birth" is measured in completed years at the time of childbirth. All variables are based on 13,519 observations.*

Table 1 represents the household's economic standing. The mean of 3.07 for the wealth status suggests that, on average, households in the over sample fall around the middle wealth quantile. A standard deviation of 1.41 shows a moderate spread across wealth quantiles. This distribution appears balanced and includes a diverse population in terms of wealth. These characteristics make this variable a good covariate for our analysis.

Mothers with at least Primary Education is a binary variable indicating whether the mother has attained primary education or higher. The variable takes the value 1 if mother has at least primary education and 0 otherwise. In our sample 83% percent of the mothers have at least primary education or above. The second variable for mothers' education is coded as 1 if mother has attained secondary or above and 0 otherwise. In our sample about 74 percent of mothers have secondary or higher education. The standard deviation of both these variables suggests some variability in the maternal education, but not extreme. These binary variables are well-suited for analysis where we want to examine the effect of education on HAZ scores.

From this table, we can also see that the mean for the Sex of the Child variable is 0.514, which means that 51.4 per cent of children are males, which is a very even gender split, as expected in population-level data. For the variable of Place of Delivery, we can see that the mean is 0.87, which means that 87.5 per cent of births occurred in a health facility. This high institutional delivery rate may reflect urban bias. The mean of Mothers' age at the time of birth of the child is 26.78 years. This number is typical of lower-middle-income countries. The standard deviation of 5.50 suggests a fairly broad distribution of the variable.

From the overview of descriptive statistics of the sample used in the analysis, we see that an average household in the dataset belongs to the middle wealth quantile, indicating a balanced distribution across socioeconomic groups. Overall, these descriptive insights set the foundation for the subsequent empirical analysis by contextualizing the key demographic and socioeconomic variables.

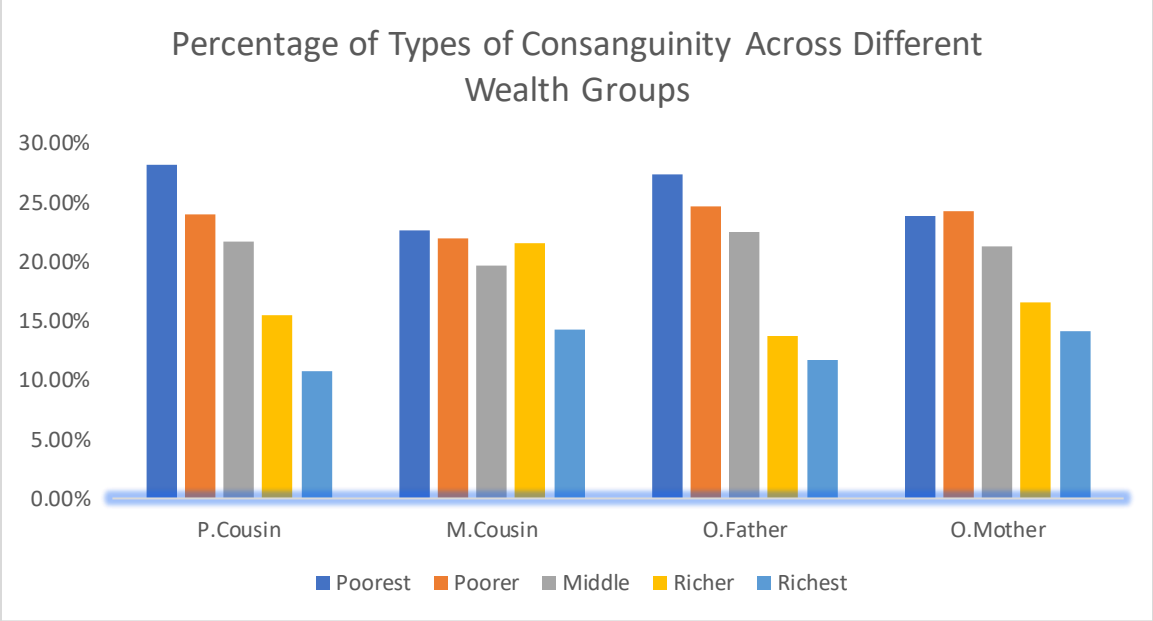
Chapter 4

4. Descriptive Statistics

4.1. Prevalence of Consanguinity across wealth groups

This section of the descriptive statistics explores the prevalence of different types of consanguinity across different wealth groups. It provides us with insights into how consanguinity is associated with socioeconomic factors.

Figure 1 This figure provides the percentage of consanguineous unions across the wealth status.



***Source**: Author's Own calculations from DHS Egypt 2014.*

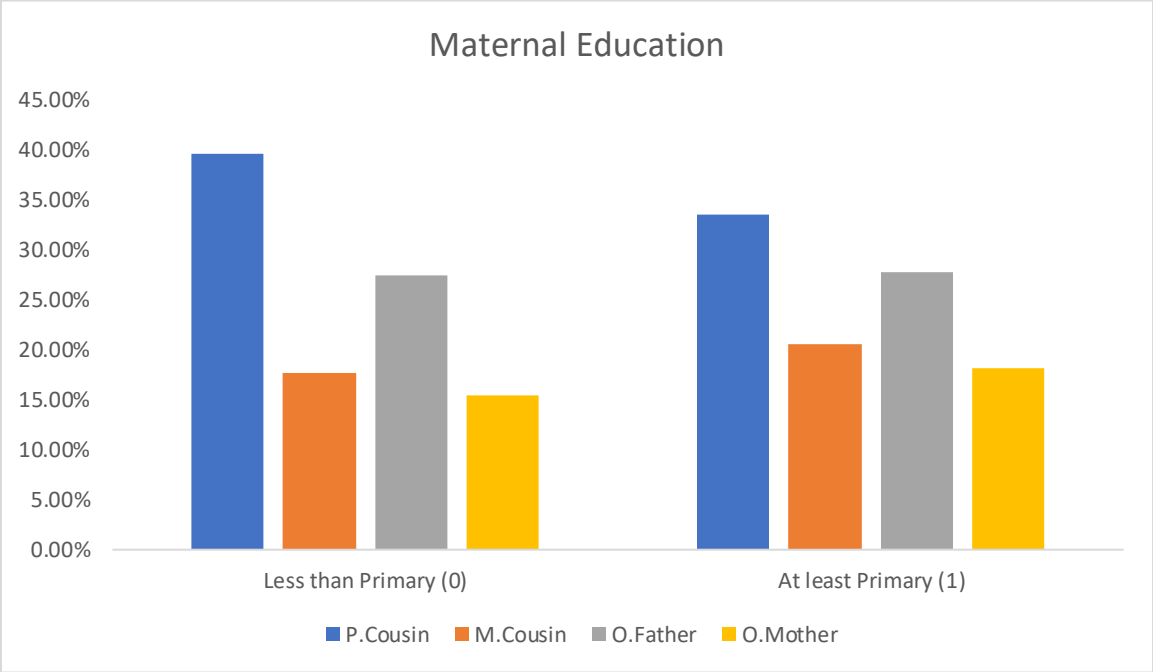
Figure 1 presents the prevalence of types of consanguinity, i.e. paternal first cousin, maternal first cousin, other relations with father or mother across different wealth groups, i.e. the poorest, poorer, middle, richer and richest. From this figure, we can see that for almost all types of consanguinity, we see a higher percentage amongst the poorest. This percentage ranges from around 28 per cent for paternal first cousins to the lowest percentage for maternal first cousins, which is around 23 per cent. Another important takeaway from this figure is that as we move up the ladder of wealth status, we see a decline in the percentages of consanguineous marriages for all types. This pattern is very much in line with the argument that consanguineous unions are culturally embedded

practices, and they are significantly more prevalent among lower-income households. (Hussein M. M., 2022).

4.2. Prevalence of Consanguinity across different levels of Education

It is also important to understand the prevalence of consanguinity across different levels of education. Figures 2 and 3 provide details about the prevalence of consanguinity across different education levels of mothers. Figures 2 and 3 reveal a consistent pattern in the relationship between maternal education and consanguineous union types. Across both thresholds – primary and secondary education- mothers with higher education levels show a lower proportion of close consanguineous unions, particularly paternal first cousin marriages and a slight increase in marriages to more distantly related kin.

Figure 2 Prevalence of Consanguinity across different levels of mothers' education

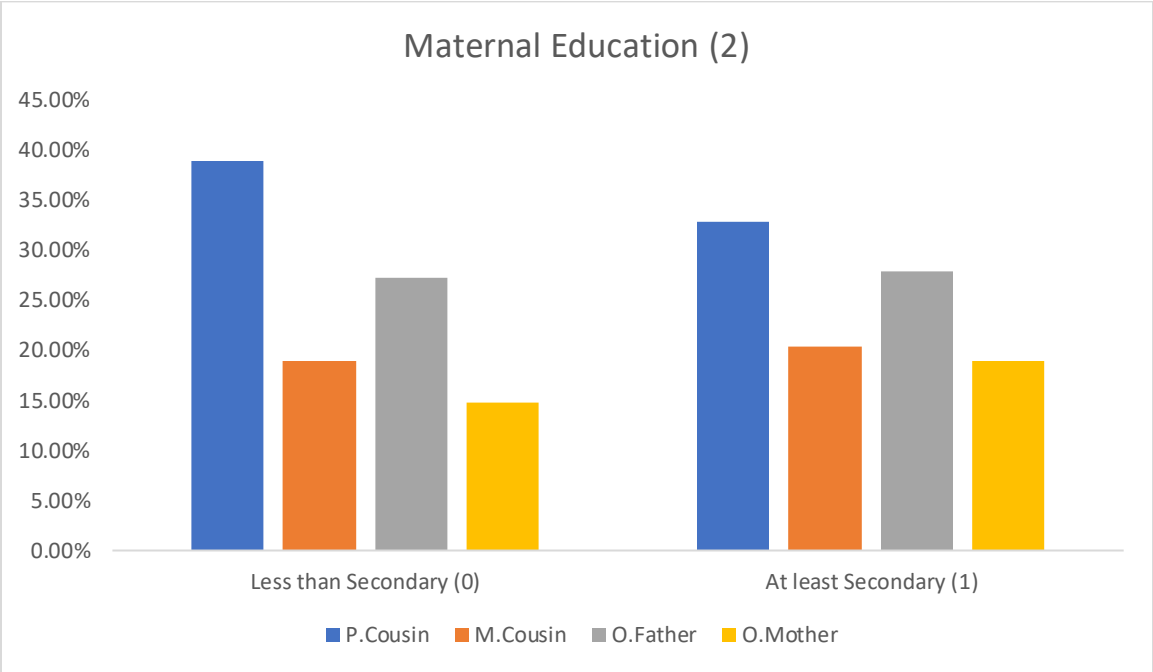


Source: *Author's Own calculations from DHS Egypt 2014.*

Paternal first cousin marriages are the most prevalent form of consanguinity among all education groups. However, their share significantly declines with increased maternal education. Among mothers with less than primary education, 39.5 percent of consanguineous unions are with paternal first cousins, compared to 33.5 percent among those with at least primary education. A similar trend appears in the Figure 2 where 39 percent of consanguineous unions are with paternal cousins

among mothers with less than secondary education, versus only 32.8 percent among those with at least secondary education. This decline suggests that education may play a protective role by reducing the prevalence of the closest kin unions, which are associated with elevated risk of genetic disorders

Figure 3 Maternal Education and Prevalence of different types of consanguinities



Source: *Author's Own calculations from DHS Egypt 2014.*

In contrast, maternal first cousin marriages increase modestly with education. Among those with at least primary and secondary education, maternal cousin unions account for 20.6 and 20.4 percent, respectively, compared to 17.6 and 19 percent among less educated mothers. Though the difference is relatively small, it may reflect changing dynamics in marriage negotiations and kin preferences, with educated women having potentially more say or access to a broader pool of acceptable relatives, including from the maternal side.

The percentages of consanguineous unions are lower for women with higher education because they tend to have greater autonomy, enabling them to make independent life choices, including the selection of marriage patterns. This autonomy reduces the likelihood of adhering to traditional familial expectations, such as marrying within the extended family (Elsayed, 2011). Also, educational environments often expose women to broader social circles beyond their immediate

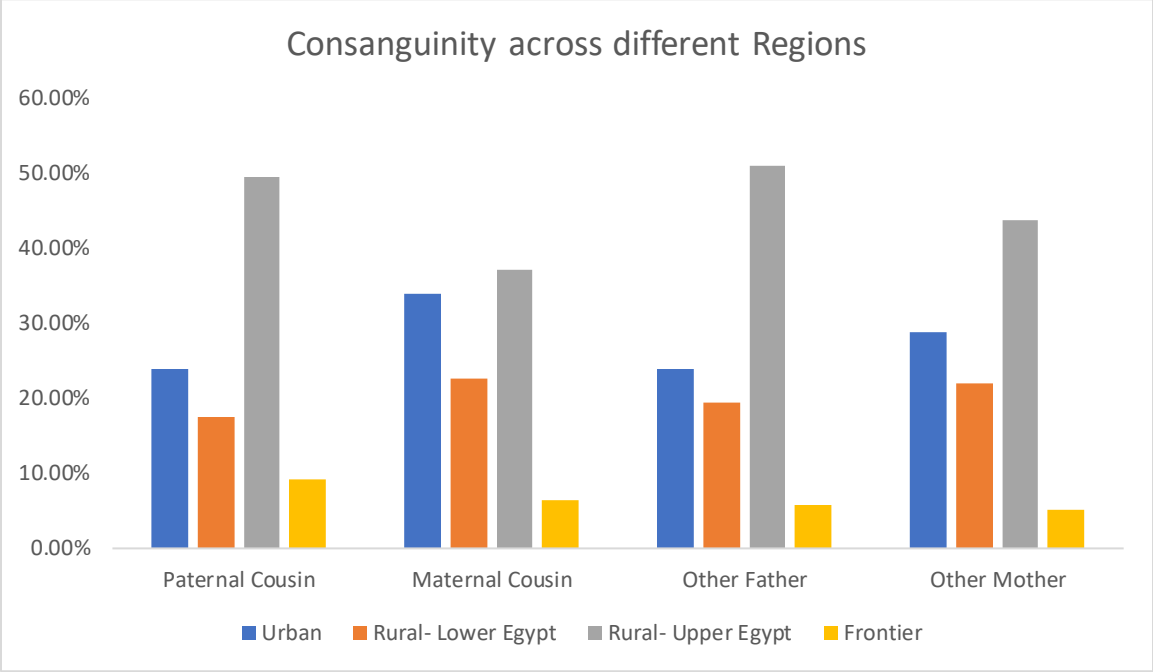
family and community. This exposure increases the chance of forming relationships outside traditional family structures, thereby reducing the prevalence of cousin marriages (Hussein, Gaafary, & Wassif, 2022). These findings under the role of education in shaping marriage patterns in Egypt highlight how increased educational attainment among women contributes to a decline in consanguineous marriages.

4.3. Prevalence of Consanguinity by Regions

Now that we have studied how consanguinity differs across different levels of education and wealth status, it is important to understand whether consanguinity is more prevalent in certain regions of Egypt. This relationship is illustrated in Figure 4. Upper Egypt – Rural is one of the least economically developed regions, which shows the highest rates of consanguinity. This region suffers from widespread poverty, poor infrastructure and lower female literacy rates compared to national averages (UNDP, 2021). Limited access to healthcare services and fewer employment opportunities for women further compound the persistence of early and consanguineous unions (CAPMAS, 2019). Lower Egypt – Rural, which comprises the Northern part of the country, displays moderate levels of consanguinity with a maximum of around 20 per cent for unions amongst maternal relatives. Although this region has seen some development, there are certain gaps in infrastructure, particularly in rural districts where access to quality schooling and healthcare is limited (World Bank, 2020). Urban Governorates such as Cairo and Alexandria report considerably lower levels of consanguinity, particularly for paternal first cousin unions. These cities benefit from a very developed infrastructure, broader educational access, and better health awareness programs (Kandil, 2017). The frontier governorates of Sinai and the Red Sea region consistently show the lowest consanguinity levels across all consanguinity types. This could be attributed to both the sparse population and possibly underreporting due to weaker statistical coverage. These areas also face distinct development challenges, including geographic isolation and lack of basic services (OECD, 2022).

These findings indicate that the prevalence of consanguineous marriages is closely linked to regional socioeconomic inequality. Areas with poorer infrastructure, such as Upper Egypt – Rural, continuously report the highest levels of consanguinity. In contrast, Urban governorates where investment in human capital is higher and societal structures are more fragmented, show lower rates.

Figure 4 Percentage of different types of consanguinities for different regions of Egypt



Source: *Author's Own calculations from DHS Egypt 2014.*

What we conclude from this descriptive analysis of the prevalence of consanguinity is that consanguinity is significantly affected by different socioeconomic factors. The key takeaways from all these figures are that as we move up the ladder of wealth status and education level, the percentage of consanguineous unions decreases. This result is mainly derived from educated and richer women having more financial and decision-making autonomy and not making their decisions merely because of culture or traditions. In rural areas, where women are less educated and not financially well off, we see higher percentages of consanguineous unions, especially where the woman marries her paternal first cousin. Given the poor infrastructure and underdevelopment within rural populations, we can see a higher prevalence of consanguineous marriages.

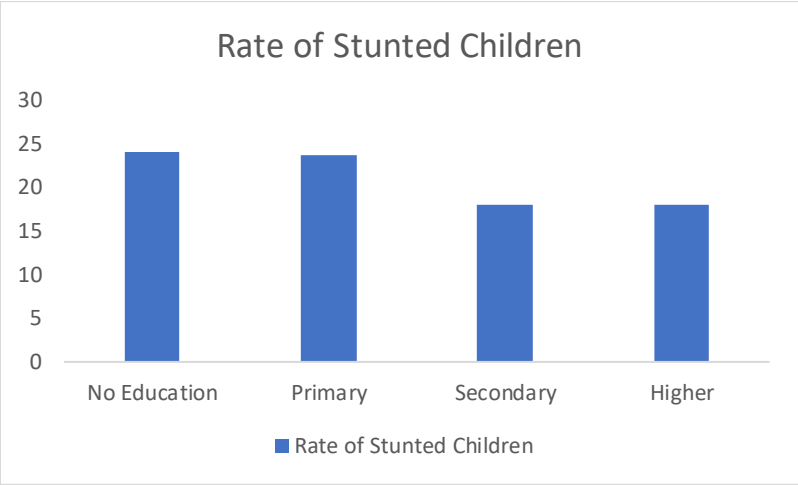
4.4. Prevalence of Stunting

4.4.1. Incidence of Stunting by Mother's Education

Figure 5 illustrates the prevalence of stunting among children categorized by their mothers' education attainment. The data indicates a clear inverse relationship between maternal education level and the rate of stunted children. Specifically, the rate of stunted children among women with no education is the highest at 25 percent. This rates then drops slightly for women with primary

education and drops further for women with secondary and higher education. What we can infer from these statistics is that the rate of stunted children drops significantly as the levels of maternal education increase.

Figure 5 Rate of Stunted Children by Mothers' Education.

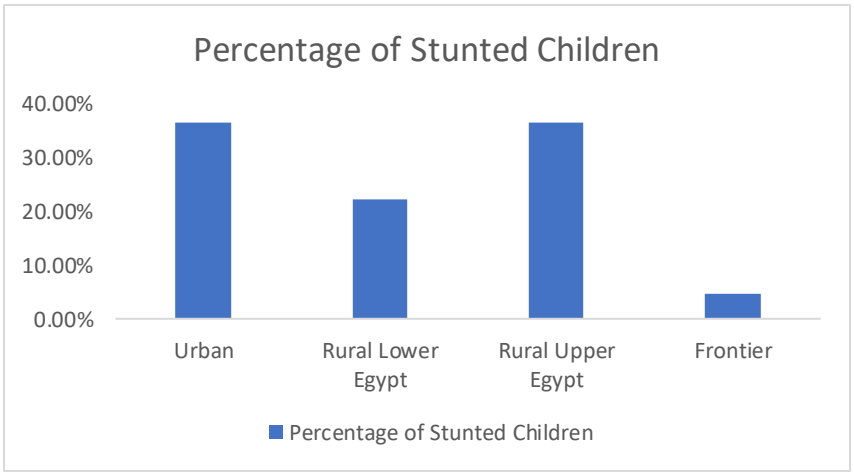


Source: *Author's Own calculations from DHS Egypt 2014.*

4.4.2. Regional variation in Stunting

The purpose of analyzing the prevalence of stunted children across different regions in Egypt is the same as for the prevalence of consanguinity. We can see in Figure 6, in line with what we had seen for consanguinity, that the highest percentage of stunted children are in the Rural – Upper Egypt region.

Figure 6 Different geographical areas of Egypt and the prevalence of stunting.



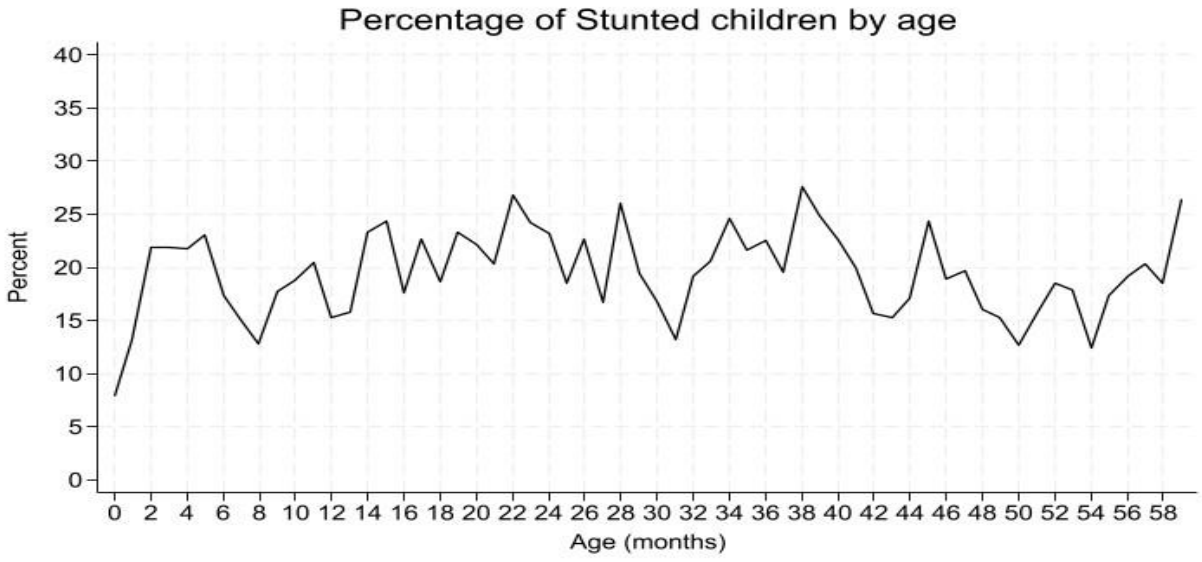
Source: *Author's Own calculations from DHS Egypt 2014.*

As mentioned earlier, this region is one of the least developed in Egypt with poor infrastructure, healthcare services and quality of education. For other parts of Egypt that are more developed as compared to Rural Egypt, we see lower percentages of stunted children. These figures make it very interesting to see the association between consanguinity and the well-being of children.

4.5. Percentage of Stunted Children by Age

The graph in Figure 7 shows the percentage of stunted children across different ages (in months) in Egypt. What we can see from the graph is that stunting begins to rise sharply after birth and becomes significantly visible after 6 months of age. This timing coincides with the weaning period, where children are introduced to complementary foods, often in conditions of poor sanitation and inadequate dietary quality (UNICEF, 2021). The prevalence of stunting remains high and fluctuates between 18 and 25 per cent from around 12 to 36 months. This period is known globally as the "window of vulnerability", where poor diet, repeated infections, and inadequate caregiving contribute to growth faltering (Victora C. G., 2008). After 36 months, the stunting rates show a slight decline and become more stable, although still high compared to birth. By this time, surviving children might have adapted somewhat, or severe cases of undernutrition might have resulted in mortality, thereby affecting the distribution (a phenomenon known as survivor bias.

Figure 7 Percentage of Stunted children (SD <2.0) by age groups (in months) in Egypt



Source: *Author's Own calculations from DHS Egypt 2014.*

In the descriptive analysis, we observed that the prevalence of consanguinity was significantly associated with key socioeconomic factors such as wealth status, maternal education, and urban-rural residence. Consanguineous marriages were more common among families with lower wealth status, lower levels of maternal education, and among rural populations. Parallel to this, the prevalence of child stunting was also higher among the same disadvantaged groups. Furthermore, the age-specific distribution of growth faltering becomes particularly pronounced after 6 months of age, aligning with the critical periods of child development. These descriptive patterns suggest that both consanguinity and adverse socio-economic conditions may jointly contribute to the higher prevalence of stunting observed in the population.

The descriptive trends also suggest that socioeconomic disadvantages and limited maternal education may interact with traditional marriage practices to produce adverse child health outcomes. While a stronger association and causality cannot be established at this point, these relationships allow for deeper investigation through a fixed-effect multivariate OLS regression analysis by estimating the effects of consanguinity on child HAZ scores while controlling for key confounding variables such as wealth, education, sex of the child, place of delivery, and region. By doing so, it provides a more rigorous assessment of whether the observed patterns persist when accounting for potential sources of bias.

Chapter 5

5. Methodology

5.1. Econometric Model

The study uses Ordinary Least Squares regression to estimate the relationship between consanguinity and Height for Age Z Scores. The OLS method is well-suited for identifying conditional associations between a key exposure and outcomes of interest while controlling relevant covariates such as socioeconomic status, maternal education, and geographic location. OLS is a commonly used approach in population and development economics for examining outcomes like stunting and child mortality, especially in contexts where randomized experimental designs are not feasible. It allows for the estimation of linear relationships between variables and produces coefficients that are straightforward to interpret as the average effect of the independent variable on the dependent variable, conditional on other covariates (Woolridge, 2010).

We can find several justifications from the literature where OLS has been used in subjects similar to this study. A study done by Black & Bittles (2010), when they investigated the relationship between consanguinity and complex diseases, used regression analysis, concluding that first-cousin marriages were associated with a higher risk of neonatal and infant mortality. Similarly, another study found significant associations between consanguinity and increased risk of genetic disorders and developmental delays using regression analysis in the health survey data across Arab countries (Hamamy H. A.-S., 2011).

While OLS is useful for estimating associations, it does not address endogeneity arising from unobserved variables or reverse causality. For instance, certain unmeasured cultural factors may influence both consanguineous marriages and child-rearing practices. These limitations are acknowledged, and the findings are interpreted as associational rather than causal, consistent with prior literature (Victora C. G., 2008). Nevertheless, OLS serves as an important foundation for understanding the socioeconomic and demographic patterns underlying child malnutrition, and the results can guide future research using quasi-experimental or longitudinal methods.

These studies reinforce the use of OLS as a valid first-stop method for examining observational associations, particularly when datasets are cross-sectional and contain rich demographic and socio-economic information.

5.2. Ordinary Least Squares

OLS is used to regress the continuous outcome variable Height for Age Z Scores on consanguinity and various other control variables. This model is used to see the correlation between different kinds of consanguinity and HAZ scores while it controls other possible variables that might be correlated with HAZ scores. OLS is a good option when the dependent variable is continuous because it provides unbiased and efficient estimates under standard assumptions. Under the Gauss-Markov assumptions, OLS provides the most efficient (minimum variance) linear estimates (Gujarati, 2009). The OLS model that the study uses is given as:

$$\mathbf{HAZ_i = \beta_0 + \beta_1 Consaguinity + Xi'\beta + \varepsilon_i}$$

In the above OLS model, HAZ is the outcome variable, which is Height for Age Z scores for the children in our sample. $\boldsymbol{\beta_1}$ is a categorical variable that explains the relation of the respondent with her husband, i.e. type of consanguinity. $\mathbf{X_i}$ is a **vector of control variables**, including the wealth status of the household, sex of the child, the place of delivery of the child whether it is in hospital coded as 1 or at home coded as 0. Other covariates are mother education, different geographic regions and mothers' age at time of child's birth. β is a corresponding vector of coefficients.

5.2.1. Validity of the OLS Model

To see how well our OLS model is, it has to follow certain assumptions. These assumptions are that the model is Linear and Unbiased. To check the validity of the model, the study applied a test called the Variance Inflation Factor, which measures how much of the variance of regression coefficients is inflated due to multicollinearity within other independent variables in the model. For our model, the value of VIF is well below the threshold, which means that the model is free of multicollinearity. The results of the model are provided in Appendix A.

5.2.2. Ramsey RESET Test

The Ramsey Test checks if additional nonlinear combinations of the explanatory variables can significantly improve the model. If they do, it suggests that the original model is misspecified. A well specified model suggests ensures that estimates are unbiased and consistent. It is particularly useful in OLS regressions, where omitted variable bias can lead to misleading results (Ramsey, 1969). The results of this test are provided in Appendix A.

5.3. Choice of Control Variables

The covariates that have been mentioned in the previous section account for socio-economic, demographic, and biological factors that are well-established determinants of child health. In this section, they will justify the choices that they study makes.

5.3.1. Sex of Child

Biological differences between male and female children can influence growth outcomes. Studies have consistently found that male children are at a slightly higher risk of stunting and mortality compared to females, particularly in resource-constrained settings (Wamani, 2007). Controlling for the sex of the child helps ensure that observed differences in child health are not confounded by biological risk factors.

5.3.2. Mother's Age at Birth

Younger maternal age at birth is associated with a higher risk of malnutrition and poor health outcomes. Adolescent mothers often have lower nutritional reserves, reduced access to healthcare, and fewer parenting skills (Fall, 2015). Including the mother's age at the time of the birth of the child, controls intergenerational effects and maternal biological readiness for childbearing.

5.3.3. Wealth Status

Household wealth status is one of the most important control variables in the model. It is understood from empirical literature that women who belong to poorer households tend to have less knowledge about childbearing practices, prenatal and postnatal care and information about proper nutrition and breastfeeding practices. Less awareness can lead to nutritional deficiencies, which can significantly affect child growth, reflected in HAZ and WAZ scores (Yount K. M., 2004) Thus, it is important to control for household wealth status as it will provide insights into how stunting differs across wealth groups. Also, by controlling wealth status, we isolate the effect of the primary variable of interest, i.e. consanguinity.

5.3.4. Regional fixed effects

To account for unobserved heterogeneity across different geographical areas in Egypt, the regression model includes region fixed effects. Region fixed effects control all the time-invariant regional characteristics that might influence the outcome variable, ensuring that comparisons are

made within regions rather than across them (Woolridge, 2010). Egypt exhibits substantial variation across different regions in terms of access to clean water, electricity and sanitation, educational opportunities and the quality of healthcare services. Different regions of Egypt may also see different policy implementations and governance efficiency (Mohamed & Ashraf, 2024). These differences can systematically influence child health and nutritional outcomes independent of individual or household-level characteristics. This approach helps isolate the effect of individual and household-level variables on child health by holding the regional context constant. Region fixed effects ensures that comparisons are not made between, for example, Rural Upper Egypt and Urban Governorates, but rather between households within the same regional context. As such, any remaining variation in outcomes associated with consanguinity is more likely to reflect differences in intra-household dynamics, such as women's autonomy or health-seeking behavior, which may vary even among families living in the same region. The econometric model after the inclusion of region fixed effects is given as:

$$\mathbf{HAZ_{ij} = \beta_0 + \beta_1 Consanguinity_i + X_{ij}'\beta + \delta_r + \varepsilon_{ij}}$$

In this econometric model, $\mathbf{Y_{ij}}$ is the outcome variable (HAZ scores) for child ***i*** in region ***r***. Consanguinity is the indicator for consanguineous marriage, **Xij** is the vector of control variables for individual and household level factors for child ***i*** in region ***j***. $\boldsymbol{\delta_r}$ captures the fixed effects for region **r,** and $\boldsymbol{\varepsilon_{ij}}$ is the error term. This ensures that comparisons of effects like consanguinity or maternal education are not confounded by whether the child is from Upper Egypt versus Urban Governorates.

5.3.5. Institutional Delivery

The question of whether the child was born in an institute or at home is of great importance. Children born in institutions such as hospitals and basic health units are more likely to have received prenatal and postnatal care. These children are also at a lower risk of neonatal mortality. A study analyzing EDHS from 1995 to 2014 found that the proportion of women delivering in health facilities rose from 35% to 87%. This shift contributed significant reductions in maternal and neonatal mortality (Pugliese-Garcia, 2020). Thus, adding the variable of institutional delivery controls health issues and risks associated with the place of delivery.

5.3.6. Mother Education

Mother's education is another important factor that can have a strong influence on the HAZ scores of children. Mothers with higher education are expected to have a better understanding of childbearing practices. These mothers are also well-informed about proper nutrition, healthcare practices, and hygiene, leading to better outcomes for their children. Education also tends to improve economic opportunities and overall household well-being, which can translate into improved food security and health care access (Victora C. G., 2008).

These points, supported by a range of empirical studies, provide a clear justification for the choice of control variables and help set the stage for a thorough analysis of the research question. Together, these control variables are essential for mitigating omitted variable bias and ensuring that the estimated associations more accurately reflect the effects of consanguinity on child Height for Age Z scores.

5.4. Heterogeneity Analysis

To investigate whether the effect of consanguinity on children's HAZ scores varies across socioeconomic groups, the study conducts heterogeneity analysis using interaction terms in the regression model. Specifically, the study interacts with maternal education and wealth status to examine whether these factors moderate the association between children's HAZ scores. This approach helps identify whether consanguinity is more pronounced among certain sub-populations. All the models are controlled for relevant covariates, and robust standard errors were used to account for heteroskedasticity.

1. $$HAZ_{ij} = \beta_0 + \beta_1 Consanguinity_i + \beta_2 Education_i + \beta_3 (Consanguinity_i \times Education_i) + X_{ij}' \beta + r\sum \delta_r Region_r + \varepsilon_{ij}$$
2. $$HAZ_{ij} = \beta_0 + \beta_1 Consanguinityi + \beta_2 Education_i + \beta_3 (Consanguinity_i \times Wealth\ Status_i) + X_{ij}'\beta + r\sum \delta_r Region_r + \varepsilon_{ij}$$

Equation 1 and 2 are used to account for heterogeneity analysis by introducing an interaction term. In equation 1 β_1 is the coefficient of the effect of consanguinity on child HAZ when maternal education is primary or less than primary which is the reference category. β_2 is the effect of maternal education on HAZ scores when consanguinity is 0. β_3 is the interaction term which

explains how the effect of consanguinity changes with maternal education. $\mathbf{X_{ij}}$ is the vector of control variables, $\mathbf{r\sum\delta_r Region_r}$ are the region fixed effects while $\boldsymbol{\varepsilon_{ij}}$ is the error term.

In the second equation the overall explanation is the same as equation 1, however here the interaction term is different. $\boldsymbol{\beta_3}$ explains how the effect of consanguinity on HAZ scores changes with wealth status. These results were further visualized using marginal effects plots derived from interaction models to facilitate the interpretation of subgroup differences.

5.5. Use of Robust Standard Errors

In all regression models, robust standard errors are used to correct any potential heteroskedasticity. Robust standard errors provide more reliable statistical inference by adjusting the estimated standard errors of the coefficients, ensuring that the significance levels are not biased due to heteroskedasticity (White, 1980). This adjustment is particularly important in this study as household-level data may have an unequal variance in error terms, particularly across wealth quintiles. For example, poorer households or those in rural areas may have more variability in unobserved factors affecting child health, leading to heteroskedasticity. By using robust standard errors, this analysis accounts for this heterogeneity and ensures that the reported p-values and confidence intervals for the coefficients are valid even in the presence of noise.

Chapter 6

6. Results and Discussion

6.1. Results of OLS Estimation

In the first section of this chapter, the study provides the coefficient plots for the main variable of interest, i.e. consanguinity, and the association between HAZ scores and other socioeconomic factors specific to the child and the mother. Figure 8 illustrates the estimated effect of different types of consanguineous relationships on Height for Age Z scores. Each dot represents the point estimate of the effect of that specific relationship (e.g., "Paternal First Cousin"). The horizontal lines show the confidence interval, while the vertical dashed line at zero is the null effect line. If a confidence interval crosses this line, it suggests that the effect is not statistically significant at conventional levels. What we can see from the figure is that all point estimates are negative, suggesting that children born from a consanguineous union tend to have lower HAZ scores, indicating worse nutritional status or stunting. Significant effects can be seen for Paternal First Cousins marriages, where the coefficient is almost -0.122. This means that children born to mothers who are in a paternal first cousin union have, on average, 0.122 lower HAZ scores compared to the reference group, i.e. not related, holding all other variables constant. Almost all of the confidence intervals, except for the category of any "other relative mother", do not cross the zero line, which implies that these relationships are statistically significant.

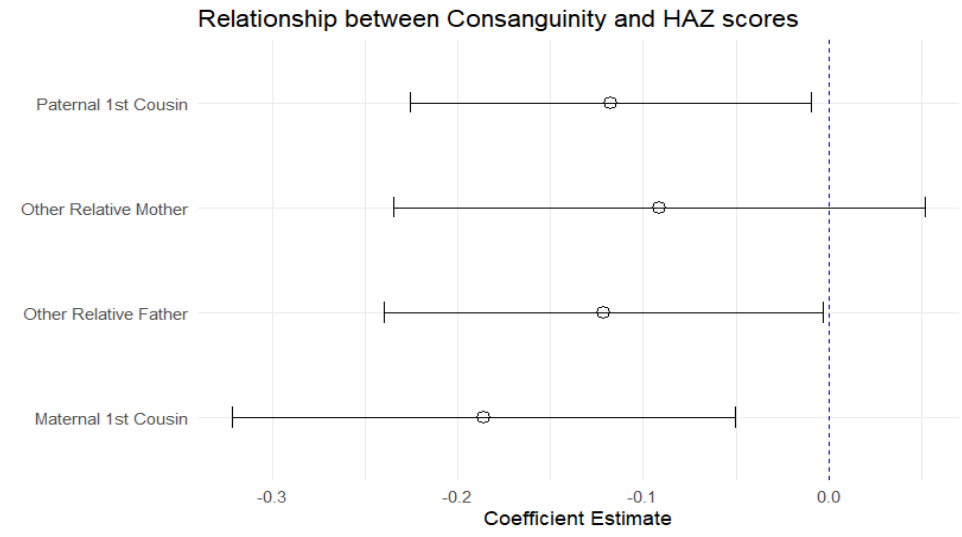


Figure 8. OLS coefficients of the regression of HAZ scores on types of Consanguinity

6.2. Relationship between HAZ scores, Mother and Child Related Characteristics

From Table 2, we can see a positive relationship between HAZ scores and the place of delivery. The coefficient for place of delivery is around 0.110, which means that children born in health facilities tend to have higher HAZ scores than those born in houses. This suggests better birth environments may support early growth; this result is statistically significant at 5 per cent.

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. *Children from paternal and maternal first cousin unions have significantly lower HAZ scores, indicating poorer growth outcomes linked to consanguinity. Maternal Age, maternal education, and institutional delivery are positively associated with better HAZ scores. Male children and those in the Rural Upper region have lower HAZ. Wealth effects vary, with only the middle wealth group showing a positive association. Results are based on 13,516 observations.*

VARIABLES	HAZ1
Paternal First Cousin	-0.122**
	(0.0534)
Maternal First Cousin	-0.190***
	(0.0703)
Any other relation with paternal relative	-0.123**
	(0.0571)
Any other relation with maternal relative	-0.0902
	(0.0699)
Mother age at Birth	0.00923***
	(0.00316)
Wealth Status: Poorer	0.0681
	(0.0538)
Middle	0.138**
	(0.0559)
Richer	-0.0281
	(0.0654)
Richest	-0.0672
	(0.0766)
Sex of the Child: Male	-0.168***
	(0.0340)
Mother Education	0.103***
	(0.0344)
Institutional Delivery	0.108**
	(0.0534)
Region: Rural Lower	0.205***
	(0.0612)
Rural Upper	-0.452***
	(0.0610)
Frontier	0.723***
	(0.0832)
Constant	-0.767***
	(0.122)
Observations	**13,516**

Table 2 Regression - HAZ scores and different types of Consanguinity.

The second inference that we can make from this figure is that being male is associated with lower HAZ scores as compared to females, which is the reference category. This means that boys may be more vulnerable to stunting or growth faltering than girls, a well-known pattern in child nutrition studies.

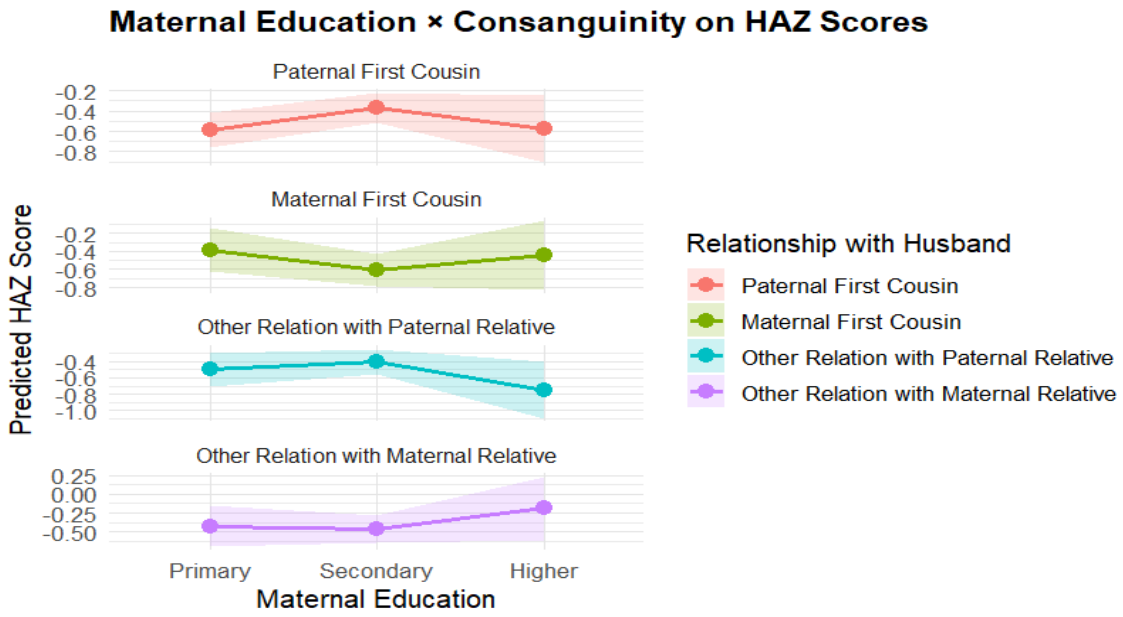
Maternal education emerges as one of the most consistent and powerful predictors of HAZ scores. Compared to mothers with primary or less than primary education, more educated mothers had significantly higher HAZ scores. On average, maternal education is associated with an increase of 0.103 standard deviations in HAZ, keeping everything else constant.

Another interesting finding from this OLS regression is the association between HAZ scores and different regions of Egypt. Children born in the Rural Upper Part of Egypt tend to have HAZ scores that are, on average, 0.452 standard deviations lower as compared to the reference category, i.e. Urban Egypt. As mentioned earlier, the Upper Rural part of Egypt sees very low economic development and growth. It is categorized as an area of lower resources, such as healthcare facilities and poor infrastructure. This coefficient for Rural Upper Egypt is statistically significant at 1 per cent, which shows a very strong association. In the Lower Rural part of Egypt, which sees a tinge of higher development as compared to the Rural Upper Egypt, the coefficient is positive. The coefficient indicates that children born in this region have HAZ scores that are, on average, 0.205 SDs higher than those of the reference category. This result is also significant at 1 per cent.

6.3. Heterogeneity Analysis

The heterogeneity analysis of the impact of maternal education on child HAZ scores reveals significant variations across different levels of consanguinity. The interaction between consanguinity and maternal education was examined to determine how the effect of maternal education on HAZ differs depending on the type of familial relationship between the mother and father.

Figure 9 Heterogeneity Analysis. Effects of Maternal Education on Children's HAZ scores for different types of consanguinity.



Notes: *This plot illustrates the interaction between maternal education levels and different types of consanguineous unions on predicted HAZ scores. Across all categories, consanguinity is associated with lower HAZ, but the degree of negative impacts varies by both relationship type and maternal education. Overall, higher maternal education appears to mitigate – though not fully offset- the adverse nutritional outcomes associated with consanguineous unions.*

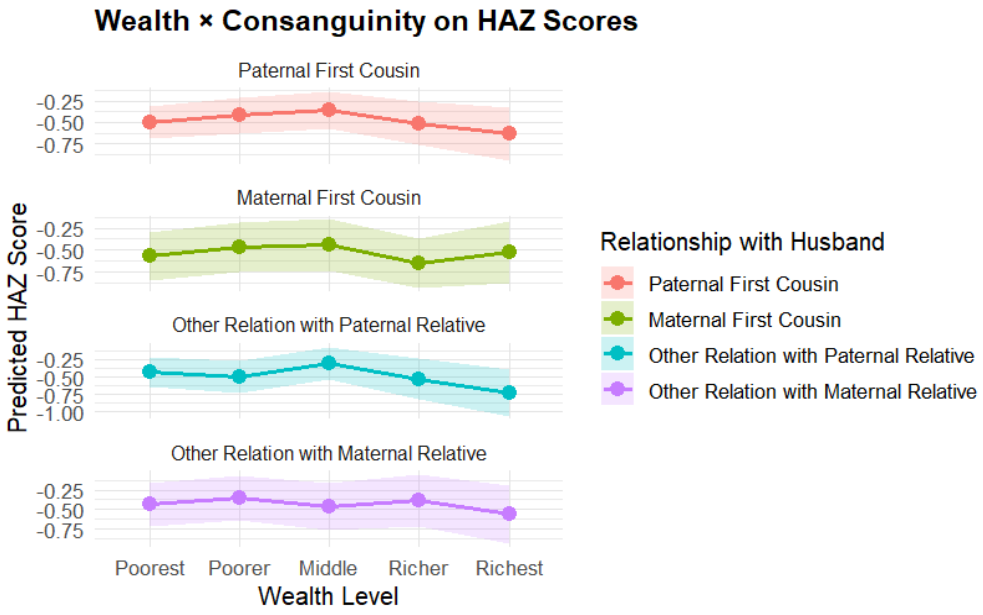
The model includes maternal education, consanguinity type and their interaction term, along with other control variables that have been used previously. Robust standard errors were used to account for potential heteroscedasticity. The results from the heterogeneity analysis reveal that the effect of maternal education on HAZ varies significantly across different types of consanguinity. The estimated marginal means were computed for each level of maternal education, stratified by consanguinity types. The results show that the predicted HAZ scores associated with maternal education are not uniform across consanguinity groups. The visual pattern in Figure 9 suggests that in some groups where consanguinity is closer (e.g., paternal first cousins), maternal education has a strong positive impact on child HAZ scores. However, in other consanguinity groups, the effect is weaker or absent, indicating that the benefits of maternal education on child health may vary depending on the degree of familial relatedness. Moreover, this finding suggests a potential moderating role of maternal education in mitigating the adverse effects of consanguinity. These results show some buffering effect, indicating that educated women in consanguineous marriages may be better positioned to advocate for child health needs.

6.3.1. Heterogeneity analysis across wealth groups

The graphs in figure 10 explore how consanguinity and wealth levels interact to influence a child's HAZ scores. Each of the four panels represents the different consanguinity categories that we have used in our analysis. Within each category of consanguinity, the trend of predicted HAZ scores varies across wealth levels.

For the category of Paternal First Cousin, we see a positive trend, suggesting that as the wealth increases, the predicted HAZ scores also slightly increase. Paternal cousin marriages seem to benefit more from increased wealth or at least are less negatively associated with negative HAZ scores.

Figure 10 Heterogeneity Analysis - Consanguinity and Wealth Status



Note: *This plot illustrates the relationship between wealth status and different types of consanguinity on predicted HAZ scores. The varying slopes for all types of consanguinities suggest that association between the interaction term and predicted HAZ score s is not the same.*

Maternal relative consanguinities show less sensitivity to wealth improvements, suggesting a more persistent negative effect. The slope of the lines in each panel provides insights into the interaction between different types of consanguinity and wealth. If the lines were parallel, it would suggest that the effect of wealth on HAZ scores for different types of consanguinity remains the same. However, the varying slopes suggest that the association between the interaction term and HAZ scores is not the same, and it differs depending on the type of consanguinity.

In summary, the heterogeneity analysis reveals that consanguinity and wealth levels are associated with Children's HAZ scores, and importantly, the effect of wealth on HAZ scores may vary depending on the specific type of consanguinity.

In sum, the empirical analysis confirms that consanguineous unions, particularly those involving paternal first cousins, are significantly associated with lower child HAZ scores. Maternal education is a strong protective factor against child undernutrition and may offset some of the negative effects of consanguinity. Similarly, births taking place in a public or private health facility improve child HAZ scores, though less than maternal education. Female children fare slightly better in terms of HAZ scores, mainly due to biological or social factors.

These results are consistent with both the household bargaining framework and the social determinants of health model, which post that individual child outcomes are shaped by a combination of family or household dynamics, maternal capital, and broader structural inequalities.

6.4. Discussion

The study aims to see the association between different types of consanguinity and children's well-being. The key outcome variable to examine a child's wellbeing is the Height for Age Z scores, and the main variable of interest is the type of consanguinity. The variable of consanguinity is categorized into consanguineous unions that are amongst paternal first cousins, maternal first cousins and consanguineous unions that are amongst paternal or maternal relatives other than first cousins. The model also controls for different maternal and child-specific socioeconomic characteristics, which helps to isolate the effect of consanguinity and better understand the factors that affect child HAZ scores other than consanguinity. In the later part of the analysis, the study performs heterogeneity analysis to see how the effect of maternal education and wealth status affects HAZ scores for different types of consanguinity.

6.4.1. Consanguinity and Child Health

For the main variable of interest, i.e. consanguinity and HAZ scores, we see a consistent negative association between different types of consanguinity and children's HAZ scores. The most pronounced effect can be seen for children born to paternal first cousins. A statistically significant and negative coefficient of -0.118 means adverse health and well-being for children born to these

unions. This negative association is primarily derived from the biological and genetic risks, such as inbreeding depression and autosomal recessive disorder (Bittles A. H., 2001). However, it is not solely the expression of the autosomal recessive gene, but there are certain socioeconomic and cultural dynamics specific to Arab and Muslim Majority populations. Social isolation and lower autonomy for women are the main drivers of consanguineous unions in Egypt.

Even though our econometric model controls for wealth status, rural households in Egypt, particularly those with high rates of consanguinity, may still allocate resources in ways that disproportionately disadvantage child health outcomes. In extended family households, resources such as income, food and time may be shared across multiple nuclear families.

While wealth status controls for income disparities, it does not capture the differential allocation of wealth within families. In consanguineous households, shared wealth may be more focused towards other family members, particularly elders or male family heads, leading to lower investments in child health and nutrition. Thus, in Egypt, the reliance on family-based resource allocation in consanguineous marriages may dilute the benefit of wealth, resulting in poorer HAZ scores. (Yount K. M., 2005) .

The model also controls for maternal education, but it does not necessarily guarantee economic empowerment for the women. The impact of limited maternal autonomy in consanguineous marriages leads to lower health investment in children, reducing the effect of maternal education on child development. Maternal influence in decision-making is economically constrained by family structures that priorities other family members' needs. (Samari G., 2019).

These findings underscore the need to consider economic factors, such as resource allocation within families, alongside more traditional explanations of consanguinity. Even when wealth and the place of delivery are controlled for, family structure and the decision-making dynamics remain crucial in understanding health outcomes for children in Egypt (El-Zanaty F. a., 2009).

6.4.2. Place of Delivery and Child Health

Analysis finds that children born in health facilities are associated with significantly higher HAZ scores compared to those born at home. This finding aligns with the growing body of literature that emphasizes the crucial role of institutional births in improving child health outcomes,

particularly through the mechanisms of improved prenatal and postnatal care and early growth monitoring.

Pregnant women who deliver in health facilities are more likely to have received pre-natal and post-natal care, which includes nutritional counselling, micronutrient supplementation and screening for complications. These services can have a very significant effect on child health outcomes. According to the World Health Organization, appropriate ANC reduces the likelihood of low birth weight, which is a key predictor of stunted growth. (WHO, 2020).

In contrast, home births often occur without skilled birth attendants, medical equipment or hygienic conditions. This can result in untreated complications, poor newborn care practices and missed opportunities for nutrition and health education for mothers. Such environments increase the child's vulnerability to growth, impairing infections, nutritional deficiencies, and even early-life mortality. (Zulfiqar Ali Bhutta et al., 2008).

6.4.3. Discussion on Heterogeneity Analysis

The heterogeneity analysis reveals that we see a stronger impact of maternal education in close consanguineous unions. The results indicate that the protective effect of maternal education is more pronounced in closely related consanguineous unions. This pattern suggests that educated mothers in a close-kin union may play a pivotal role in mitigating the negative health consequences. Educated mothers are more health literate, have better decision-making capacity and awareness of proper nutrition and healthcare practices.

However, this positive effect is not uniform across all consanguinity types. In more distant maternal consanguinities or unions involving other relatives on the mother side, maternal education appears to have a weaker or negligible effect on predicted HAZ scores. The primary cause of this result can be linked to women's agency or lower autonomy in such unions.

These findings resonate with literature where one study seeing the effect of Education as a factor in mortality emphasized education as catalyst in reducing child mortality through behavioral and attitudinal shifts (Caldwell, 1979). Another comprehensive study of developing countries indicated that women's education plays an important role in reproductive autonomy and improved child health outcomes. (Jejeebhoy, 1995).

The second layer of heterogeneity emerges in the interaction between consanguinity and household wealth. The results suggest that wealth improvements disproportionately benefit children in paternal cousin marriages, where predicted HAZ scores rise more steeply with increased wealth compared to maternal cousin or distant consanguineous unions.

This variation can be attributed to the dynamics of male-centred households in Egypt. In paternal consanguineous unions, resources may be more reliably pooled and invested within the nuclear family. This allows wealth to be more directly translated into better child health outcomes through improved nutrition, sanitation and healthcare access. On the other hand, in maternal cousin consanguineous unions, access to resources may be limited or more fragmented. These unions may fall outside the protective bonds of patriarchal support, reducing the capacity of rising wealth to improve children's nutritional status.

The findings of this study align closely with previous literature. A study that analyzed DHS data from 35 countries revealed a steep socioeconomic gradient, where children from wealthier households consistently show better health and nutrition indicators. However, they also noted that the translation of wealth into health gains is not direct. Other factors like intra-household allocation, parental agency and local norms mediate these effects (Filmer, 2001).

These results have also been complemented by another study, which argues that economic development alone cannot fully explain demographic and health transitions without considering the intervening role of cultural and gender norms. The study emphasized that in strong patriarchal societies, the benefits of rising income and education may be dampened by entrenched gender hierarchies and familial power dynamics (Basu, 1992).

In the Egyptian context, where patriarchal values intersect with consanguineous marriage patterns and extended family living arrangements, these dynamics become even more pronounced. Kin-based hierarchies may limit women from translating resources into better child health. Thus, the negative association between consanguinity and HAZ scores in Egypt may reflect not just genetic or biological risks, but also economic inefficiencies in how household resources are allocated and utilized within kinship-bound social systems.

This discussion on the findings of the study provides a detailed examination of the empirical associations between consanguineous marriages and child nutritional outcomes, specifically HAZ

scores. The results underscore the multifaceted nature of the child nutritional outcomes in Egypt and the importance of accounting for familial structures, maternal resources, and regional contexts when analyzing child health. These findings lay a strong empirical foundation for further inquiry into the mechanisms through which consanguinity influences child wellbeing.

Chapter 7

7. Conclusion

The study aimed to examine the impact of different types of consanguinity on child wellbeing, i.e. child's HAZ scores, which is a key indicator of child nutritional status and growth. By analyzing data from Egypt, this study sought to contribute to the literature on the relationship between consanguineous unions and child health outcomes in a context where consanguinity is more prevalent, and by exploiting a nationally representative data set which is unique to this study. The results of the study reveal that consanguineous unions are associated with significant differences in HAZ scores, suggesting a potential negative impact on child growth. A more pronounced negative effect on children's HAZ scores was seen for paternal first-cousin unions. This effect can be partly explained by the compounded genetic risks of consanguinity, which can result in a higher incidence of recessive genetic disorders and other health complications that affect child growth. However, the relationship between consanguinity and child health is not solely determined by genetic factors but is also affected by household dynamics and socioeconomic conditions. Household structure and family dynamics, such as the presence of extended family members and caregiving roles, can also influence health outcomes. In many cases, consanguineous marriages are more likely to occur in extended family settings, where cultural practices and traditions around family roles may affect the overall well-being of children. The study concludes that despite controlling for child, maternal and regional socioeconomic characteristics, a negative association can be seen, which allows us to argue that intra-household resource allocation and decision-making power of women within extended consanguineous families limit investments in child health. These results align with previous studies that have highlighted the potential health risks associated with consanguinity, including genetic disorders and poorer maternal health outcomes, which may indirectly affect child health.

Additionally, household wealth status and maternal education were found to be important determinants of child health. Wealthier households are more likely to have better access to healthcare services, nutritious food and other resources that promote child growth. On the other hand, children from poorer families are more vulnerable because of limited resources, access to healthcare and nutritional deficiencies.

In conclusion, the study provides robust evidence of the negative impact of consanguinity on child wellbeing as measured by HAZ scores and emphasizes the importance of socio-economic and demographic characteristics in shaping child health outcomes. This research contributes to the pool of literature and knowledge by providing empirical evidence on the effects of consanguinity in Egypt, a country where consanguineous unions are relatively common.

7.1. Limitations

While this study provides important insights into the association between consanguinity and child wellbeing in Egypt, several limitations must be acknowledged. These limitations help contextualize the scope of the research and highlight areas for future investigation.

The analysis in this study relies on cross-sectional data, which restricts the ability to establish statistical causality. Although the regression models do control for a number of individual and household-level variables, unobserved heterogeneity cannot be completely ruled out. On the other hand, longitudinal data would allow for more precise tracking of the long-term health outcomes and also can explain the inbreeding factor in more detail by providing data on previous generations.

Although wealth index and maternal education are powerful controls, they may not reflect qualitative differences in access to health services, nutritional diversity, or the actual use of health resources. Lastly, the data used in this study comes from the 2014 round of the Egypt DHS. While this data set remains one of the most comprehensive and nationally representative sources, it may not fully reflect recent policy changes, health interventions or social shifts. Nonetheless, consanguineous marriages remain deeply rooted in the traditions and cultural practices of Egypt. Therefore, the findings still offer valuable insights into long-standing public health and development challenges.

7.2. Policy Recommendations

Egypt has one of the highest rates of consanguineous marriages. These consanguineous marriages have negative health outcomes that carry long-term socioeconomic costs. This section of the study will provide policy recommendations that are culturally sensitive, evidence-based, and feasible. The main objective of these policy recommendations is to mitigate the negative effects associated with consanguinity.

To have better informed policies, it is first necessary to understand the prevalence and context of consanguineous marriages in Egypt. These unions are mostly rooted in traditions, related to family honor, inheritance and trust. In addition, health system limitations such as urban and rural disparities are the major drivers of the negative effects of consanguinity, as higher prevalence can be seen among rural populations where health facilities are not of a good standard. There is also very weak enforcement of genetic counselling policies, creating a vacuum of formal national strategies targeting consanguinity and genetic risks. In light of these gaps, immediate elimination of the practice of consanguineous unions is a complex task and cannot be done in the short run. Therefore, policy interventions should focus on child health outcomes as it will be an effective policy entry point.

To expand access to and awareness of Genetic counselling services, Egypt should integrate free and low-cost genetic counselling into primary healthcare, especially in rural and high-risk regions. Studies show that informed couples may reconsider consanguineous unions (Bittles A. H., 2001). This can be done by training local health workers, especially females, to offer basic counselling and by embedding counselling within premarital health checkups, which is already required by law in Egypt. One such example can be seen in Iran, where the integration of genetic counselling in primary health care has shown promising results (Fathzadeh, 2008).

Since household dynamics do play an important role in child health, specifically in the case of consanguineous unions, policy targeting these dynamics is very important. Maternal decision-making can be empowered through community-based health education. These community-based women's health collectives in rural and peri-urban areas shall provide safe spaces for discussion, education and peer support. Also, female community health workers (CHWs) trained to navigate conservative households can educate women on child nutrition, growth monitoring and the importance of timely care in designated facilities. This policy intervention shall enhance maternal

confidence and bargaining power in household health decisions as well as increase utilization of antenatal and child health services, improving child health outcomes.

Another significant policy prescription can be the integration of male and extended family members into health interventions. Family inclusive health programs should be launched targeting fathers, uncles and grandparents to reshape norms around maternal care and child health. Leverage should be given to religious leaders and respected community figures to promote messages of shared health responsibility. An example of implementation is to conduct mobile health sessions in villages where extended families are invited to participatory workshops on child development and the consequences of delayed treatment. These interventions shall reduce resistance to maternal autonomy by creating collective awareness. This will also build social legitimacy for women's health decisions within traditional family structures.

Economic dependency is the major factor of maternal autonomy, specifically in extended families common to consanguineous unions. A higher economic dependency means a low bargaining power in consanguineous unions where family assets and income are typically concentrated among male relatives. Conditional or in-kind transfer programs, such as food baskets for women, that are directly tied to child health outcomes, such as completing regular check-ups or immunisations (Fiszbein, 2009) . These transfers should only be made in the name of the woman, with mobile money or food stamps systems, to protect spending autonomy. The expected impact of these programs is that they will strengthen maternal investment in child health and enable negotiations within households. Such a policy will also encourage health-seeking behaviour without requiring the dissolution of consanguineous unions.

In the absence of these interventions, the health consequences of consanguinity will perpetuate cycles of poor child development. The findings from this study provide a clear direction for policy tailored to the context of Egypt. A coordinated, community-informed policy prescription could substantially improve child health and long-term human capital outcomes in Egypt.

In the context of Egypt, where the majority of the population is very conservative, implementing these policies will see greater resistance. To counter resistance from conservative communities, certain mitigation strategies, such as engagement with local religious and tribal leaders, should be implemented. To overcome the constraint of resources, cost-effective and scalable interventions can be adopted, e.g., media and school-based education. These school-based education programs

can be a long-term preventative strategy. Educational curricula that include basic genetics, reproductive health and their implications for future generations can foster informed decision making among adolescents. Engaging youth is particularly important, as they are the future decision makers regarding marriage and family planning. Such programs can also help increase gender equality by challenging restrictive norms that limit women's educational and reproductive autonomy. In the context of low literacy levels, which is also the case in consanguineous unions, visual and audio-based communication can be used. One such example is the training module of the Women Empowerment in Agriculture Index (Pro-WEAI). Since Egypt is a developing country and there is data limitation, surveys such as MICAs and DHS can be used to monitor consanguinity and child health indicators.

Another dimension that deserves policy attention is the role of civil society. NGOs can act as intermediaries between government programs and local communities. They are often more trusted by conservative populations and can help tailor interventions in the local context. For instance, NGOs can facilitate women's support groups by running workshops on reproductive health and child nutrition. They can also offer legal aid to women seeking greater autonomy in health-related decision-making. Additionally, partnerships between NGOs and academic institutions can ensure that interventions are both evidence-based and grounded in the lived experience of the target populations.

All these policy interventions should respect local customs while slowly and gradually challenging harmful norms. This can be achieved by working with grassroots NGOs, religious institutions, and rural development councils. For the monitoring and evaluation part, tracking should be done of both the health outcomes of the child and empowerment indicators as who decides on health expenditure or facility use.

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Appendix A

1. Variation Inflation Factor

Table 3 Variance Inflation Factor - Post Regression Multicollinearity Test

Variable	VIF	1/VIF
Paternal First Cousin	1.09	0.9147
Maternal First Cousin	1.04	0.9614
Other Relation with Paternal First Cousin	1.07	0.9305
Other Relation with Maternal First Cousin	1.04	0.9604
Mother Age at Birth	1.05	0.9506
Wealth Status: Poorer	1.65	0.6058
Middle	1.86	0.5377
Richer	2.38	0.4210
Richest	3.36	0.2977
Male	1.00	0.9975
Mother Education at least Primary	2.57	0.3889
Mother Education at least Secondary	2.65	0.3768
Institutional Delivery	1.10	0.9104
Rural Lower	2.33	0.4292
Rural Upper	2.84	0.3519
Fronter	1.22	0.8200
Mean VIF	**1.77**	

To assess multicollinearity among the independent variables, the VIF was calculated. All VIF values are well below the conventional threshold of 5, with a mean of 1.77, indicating that multicollinearity is not a concern in this model (Kutner, 2005)

2. Ramsey RESET Test

To check model misspecification, the Ramsey RESET test was applied. The p-value of 0.2696 indicates that the null hypothesis of no omitted variables cannot be rejected. This suggests that model is appropriately specified and does not suffer from major functional form errors (Ramsey, 1969)

Table 4 Ramsey RESET Test for model misspecification

Test	F-statistic	df (numerator, denominator)	p-value	Conclusion
Ramsey RESET Test	1.31	(3, 13496)	0.2696	No evidence of omitted variables