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Can Maternal Education Enhance Children's Dietary Diversity and Nutritional Outcomes? Evidence from 2003 Education Reform in Kenya[*]

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Abstract

Education is widely believed to have positive effects on multiple aspects of health outcomes. Nevertheless, the extent to which this association is causal or the factors that could explain the observed correlation remain uncertain, particularly in low-income nations. This study examines the causal impact of maternal education on child nutritional outcomes and their dietary diversity. The empirical research employed a fuzzy regression discontinuity design, where school reform exposure in 2003 is utilized as an instrumental variable to measure educational achievement in Kenya. The findings indicate that increasing a year's education of women enhances the nutritional status and dietary diversity of her children. One more year of women's schooling considerably affects a child's nutritional status, regardless of their gender. However, the effect is slightly better for boys than girls. The results are also robust across sensitivity tests. Further investigation indicates that the pathways through which maternal education enhances child health outcomes include factors such as the mother's age at first birth, the total number of children under the age of five, the father's level of education, the frequency of prenatal care visits, women's access to information through reading newspapers and watching television, the mother's literacy level, and her employment status. The results of the study suggest that increasing access to education, specifically for young girls, in developing nations such as Kenya may serve as an effective policy tool to improve the nutritional outcomes and feeding practices of children.

Keywords: Maternal education, Education reform, Child nutritional outcomes and dietary diversity, Fuzzy regression discontinuity design, Kenya

JEL classification: I1, I12 I21, I25, I28, O12

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1. Introduction

Nutrition plays a crucial role in every stage of human life, from conception and infancy to adulthood and old age, significantly impacting overall well-being. It is imperative for everyone, particularly those children who are under the age of 5, to receive sufficient and appropriate nourishment. Improving child nutritional outcomes remains a significant concern, primarily attributed to the vulnerability of children to malnutrition[1], particularly in developing countries. According to Dukhi (2020), in 2013, 99 million children were underweight and 161 million children were stunted among children under the age of five years worldwide. Black et al. (2008) reported that children who are under the age of five years have a burden of disease of 35 percent[2]. These statistics demonstrate a profound prevalence of undernutrition, which is responsible for approximately 50% of all deaths among children under the age of five (UNICEF, 2019). Besides the negative effects of poor early-life health in the form of malnutrition, childhood undernutrition has a lasting impact on various aspects of life, such as cognitive impairment, lower educational attainment, increased vulnerability to chronic diseases, and declining productivity and earnings (Khanh et al., 2016). Hence, improving the nutritional status of children is vital, associated with a greater chance of child survival, and is considered a necessary condition for a potential impact on both community and human development (UNICEF, 2019). Considering the negative private and social consequences, significant focus has been directed in recent times on enhancing child health, with maternal education recognized as one of the primary solutions[3]. Investing in women's education is considered a crucial developmental objective for enhancing child well-being particularly in underdeveloped nations (Desai & Alva, 1998). Previous research studies have identified that female education in developed societies has led to healthier children (Desai & Alva, 1998). Subsequently, the literature has extensively focused on the correlation between mother's education and better child health (Frost, Forste, & Haas, 2005; Imdad, Yakoob, & Bhutta, 2011).

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[1]Malnutrition not only exhibits a major concern related to public health, yet also obstructs endeavors to eliminate worldwide poverty, encourage productivity, and cultivate economic advancement (Dukhi, 2020).

[2]UNICEF (2019) states that a significant correlation exists between malnutrition and increased mortality cases among children under the age of five. UNICEF (2019) estimates that about 45 percent of fatalities among children under the age of five in low- and middle-income countries is due to underweight.

[3]Enhancing educational opportunities, with a specific focus on girls, has emerged as a prominent priority in the development goals of multiple countries, including the developing world. This emphasis is driven by the extensively documented beneficial impacts of female education on many different child health outcomes (Grossman, 2006; Black et al., 2013).

Several researchers have demonstrated that there is a lack of compliance in the empirical literature[4] about the causality of the underlying relationship between a mother's education and child health outcomes (Chou et al., 2010; Cutler & Lleras-Muney, 2010). A significant fraction of the prior research has focused on exploring the potential links between maternal educational achievements and the health outcomes of children (Chou et al., 2010; Currie & Moretti, 2003; Grossman, 2006; Lindeboom, Llena-Nozal, & van der Klaauw, 2009; Silles, 2015). These empirical studies examine the relationship between maternal education and HIV status, fertility outcomes (Duflo, Dupas, & Kremer, 2015), and child mortality outcomes (Grépin & Bharadwaj, 2015; Makate & Makate, 2016). However, there is a scarcity of research that specifically focuses on feeding practices and nutritional outcomes[5].

Kenya is an ideal case for this study because, prior to the implementation of the 2003 education reform, females frequently faced obstacles in accessing education, such as financial limitations or social norms. Nevertheless, this education reform has resulted in a more equitable enrollment of male and female students (Syomwene & Kindiki, 2015). Further, Kenya is an appropriate setting because it is one of the countries in the world where all types of malnutrition exist (Global Nutrition Report, 2020). The 2022 Kenyan Demographic Health Survey (KDHS) revealed that 18 percent of children under the age of five were experiencing stunted growth, which corresponds to approximately 1.13 million children. Additionally, 10 percent of children were found to be underweight, amounting to 631,196 individuals. Past research conducted in Kenya has primarily examined the impact of maternal education on fertility timing, as evidenced by Ferre (2009) and Chicoine (2012). Further, there are only a few studies present in Sub-Saharan Africa that evaluate the causal inference of maternal education on a child's nutritional outcomes and dietary diversity. It is crucial for policymakers and planners to have a comprehensive understanding of the impact of the education gradient on enhancing the nutritional status and feeding practices of children. Thus, this study seeks to address this gap in current understanding with the aim to examine the hypothesis that improving the level of a mother's education leads to improvements in a child's dietary diversification[6] and nutritional

[4]Caldwell (1994) stated that the impact of maternal education on child health should not be examined independently of the broader context; therefore, studies should distinguish and analyze the impact of education in different contexts. However, there is a lack of sufficient empirical evidence about causal impacts in poor countries.

[5]Günes (2015) is the initial researcher to empirically examine the causal relationship between tuition-free maternal education and stunting in developing countries.

[6]The empirical research has paid less attention to examining the significant association between a mother's level of education and the dietary diversity of her child, which is a crucial factor in determining the child's nutritional condition (Makate & Makate, 2018).

outcomes[7] in Kenya. Specifically, the study exploits the following questions using a quasi-experiment approach:

1. Can maternal education affect the nutritional outcomes and dietary diversity of children in Kenya?
2. Whether there is a heterogeneous impact of maternal education on child nutritional outcomes and dietary diversity among the gender of children?
3. What are the pathways linking maternal education to the nutritional outcomes and dietary diversity of children?

The present research focuses on the 2003 education reform in Kenya, which enhanced primary schooling opportunities for children, as a means of identification. The approach we employ is a fuzzy regression discontinuity method, estimated using a two-stage least squares (2SLS) framework. In line with prior research conducted in developing nations (Agüero & Bharadwaj, 2014; Behrman, 2015; Grépin & Bharadwaj, 2015; Makate & Makate, 2016; Tsai & Venkataramani, 2015), the present study utilizes an identification technique that takes advantage of the natural variation in schooling caused by a reform. Specifically, the study focuses on individuals who were 14 years of age or younger in 2003, comparing them to those who were older than 14 in the same year and therefore did not complete primary school.

The contribution of this study to the existing literature, particularly in relation to developing countries, is threefold. First, this research presents new findings regarding the causal relationship between maternal education and child nutritional outcomes and dietary diversification, specifically in low-income nations. As indicated previously, we accomplish this by employing a natural trial fitting a fuzzy RDD, where estimates represent local average treatment effects and closely resemble the estimates frequently presented in program evaluation literature[8] (Imbens & Angrist, 1994). Second, we take into account the possibility of variation in the effects of educational reform on a child's gender. Third, we investigate various possible mechanisms through which a mother's education can impact the dietary diversification of children and their nutritional outcomes. The empirical approach makes use of data collected by the Kenya Demographic Health Survey (KDHS) in 2014 and 2022, which are more recent and nationally representative surveys.

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[7] Among the key objectives of the Sustainable Development Goals (SDG) (United Nations, 2015), one of the primary targets is related to child nutritional status.

[8] These issues are usually explored in nations where there is a scarcity of resources in terms of inadequate health care infrastructure, which contributes to deteriorating child health and nutrition outcomes (World Health Organization, 2013).

The rest of the paper is structured as follows: Section 2 is based on the study context related to the existing literature on the subject; Section 3 describes the research methodology, including the data source, selected samples, variables used in the analysis, identification, and empirical strategy, along with a description of robustness tests, heterogeneity, and potential pathways; Section 4 reports the result of the analysis; Section 5 presents a discussion on the empirical findings and limitations of the study; and Section 6 concludes the study.

2. The study context

2.1. Related literature review

Child malnutrition remains a persistent challenge in developing countries, even in the present time (Imdad, Yakoob, & Bhutta, 2011; Ali Naser et al., 2014). It has emerged as a significant risk factor for child morbidity and mortality, accounting for almost half of all child fatalities worldwide (Ali et al., 2005). Malnutrition[9], particularly within the early thousand days of life, results in impaired physical growth, reduced cognitive function, and lower educational achievement (Anderson et al., 2010). The global prevalence of undernourishment increased from 7.5 percent in 2017 to 9.2 percent in 2022, affecting around 735 million people (Von Grebmer et al., 2023). In particular, the percentage of children who are undernourished is highest in the sub-Saharan African region. It has affected approximately 19.1% of the African population, which is more than double the 8.3% rate in Asia (Ayele et al., 2023). In addition, Kenya is positioned within the top 20 nations in terms of the absolute burden of malnutrition (World Bank Group, 2017). In the absence of any effective intervention, undernutrition might persist throughout the life span (Blössner & de Onís, 2005).

It is widely acknowledged that investing in the education of girls has numerous positive externalities for the improvement of economic and social development. These externalities include increased income (Oreopoulos, 2006), improved health (Clark & Royer, 2013), improved cognitive ability (Banks & Mazzonna, 2012), and increased political and civic involvement (Larreguy & Marshall, 2017). As a result, many developing nations have made growing access to education a primary policy objective. Numerous research studies undertaken previously have examined the non-market impacts of education. This relation

[9]Malnutrition is a term that includes both undernutrition and overnutrition (Blössner & de Onís, 2005). In many literature, undernutrition is frequently employed concurrently with malnutrition. It occurs when there is an inadequate intake of energy and other important nutrients (Blössner & de Onís, 2005; Maleta, 2006). It includes wasting (low weight for height), stunting (low height for age), underweight (low weight for age), and micronutrient deficiencies (Ayele et al., 2023).

has received huge attention in past empirical research. The main aim of these studies was to find the association between education and non-market outcomes (Grossman, 2015). However, in recent times, there has been a shift in the evidence from finding basic correlations to examining causal inferences through the use of quasi-experimental procedures (Mensch et al., 2019). The causal impact of education in these studies has been determined primarily through the utilization of exogenous changes in education resulting from the implementation of universal schooling policies. The correlation between education and health outcomes has drawn significant attention from various scholars, particularly in the fields of economics and other relevant social science fields (Grossman, 2006). Despite the fact that various research studies[10] have acknowledged the positive association between educational attainment and general well-being, the existing evidence on the causal relationship between these two variables is not yet conclusive (de Walque, 2007; Lleras-Muney, 2005).

Research studies conducted within the Sub-Saharan African (SSA) context have directed their focus toward investigating the effects of education on diminishing the probabilities of marriage, fertility, engagement in adolescent sexual activity (Behrman, 2015a; Ozier, 2018; Makate & Makate, 2018b; Moussa & Omoeva, 2020) and enhancing knowledge about HIV (Agüero & Bharadwaj, 2014; Bago, Ouédraogo, & Lompo, 2021; Behrman, 2015; De Neve et al, 2015). Despite the breadth of existing evidence, a very limited and scarce body of literature exists to systematically investigate the underlying causal relationship between educational attainment and child feeding and nutritional outcomes. Empirical evidence suggests that education has a significant impact on the health and nutrition outcomes of children. This influence is also exerted through multiple channels, such as strengthened health knowledge, greater investments in health, and improved socioeconomic status (Grossman, 2006). Higher educational achievements are likely to improve high-quality diets that are necessary for growth, fostering, and consumption patterns.

Previous studies have encountered a significant challenge in establishing a causal relationship between maternal education and child health due to the problem of endogeneity (Grossman, 2006, 2015). The identification and isolation of the independent and causal effects of maternal education on child health outcomes pose a methodological challenge, as it requires to taking into account bias from both observed and

[10] A large number of research studies have generally concentrated on the settings of developed countries, whereas there are unresolved concerns that still exist in less developed countries (Lochner, 2011).

unobserved variables. Several studies solve this endogeneity problem by utilizing the exogenous variations in schooling induced by different government initiatives as part of the instrumental-variable framework (Chou et al., 2010; Günes, 2015; Grépin & Bharadwaj, 2015; Keats, 2018). Other studies utilize the age-at-school-entry policies and employ the regression discontinuity design approach (McCrary & Royer, 2011). Nevertheless, these research studies determine an impact of particular significance for a subgroup of the population within the framework of a particular nation. Following what other researchers have done, we use the two-stage least squares (2SLS) regression method under the framework of fuzzy regression discontinuity design (FRDD) to find the causal link between a mother's education and child feeding and nutritional outcomes, while also taking into account relevant explanatory variables. This empirical research also tends to explore the heterogeneous impact of maternal education and the potential pathways.

2.2. Educational reforms in Kenya

Before Kenya gained independence, local communities and non-governmental organizations were primarily in charge of running primary schools. Following independence in 1963, Kenya embarked on an overall educational initiative with the goal of providing educational opportunities to all individuals. Over the past few decades, the country's education system has undergone significant changes as a result of the implementation of Universal Primary Education (UPE) in Kenya. The initial measure taken to facilitate the establishment of Universal Primary Education (UPE) in Kenya involved the elimination of the racially segregated school system that had been in place during the colonial administration. The Kenyatta administration, which regulated Kenya from 1963 to 1978, showed a firm dedication to providing seven years of primary education after the country gained independence. In the year 1974, a governmental decree was enacted, effectively eliminating fees for primary school students in classes one to four across the entire nation (Bogonko, 1992; Government of Kenya, 1984, 1988). Then, in 1985, a significant governmental reform was implemented, wherein a decree was issued to transition the country's educational system from the 7-4-2-3 structure to the 8-4-4 framework. The former system encompassed seven years of primary school, four years of secondary school, two years of higher secondary education, and three years of university education. The latter system, on the other hand, entailed eight years of primary school, four years of secondary school, and four years of university education. Therefore, the current education system in Kenya includes pre-school education for one or two years for children aged between 3 and 6; however, it is not compulsory; 8 years of compulsory primary school from age 6 to 14 years; 4 years of secondary school from age 14 to 18 years; and 4 years of university education from 18 to 22 years (Wango, 2011). Free primary education (FPE) was reintroduced in 2003 with the expectation of achieving the essential right of universal primary education for all Kenyan residents. This subsequent decree was enacted to eliminate all fees pertaining to primary school classes for the eight years of Kenya's primary education, and the policy was implemented at once for all grades nationwide beyond the aforementioned ones (Republic of Kenya, 2005, 2010, 2012). In response to the education reform in 2003, the total number of primary school students in Kenya rose from 6.3 million in 2002 to 7.2 million in 2004 and 8 million in 2007 (The World Bank, 2004). This represented a significant surge, considering that the annual growth rates prior to the implementation of the free primary education plan were around 1% (Kenya & Kenya Ministry of Education Science & Technology, 2003). The Minister for Education of Kenya reported during the 34th UNESCO General Conference in 2007 that the gross enrolment rate[11] rose at 112.4% and the net enrolment rate[12] at 86.5% (Nungu, 2010).

3. Research methodology

3.1. Data source

The datasets used for this research analysis are obtained from the Kenya Standard Demographic Health Survey (KDHS), conducted in 2014 and 2022. These two surveys are employed for the analysis as they have relevance to the nutritional outcomes of children for women of reproductive age[13]; many years later, in 2003, when education reform in Kenya was enacted. The KDHS data is suitable for this analysis as it is very comprehensive and contains consistent information on household structure, maternal education, household assets and wealth, household food consumption, maternal and child health, anthropometry, labor market, access to information, etc. This survey is a nationally representative cross-sectional survey led by ICF International in partnership with the government of Kenya. It utilized a two-stage stratified sampling design constructed on the census of the Kenyan population as the sampling frame. In the first stage of sampling, clusters are determined independently; then, household listing is executed in the chosen clusters; and finally,

[11]Gross school enrollment rate (GER) is defined as the number of children who are actually in school divided by the number of children who are of school age. The percent for Gross school enrollment ratio can be greater than 100 because students outside of the primary school age range may still be in school (Vos et al., 2004).

[12]Net enrolment rate (NER) number of students of official school age enrolled in primary education by the population of the age group which officially corresponds to primary education. The significant disparity between gross and net enrolment rates can be attributed to the inclusion of a substantial number of over-age children, such as street children or those who left school to work and later returned when fees were eliminated (Vos et al., 2004).

[13]Kenya Standard Demographic Health Survey present information on women of reproductive age between 15 and 49 years, as well as for children under the age of 5.

the listed households constitute a sampling frame in the second stage. 10,710 ever-married women[14] of reproductive age are chosen as the main sample for the analysis. The sampling probability weights provided in the KDHS are adjusted to ensure an equitable illustration of each survey in the sample, as data from some surveys are pooled together[15]. It is imperative to make this adjustment in order to mitigate any potential biases that may arise from combining data from these surveys, particularly when estimating the descriptive statistics. All the data for the analysis[16] is obtained from the children-recode data files (KR) and then merged with the household members data files (PR), as it contains information on both the mother and child levels.

3.2. Sample

To examine the specific impacts of the education reform in Kenya, a comparative analysis is conducted on women who were slightly older and slightly younger than the average age of completing primary school in 2003. Considering the information highlighted in Figure 1, women who were just above the age of completing primary schooling (15-18 years old in 2003) should not have been exposed to the education reform as they had already fulfilled their educational requirements prior to the implementation of the policy reform. Women who were just below the age of 11 to 14 in 2003 should have been exposed to the policy as they were still enrolled in primary school during the period of reform implementation.

3.3. Outcome variables

In this study, five outcome variables are considered to examine the impact of maternal education on a child's nutritional outcomes and dietary diversity. First, the nutritional outcomes of children who are under the age of five years are measured through two anthropometric[17] indicators: height-for-age and weigh-for-age. Both anthropometric measures exhibit standard deviations (SD) in comparison to the standard median (z-score) of the World Health Organization (WHO) reference populations (WHO Multicentre Growth Reference Study Group, 2006). The height-for-age z-score (HAZ) refers to the situation when children do not gain sufficient height for their age. Whereas weigh-for-age z-score (WAZ) reflects the situation where

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[14]Ever-married women are selected to emphasize the possibility of marriage at a young age and its implication on nutritional outcomes and the dietary diversity of their children (Kalanda , Verhoeff, & Brabin, 2006).

[15]The strategy is adopted by Makate & Makate (2016).

[16]Information on how to access the data is available at http://www.dhsprogram.com/

[17]Anthropometry is a very common method for assessing the nutritional condition of children. Anthropometric measurements are employed to monitor child growth markers.

the weight of children is less than expected, given their age. A binary indicator to measure stunting[18] and underweight[19] is also computed in the analysis. Stunting is equal to one if the height-for-age (H/A) z-score is less than minus two standard deviations (HAZ<-2 SD) and zero otherwise (HAZ >-2 SD). Similarly, underweight is equal to one if the weight-for- age z-score is below minus two standard deviations from the median of the reference population (WAZ<-2 SD) and zero otherwise (WAZ >-2 SD). Children under the age of five represents the main sample for the analysis of nutritional outcomes.

Second, dietary diversity[20] is measured for children aged 6-23 months. To compute the index for measuring dietary diversity, a set of questions were asked in the survey of KDHS by the women. The mother of the children who were able to survive, as identified at the time of each survey, asked these questions. Women were asked whether they had fed their children the food mentioned in various groups[21] within 24 hours before the time of each survey. Each question elicited a binary response, either the child was given an indicated food item ('yes, gave child') or the child was not given an indicated food item ('no, did not give child'). An additive index is computed in which each response of 'yes' or 'no' gains a score of 'one' or 'zero' to develop the dietary diversity score. This score indicates the consumption of food items within the past 24 hour time period for children (Kennedy, Ballard, & Dop, 2011; Steyn et al., 2006). This dietary diversity score ranged from zero to eight. The lowest score (zero) indicates that the child did not receive any

[18]Stunting refers to a condition characterized by a significantly low score in terms of height compared to age, known as the "height-for-age" (H/A) score. Stunting is commonly linked to persistent causes such as chronic malnutrition and frequent sickness. It serves as an indicator of the poor conditions in which children must have grown up and represents the general state of health and well-being of a population (Perumal, Bassani, & Roth, 2018). Consequently, it serves as a measure of past growth failure (Fenske et al., 2013). Inadequate nutrition can be one of the contributing factors to stunting. Other factors that might cause stunting include frequent infections and chronic diseases, a lot of which are complicated and not well understood (World Health Organization, 2013). Given its correlation with the risk of morbidity and death, childhood stunting is a powerful composite indicator of a child's well-being (World Health Organization, 2013).

[19]Underweight is defined as having an exceptionally low "weight-for-age" (W/A) score. W/A represents the ratio of body mass to age. Contrary to height, weight varies over time and thus indicates both acute and chronic malnutrition. It is frequently utilized for monitoring growth and evaluating changes in the magnitude of malnutrition over a period of time.

[20]Dietary diversity serves as an indicator of the sufficient micronutrient content in foods.

[21]Food groups include: 1) breast milk; 2) grains, roots, and tubers; 3) legumes and nuts; 4) dairy products (milk yogurt, cheese); 5) flesh foods (meat, fish, poultry, and organ meat); 6) eggs; 7) vitamin A-rich fruits and vegetables; and 8) other fruits and vegetables. It is recommended that children consume food from at least five out of the eight food groups. This diversified food item increases the chances of including an animal source of food, as well as a fruit or vegetable, alongside staple foods like grains, roots, or tubers.

of the food items mentioned in the food groups, and the highest score[22] (eight) represents that the child received all the food items, thus having diversification of food.

3.4. Explanatory variables

The main explanatory variable is a woman's educational status, which is measured by the number of years she has spent in school at each survey date. Other control variables include child gender, the age of the children in months, including its square, and the mother's age, including its square. Considering that dietary diversity and nutritional outcomes are likely to be influenced by factors like household wealth and food competition within the household, we accounted for the indicator for household wealth quintiles (1-5), total number of children under the age of five in the household, and a binary indicator for female-headed households as controls. By incorporating the indicator pertaining to households managed by women, we can consider the possible difficulties that these families may encounter as they attempt to manage their personal and professional responsibilities. Also, other explanatory variables include provincial fixed effects, survey fixed effects and a binary indicator for urban residence to account for any potential geographical heterogeneity. Father's years of schooling is not included as a control variable due to its potential endogeneity and its high correlation with mother's education (Chou et al., 2010). We include father's education in the section exploring the potential mechanisms by which mother's education might affect the child's nutritional outcomes and dietary diversity. This study particularly explores the influence of a mother's education on the nutritional outcomes for future generations. Similar to earlier research by Makate (2016) and Grépin & Bharadwaj (2015), the control variables taken into account are primarily those that happen after the treatment (exposure to reform).

3.5. Identification framework

The causal effect of the educational reform on potential outcomes, such as a child's nutrition and dietary diversity, can be determined by computing the difference between the child's individual health outcome when they are subjected to the education reform $\boldsymbol{Y_i(1)}$ and the individual's child health outcome when they are not subjected to the education reform $\boldsymbol{Y_i(0)}$. In this study, we aim to investigate how a mother's level of education impacts nutritional outcomes and the dietary diversity of her children. The primary challenge in inferring causality from research studies is that we are unable to simultaneously observe both states of the

[22]According to Hoddinott & Yohannes (2002), the greater score reflects the diversity of a child's diet in the past 24 hour period, as well as the financial capacity of parents to obtain and consume a wide range of such food items for their children, keeping all the other factors constant.

world. Instead, we can only observe the outcome variables associated with an individual receiving treatment. Let's define $\boldsymbol{D_i}$ as a value of **0** and **1**, where $\boldsymbol{D_i} = \mathbf{1}$ represents exposure and $\boldsymbol{D_i} = \mathbf{0}$ non-exposure to the reform. The primary difficulty lies in creating an appropriate comparison group that accurately depicts the expected outcome in various states of treatment. Next, we can establish the outcomes of the children of each individual mother by defining them as a function of their eligibility for the reform:

$$\boldsymbol{Y_i = (1 - D_i) * Y_i(0) + (D_i) * Y_i(1) = \begin{cases} Y_i(0) \; if \; D_i = 0 \\ Y_i(1) \; if \; D_i = 1 \end{cases}} \quad \textbf{(1)}$$

The present research employs a regression discontinuity design (RDD) to determine the causal impact of the 2003 education reform on the nutrition outcomes and dietary diversity of children in Kenya. The fundamental concept of RDD is based on the understanding that an individual's exposure to the reform is determined randomly by whether they lie either above or below the running variable or an assignment variable $\boldsymbol{Z_i}$, which in this analysis is represented by the respondent's age at the time the reform was implemented. By comparing the individuals on each side of the threshold (or cutoff point), we can calculate the causal impact of maternal education without any selection bias. According to Imbens & Lemieux (2008), there is a potential for $\boldsymbol{Z_i}$ to be substantially correlated to the outcome variables; however, this association is assumed to be smooth. The identification approach exploited in this study is derived from other previous studies conducted in low-income countries (Agüero & Bharadwaj, 2014; Behrman, 2015a; Makate & Makate, 2016; Tsai & Venkataramani, 2015). The key component of this technique depends on comprehending the fact that the probability of the reform was determined by whether the mother's age fell within the range of completing primary school or not. Therefore, we can describe an individual's probability of this educational reform in the following manner:

$$\boldsymbol{D_i = 1\,[Z_i \leq c]} \quad \textbf{(2)}$$

Here, $\boldsymbol{Z_i}$ represents the age of the respondent at the time of the implementation of reform. In situations where we have full compliance, the probability of being affected by education reform $\boldsymbol{D_i}$ can either be zero (no exposure) or one (full exposure), and thus is a function of an assignment variable $\boldsymbol{Z_i}$. Nevertheless, it is worth noting that grade repetition is a widely occurring incidence in various African nations (Alderman, Gilligan, & Lehrer, 2012; Nishimura, Yamano, & Sasaoka, 2008). In Kenya, there are instances of students repeating grades or entering school later than usual (Mariara & Kirii, 2006). This means that some women who were older than 14 in 2003 were still attending primary school due to the education reform implementation, which mandated eight years of primary schooling even if it didn't apply to the majority of their age cohort. Similarly, due to challenges in enforcing compulsory primary education, certain women exposed to reform might have left school before completing the required 8 years. This means that there is imperfect compliance around the cutoff value, therefore suggesting that fuzzy regression discontinuity design is a good choice for estimation. Hence, we chose to adhere to the imperfect compliance assumption throughout this research. This enables us to utilize a "fuzzy" rather than a "sharp" regression discontinuity design (Angrist & Pischke, 2009). When using the fuzzy RDD, we have the following form:

$$\boldsymbol{lim_{x\downarrow c} prob(D_i = 1|Z_i = x) \neq lim_{x\uparrow c} prob(D_i = 1|Z_i = x)} \quad \textbf{(3)}$$

Where, $\boldsymbol{lim_{x\downarrow c} prob(D_i = 1|Z_i = x)}$ demonstrates the limit in the probability of exposure to reform when the value of $\boldsymbol{x}$ close to value of $\boldsymbol{c}$ in the right side and similarly, $\boldsymbol{lim_{x\uparrow c} prob(D_i = 1|Z_i = x)}$presents the value of $\boldsymbol{x}$ close to value of $\boldsymbol{c}$ in the left side. The estimand in fuzzy RDD is formally expressed as:

$$\boldsymbol{\tau_{FRD} = \frac{lim_{x\downarrow c} E[Y|Z=x] - lim_{x\uparrow c} E[Y|Z=x]}{lim_{x\downarrow c} E[D|Z=x] - lim_{x\uparrow c} E[D|Z=x]}} \quad \textbf{(4)}$$

Here, the FRD estimator is defined as the ratio of the jump in outcome variables and the discontinuous change in the education reform variable (Hahn, Todd, & Van der Klaauw, 2001; Imbens & Lemieux, 2008). As presented in Equation (3), this estimation is computed at the limit as it approaches the designated threshold point from either below or above, as outlined by (Lee & Lemieux, 2010). Put simply, within the context of fuzziness, the causal impact of an extra year of education can be understood as the difference in the mean outcome resulting from a regression on the variable that determines the treatment (running variable - age of the respondent at educational reform in 2003), divided by the difference in the treatment itself (an additional year of schooling due to education reform) resulting from a regression on the variable that determines the treatment, both assessed at the specified cutoff value. Equation (5) provided below, $\boldsymbol{x}$ is the running variable, $\boldsymbol{c}$ is the cutoff point, $\boldsymbol{educ}$ is the number of years women have spent in school, and $\boldsymbol{Y}$ is the outcome of interest (nutritional outcomes and dietary diversity of children).

$$\boldsymbol{\tau_{FRD} = \frac{lim_{x\downarrow c} E[Y|age2003=x] - lim_{x\uparrow c} E[Y|age2003=x]}{lim_{x\downarrow c} E[educ|age2003=x] - lim_{x\uparrow c} E[educ|age2003=x]}} \quad \textbf{(5)}$$

3.6. Empirical strategy

To assess the impact of women's education on child nutritional outcomes and dietary diversity, the naïve method (OLS) is first exhibited, which is a very basic model that represents nutritional outcomes and dietary diversity as a function of maternal education and other relevant explanatory variables. It is presented as follows:

$$\boldsymbol{Y_i = \beta_0 + \beta_1 educ_i + X'_i\beta_2 + p_i + \varphi_i + \epsilon_i} \quad \textbf{(6)}$$

Where $\mathbf{Y_i}$ denotes the nutritional outcomes (height-for-age z-scores, stunting, weight-for-age z-scores and underweight) and dietary diversity for the i[th] children; $\mathbf{educ_i}$ is maternal schooling (i.e., mother's years of education) as observed at the survey date; $\mathbf{X'_i}$ is a vector of child-level and mother-level characteristics that are assumed to influence the child's feeding practices and nutritional outcomes. These variables include child gender, the age of the children in months, including its square, mother's age, including its square, indicator for household wealth quintiles (1-5), total number of children under the age of five in the household, a binary indicator for female-headed households and a binary indicator for urban residence; $\mathbf{p_i}$ are the province fixed effects; $\boldsymbol{\varphi_i}$ survey fixed effects; $\boldsymbol{\beta_0}$ is the intercept term; and $\boldsymbol{\epsilon_i}$ is a random disturbance error term. $\boldsymbol{\beta_1}$ is the main estimate of interest, which assesses the extent to which the mother's education influences the child's nutritional outcomes and dietary diversity. However, this coefficient should not be interpreted as having a causal impact on the outcome of interest. In this conventional ordinary least squares (OLS) model, the variable of education is only able to partially account for unobservable factors that influence both educational achievement and the outcomes of interest. As a result, this limitation introduces bias and endogeneity problems into the OLS model, which is presented in Equation (6). To address this issue, a quasi-experimental method called regression discontinuity design (RDD) is employed in this study. The regression discontinuity design is not subjected to such bias as it involves the comparison of two groups that are slightly above and slightly below a predetermined threshold, which has an exogenous impact on the number of years of education. This study has established the age threshold as 14 years old in 2003. It is expected that women who were 14 years of age or younger in 2003 have been exposed to education reform, as they were still within the age range for primary school enrollment when the policy was implemented. Conversely, women who were 15 years of age or older in 2003 have not been exposed to reform, as they have not been enrolled in primary school during the time of implementation, as depicted in Figure 1.

As stated in Section 3.5., a fuzzy regression discontinuity (FRD) design is employed in the current study, which means that the exposure to the intervention is characterized by a probabilistic rather than a deterministic factor (Lee & Lemieux, 2010; Behrman, 2015). The identification of the causal impact of the treatment is based on the assumption that there are no abrupt changes in observed and unobserved characteristics, except for the jump in the assignment variable coinciding with the implementation of the policy. Since it's not feasible to determine whether each woman was still in her initial eight years of schooling during the implementation of education reform, it is preferred to use a two-stage least squares method in such cases. Hahn, Todd, & Van der Klaauw (2001) demonstrate, under specific assumptions, when dummy indicator **D = 1** [age of the respondent at educational reform in 2003 ≤ c], the FRD estimator presented in equation (4) is considered equivalent to the two-stage least squares (2SLS) estimator. This approach computes the local average treatment effect (LATE) (O'Keeffe & Baio , 2016). The 2SLS method uses the binary indicator for exposure to education reform as an instrumental variable for education (van der Klaauw, 2002).

The model used in this study is based on the specifications followed in previous studies (Agüero & Bharadwaj, 2014; Behrman, 2015; Makate & Makate, 2016; Tsai & Venkataramani, 2015). In the first stage, we analyze the relationship between years of education and the instrumental variable as described in Equation (7) :

$$\boldsymbol{educ_i = \alpha_0 + \alpha_1 D_i + \alpha_2 D_i * (age_{i,2003} - 14) + \alpha_3 (1 - D_i) * (age_{i,2003} - 14) + \epsilon_i} \quad \textbf{(7)}$$

Here, $\boldsymbol{D_i = 1\,[Z_{2003} \leq 14]}$ is the instrumental variable for education, which is the women's age of 14 years or younger in 2003 and zero otherwise. Linear age approximations are also included below and above the age 14 cutoff point. $\boldsymbol{\alpha_0}$ is the intercept term; and $\boldsymbol{\epsilon_i}$ is a random disturbance error term. The model[23] presented in Equation (7) used the ordinary lease squares (OLS) method to compute the predicted years of a mother's education. Then, this predicted value of schooling is used in the second stage regression in the following form:

$$\boldsymbol{Y_i = \pi_0 + \pi_1 \widehat{educ}_i + \pi_2 D_i * (age_{i,2003} - 14) + \pi_3 (1 - D_i) * (age_{i,2003} - 14) + X'_i \pi_4 + p_i + \varphi_i + \epsilon_i} \quad \textbf{(8)}$$

[23]Since the majority of the control variables occur after the treatment (exposure reform), we have not included them in the first-stage. Furthermore, the province of birth, previous residency, and the places where women started and completed their education are not included in the DHS data. We are therefore unable to identify information if women have moved to a different province or location after finishing their education. As a result, introducing these two variables in the first stage could lead to measurement error-related bias. We did not employ these particular controls during the first-stage of study in order to prevent such issue. OLS and second-stage of two stage least squares include all these control variables.

Where $\widehat{educ_i}$ is the predicted value of schooling as computed in Equation (7) and π_1 give us the estimated causal impact of maternal education on a child's dietary diversity and nutritional outcomes. In this model, we also include the linear age approximations (π_2& π_3) below and above the age 14 cutoff point to completely exploit the discontinuity in education, as it is the standard practice in the regression discontinuity approach. For binary indicators in Y_i outcome variables, such as child stunting and underweight, we can use probit regression by means of the ivprobit command in Stata. However, considering the difficulties that can be encountered with the convergence in our models and for the sake of simplicity in understanding and interpretation, we chose to apply a linear probability model. The education impact, denoted as π_1 in Equation (8), determines the average causal impact of maternal education on the outcomes of interest. According to Angrist, Imbens, & Rubin (1996), this effect is also referred to as the local average treatment effect (LATE). However, it is important to note that this effect cannot be extrapolated or generalized to other data contexts beyond the specific analytical sample data from Kenya that is utilized in this study. Simply put, we are measuring the effect for those whose level of education the instrumental variable might affect, specifically those who were 14 or younger in 2003. The group of women who satisfy this criteria are referred to as "compliers," a term adapted from (Angrist, Imbens, & Rubin, 1996). Also, we employed a clustering technique by grouping the standard errors at the enumeration area level to account for any potential within-group error correlations.

The validity of the two stage least squares (fuzzy RD) model relies on certain assumptions. The first assumption is that the instrumental variable can affect our outcome variables solely through exposure to education reform after considering the relevant control variables (Wooldridge, 2010). In the event that alternative viable channels exist linking the instrument and the outcomes, the ability to determine the specific impacts of education would be compromised. Nevertheless, it is not likely that alternative means existed for enhancing the nutritional outcomes of children associated with the education reform, apart from educational interventions. The second assumption is that the instrumental variable is strongly correlated with maternal education, which means that on average, women's years of schooling are affected by their exposure to reform. For this assumption to be satisfied, a formal test is needed to determine the validity of our instrumental variable. The F-statistics[24] presented in the first stage of 2SLS suggest whether the instrument is valid or not. An additional assumption is that the covariates that affect both the schooling decisions of

[24]F-statistic of 10 or greater suggests that the instrumental variable chosen in the analysis is strong (Staiger & Stock, 1997).

women and the outcomes of interest vary smoothly across the cutoff[25]. The final assumption is that the instrument is supposed to be exogenous, as suggested by Angrist & Imbens (1995). In addition to the temporal gap of 11 to 18 years between the respondents' age and the implementation of the education reform, it is worth noting that women's were unlikely to strategically time their births in anticipation of the reform. We employed a histogram, as recommended by McCrary & Royer (2011), to visually represent the distribution of the running variable. This is done to carry out a formal verification test[26].

3.7. Robustness tests, heterogeneity and potential pathways

A number of robustness tests are conducted to check the sensitivity of estimates in our empirical analysis. Firstly, given the intrinsic trade-off between bias and precision in estimation, it is necessary to conduct additional analyses to assess the robustness of the size of the age bandwidth selection (Angrist, Imbens, & Rubin, 1996; Lee & Lemieux, 2010). The preferred age bandwidth selections for narrower and wider bandwidth are 12-17 years and 10-19 years. As the bandwidth decreases, the estimations become less precise while the probability of bias decreases as well. Conversely, a larger bandwidth results in more precise estimates, but there is also higher chances of biased estimates, as indicated by Calonico, Cattaneo, & Farrell (2017). Finally, given that a dietary diversity score of zero is unlikely to be possible, it indicates that the child did not consume any of the numerous food items that were reported in the Kenyan Demographic and Health Survey in the last 24 hours. This observation raises concerns about the potential impact of recall bias and thus further analysis is conducted as part of the robustness check to demonstrate the reliability of our estimates for dietary diversity.

The main model also considers potential heterogeneity in the impact of educational reform among the gender of their child. It is also important from a policy perspective to identify the underlying pathways that can be useful in formulating focused initiatives to enhance the positive impacts of maternal education. Thus, later in the analysis, we also explored mechanisms through which maternal education might impact the child's nutritional outcomes and dietary diversity. It is attributed to six main groups: (1) fertility behavior of the mother (proxied by the mother's age at first birth and the total number of children under the age of five years); (2) assortative mating (proxied by the father's year of schooling); (3) mother's health care utilization

[25]A smoothness assumption test using different covariates is conducted to look for potential discontinuities in relevant explanatory variables. See Figures 7, 8 & 9.

[26]One fundamental principle of regression discontinuity designs is that no one can manipulate the running or assignment variable with respect to the predetermined threshold age (McCrary & Royer, 2011).

(proxied by any prenatal care visits); (4) access to information (proxied by the mother reading a newspaper and watching television); (5) cognitive skills (proxied by the mother's literacy); and (6) labor market outcome (proxied by employment status) (Khanh et al., 2016; Smith-Greenaway, 2013; Psacharopoulos & Patrinos, 2004).

4. Results

4.1. Descriptive statistics

Table 1 exhibits the summary statistics for the selected bandwidth of women aged 11 to 18 years in 2003 (n = 10710), the treated cohort (n = 5446), and the control cohort (n = 5264), along with the t-test differences in means. In our sample analysis, the average years of schooling is about 6.61 years. However, it is different for the treated and control groups. The treated cohort (aged 11-14 years) has spent a relatively longer time (6.73 years) in school as compared to the control cohort (aged 15-18 years) with 6.49 years of schooling. Approximately 25% of the women do not receive any education, with a smaller percentage observed in the treated group (23.6%) compared to the control group (26.6%). Overall, the rate of primary school completion is about 22.5%, indicating a major school dropout rate of 77.5%. Only 12.1% and 10.2% have completed secondary schooling and obtained a higher education, respectively.

About 28% of the women in the families are household heads, with a mean age of around 28.3 years, as noted at the time of the survey. An average of 8.3% and 31% of women regularly read newspapers and watch television for access to information. Around 51.3% of women in Kenya are employed, and their literacy level (ability to read and write) is around 69.9%. Only 34.2% of the sample lives in urban areas, and the wealth index slightly differs between the treated and control groups.

There is a balanced gender distribution among the children in our analytical sample. On average, mothers of these children visit prenatal care around 4.73 times during their pregnancies. The prevalence of marriage at a younger age and early childbirth is highly significant. By the time women reach the age of 19.59 years, they have experienced their first childbirth. The mean HAZ and WAZ scores among Kenyan children are -1.031 and -0.738. Whereas, the likelihood of overall stunting and underweight is 22.7% and 12.9%, with a slightly lower level among the treated group (stunting 21.5%, underweight 12.2%) and the control group (stunting 23.9%, underweight 13.6%). The mean dietary diversity score among children is around 1.98.

4.2. The effect of the 2003 education reform on maternal education

Table 2 presents the first stage regression estimates of the effect of the 2003 education reform (proxied by the dummy indicator for the women aged less than 14 years in 2003) on completing the maternal education (proxied by the years of schooling) as presented in Equation (7). Overall, the results show that the women who have been exposed to education reform in 2003 are associated with 0.240 years of more schooling than those who have not exposed to reform. The average years of schooling in the analytical sample are 6.615 years. Being exposed to the education reform would lead to an increase of $\left(\frac{0.240}{6.615} * 100\right)$ 3.63% in years of schooling. The estimated coefficient is statistically significant at the 5% significance level. A graphical analysis of this discontinuity is evident in Figure 2[27]. To check if the instrumental variable is valid, a format test is conducted and provided by the first stage F-statistics. The F-statistics presented in Table 3 ranged from 16.95 to 26.77, and all are statistically significant (p-value = 0.000). This suggests that the selected instrument works well.

4.3. The effect of maternal education on child nutritional outcomes and dietary diversity

The main results are shown in Table 3. The upper part exhibits the baseline and naïve OLS model from Equation (6). In this model, we assume that education is exogenous, and we have not taken into account any endogeneity bias. Whereas, in the lower part of Table 3, the estimates from the second-stage regression (2SLS) are presented. In this regression model, education is instrumented, and child nutritional outcomes and dietary diversity are functions of the predicted years of schooling from the first stage, controlling for other relevant variables as presented in Equation (8). Also, the model of two-stage least squares accounts for potential endogeneity bias. The results from the OLS model show the expected signs, and all are statistically significant at the 1% and 5% significance levels. It means that there is a positive correlation between maternal education and HAZ, WAZ, and the dietary diversity score of children, and a negative correlation with stunting and underweight. In particular, an additional year of maternal education is associated with an increase in HAZ and WAZ by 0.010 and 0.031 standard deviations (SD) and a 0.027 unit increase in the dietary diversity score. Basically, mothers who were exposed to the education reform in 2003 have children with better height-for-age z-scores, weight-for-age z-scores, and dietary diversity scores as compared to their counterparts. Given the average HAZ, WAZ, and dietary diversity scores for children in our analytical sample, an increase in one year of schooling by the mother is associated with an increase of 0.97% (HAZ),

[27] See Appendix B (Figure 2), which shows a graphical representation of the effect of the 2003 education reform on maternal education in Kenya.

4.20% (WAZ), and 1.36% (dietary diversity) in these scores. In a similar manner, a one-year increase in schooling is associated with a decrease in stunting and underweight by 0.3 and 0.7 percentage points, respectively. Given the average stunting and underweight rates in the sample of our analysis, this corresponds to a decrease of 1.32% (stunting rate) and 5.43% (underweight rate), respectively.

The results of the 2SLS estimates in Table 3 show that a one-year increase in the schooling of women improves the HAZ score by about 0.133 standard deviations, which translates to an increase of approximately 12.90% $\left(\frac{0.133}{1.031} * 100\right)$ given that the average HAZ score of the children in the analytical sample is -1.031. Also, extra years of schooling for mothers decreases the possibility of a stunted child by approximately 4.9 percentage points, which translates to a reduction of 21.59% in the stunting rate given that 22.7% of the children in the analytical sample are stunted. Similarly, mothers who have spent an extra year in school have children with a better WAZ score of 0.187 standard deviations. Given the average WAZ score of -0.738 in our analysis sample, a 0.187 unit improvement in the WAZ score translates into an increase of 25.34% in the WAZ score. In addition, a one-year increase in the educational attainment of women lowers the likelihood of having an underweight child by nearly 3.5 percentage points. Given that 12.9% of the children in the analytical sample are underweight, this translates to an approximate decrease of 27.13% of underweight children. In a similar manner, an additional year of schooling increases the dietary diversity score of the children by about 0.31 units. This improvement of 0.31 units translates into a 15.60% increase in the dietary diversity score, given that the mean score in the sample of analysis is about 1.987. All the estimates of 2SLS are statistically significant at the 1% significance level. The graphical illustrations of this discontinuity are presented in Figures 3, 4, and 5. The impact of a few outcomes in graphical representation seems to be less evident and clear. One drawback of the graphical demonstration is that it does not allow for determining the extent to which years of schooling had a causal influence. Further, when comparing the estimates of OLS and 2SLS, it is evident that the 2SLS estimates are significantly larger. Potential reasons for this phenomenon are described in Section 5.1.

4.4. Robustness checks

An additional measure is conducted to ensure the robustness of the findings provided in Table 4 and 5. The main model presented in Equation (8) is re-run by incorporating smaller (+/- 3 years) and larger (+/- 5 years) age bandwidth sizes. Table 4 exhibits that our main findings for all the outcomes are robust across narrower and wider bandwidths. This defines the reliability of our estimates. Even with the smaller bandwidth size[28], the coefficient estimates are still significant for all the child nutritional outcomes and dietary diversity. A dietary diversity of zero is not likely to be plausible, as argued in Section 3.7., and thus further checks are needed to confirm the robustness of our estimates. The robustness check analysis in Table 5 confirms that our estimates remain significant even when excluding children with a diversity score of zero. However, when comparing the estimates presented in Table 3, the results of robustness check in Table 5 is somewhat lower. For instance, an additional year of women schooling improves the dietary diversity of their children by 0.233 units as compared to 0.308 units presented in Table 3 and both are statistically significant at 10% and 1% significance level. Thus, it shows that including the children with zero dietary diversity in Table 3 overestimates the overall impact of women's education.

4.5. Heterogeneous effects of maternal education on child nutritional outcomes and dietary diversity

Table 6 exhibits the possible heterogeneity in the effects of maternal education on nutritional outcomes and dietary diversity in children. This table shows the potential heterogeneity among the male and female children. By splitting our sample according to the child's gender, we show that one more year of women's schooling significantly impacts the nutrition and dietary diversity of a child, regardless of their gender. However, the impact is slightly better for boys than girls. Women with extra years of schooling increase the HAZ score of boys by 0.139 SD, the WAZ score of 0.197 SD, and the dietary diversity score of 0.342 units as compared to the HAZ score of girls (0.103 SD), the WAZ score (0.165 SD), and the dietary diversity score (0.302 units). Given the mean HAZ score of -1.138, WAZ score of -0.785 and the dietary diversity of 1.974 among the boys sample in our analysis, this translates to an increase of 12.21% in the HAZ score, 25.10% in the WAZ score, and 17.33% in the dietary diversity score. While an average HAZ score of -0.922, WAZ score of -0.668 and a dietary diversity score of 1.981 among the girls in the analysis translated to an increase of 11.17% in the HAZ score, 24.7% in the WAZ score, and 15.24% in the dietary diversity score, respectively. In a similar manner, the results show that one more year of education decreases the possibility of stunting and underweight by nearly 6.0 and 4.0 percentage points among the male child and 4.0 percentage points (stunting) and 3.1 percentage points (underweight) among the female child. Given that 25.3% and 14% of male children are stunted and underweight in our sample as compared to 19.5% (stunted) and 11.7% (underweight) female children, this change translates to an approximate 23.72% and 28.57% reduction in stunting and underweight among male children as compared to a decrease of 20.5% (stunted)

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[28] The estimates of smaller bandwidth show additional support that maternal education has a significant influence on mothers who improved their schooling as a result of the policy change (van der Klaauw, 2002; Günes, 2015).

and 26.5% (underweight) among female children, respectively. All the estimates are statistically significant at the 1% and 5% significance levels.

4.6. Potential mechanisms

Maternal education has the potential to impact the nutritional outcomes and dietary diversity of children through various mechanisms. These pathways are important and are thus explored in this analysis. We include eight main channels[29]: mother's age at first birth, children under the age of five years, father's year of schooling, any prenatal care visits, mother reading a newspaper and watching television, mother's literacy, and employment status. Table 7 presents the estimates of 2SLS for potential mechanisms. The result of this analysis shows that extra years of maternal schooling improve child nutritional outcomes and feeding practices through fertility behavior of the mother, assortative mating, mother's health care utilization, access to information, cognitive skills, and labor market outcome. In particular, women's education increases the age of first birth by about 2.188 years. This finding indicates that women with higher levels of education tend to avoid having children at a younger age, consequently leading to a lower likelihood of teenage pregnancy[30]. This delay in childbirth can have positive effects on in-utero growth, which is an important indicator of health during the initial 1000 days. Further, the effect on fertility is statistically significant at the 10% significance level, indicating that education enables mothers to reduce fertility by 2.07% $\left(\frac{0.035}{1.694} * 100\right)$. We also found that women who are more educated are likely to marry a well-educated man. The result shows that women's education improves child health through its positive impact on father's years of schooling[31]. Moreover, we present effective evidence regarding the health care utilization of mothers. Educated women are more likely to increase the number of prenatal care visits by about 0.631 visits, which translates to an increase of 13.32% in antenatal care visits. Additionally, a year more spent in school enables mothers to have access to information through watching television and reading newspapers and improves their overall literacy level with a statistical significance level of 10%. Finally, the result also indicates that

[29] These channels are attributed to six main groups. Details are already presented in previous Section 3.7.

[30] According to Muthayya (2009), teenage pregnancy is correlated with adverse birth outcomes, including low birth weight and intrauterine growth retardation. These outcomes are believed to be a result of the mother and child's nutrient needs during pregnancy. These negative birth outcomes pose a risk for stunting and underweight

[31] The study conducted by Mani (2012) examines the role of paternal education in influencing childhood development and nurturing practices, which in turn impact the decision of health inputs. The Demographic Health Survey (DHS) gathers data regarding the spouses of ever married women. This allows us to study father's education as a potential mechanism, considering that a mother's exposure to education reform influence child feeding practices and nutrition through marriage to a well-educated father.

being employed might impacts child feeding practices and nutrition status. The average child's age in our analytical sample is 29 months and mother being away from home for work purpose might impacts child health status. The result of our analysis shows that maternal education decreases the likelihood of being employed and engaging in labor force participation by 25.54% $\left(\frac{0.131}{0.513} * 100\right)$, thus playing a protective role in child care, which is similar to the findings of Günes (2015).

4.7. Validity tests

The legitimacy of the regression discontinuity design estimates lies in the credibility of the assumptions presented in Section 3.6. The first assumption is that no one can manipulate the running variable with respect to the predetermined threshold age. In other words, we check whether the respondent's age in 2003 (the assignment or running variable) exhibits any potential discontinuity or bunching at the cut-point of age 14 years. We carry out a formal verification of this assumption by using a histogram to show the density of the running variable, as McCrary & Royer (2011) suggested. Figure 6 shows the evidence that there is no bunching or any manipulation in the running variable (age 14 years) at the discontinuity point. The second assumption is that covariates that affect both the schooling decisions of women and the outcomes of interest vary smoothly across the cutoff. To check this, we test the smoothness assumption of all the explanatory variables present in our regression model of fuzzy RD. This standard practice in the literature of regression discontinuity design suggests looking for any discontinuity in the running variable in order to figure out the potential discontinuity in any explanatory variables incorporated in our regression analysis. If our estimates of fuzzy RD are credible, we are supposed to notice continuity and smoothness in these explanatory variables. Figures 7, 8, and 9 show that all the explanatory variables other than the running variable are smooth, and there is no evidence of any discontinuity in these explanatory variables that could affect the impact of maternal education on child dietary diversity and nutritional outcomes that we noticed. The validity tests' results furnish us with certainty regarding the overall impact of a mother's education on child nutritional outcomes and the dietary diversity we observed.

5. Discussion

This study utilizes the 2003 education reform in Kenya as an external source of variation in education for investigating the impact of maternal education on child dietary diversification and nutrition outcomes and thus using the data from Kenya, which is nationally representative. The results of the study reveal a significant relationship between the mother's level of education and these outcomes. The findings indicate that the education reform has a positive impact on the child's HAZ and WAZ scores. The mothers who have been exposed to the reform tend to have children that are taller, with a HAZ score of about 0.133 standard deviations in comparison to those children born to non-exposed mothers. In addition, policy reform also leads to a significant improvement in the WAZ score of children whose mothers have been exposed, compared to their counterparts. The improvement is 0.187 standard deviations. The studies by Aslam & Kingdon (2012), Günes (2015), and Makate & Makate, (2018) all found similar positive results for the HAZ and WAZ scores. The HAZ score (0.20 standard deviations) and WAZ score (0.19 standard deviations) had a slightly bigger effect than the current study. Our results also support the notion that a mother's education plays a crucial role in decreasing the prevalence of stunting and underweight among children. Exposed mother's children experience a significant decrease of 4.9 percentage points in stunting and 3.5 percentage points in underweight compared to children born to non-exposed mothers. The studies conducted in other Sub-Saharan African countries like Zimbabwe and Malawi have reported a reduction of 3.2 to 5.6 percentage points in stunting and 3.8 percentage points in underweight among children (Günes, 2015; Keats, 2018; Makate, 2016; Makate & Makate, 2018). Finally, the research by Makate & Makate (2018) shows that an extra year of education raises children's dietary diversity scores by about 0.429 units. Nevertheless, our study also presents a positive yet slightly divergent estimate. Children born to exposed mothers have shown an increase of 0.31 units in dietary diversity compared to their counterparts in the present study. The fact that the F-statistic in our model is greater than 10, indicating a strong IV selection, supports the findings (Staiger & Stock, 1997).

Additionally, the results of this study remain consistent and robust even after conducting sensitivity tests. This provides an additional finding to the existing literature on the impact of women's education on various health outcomes in low-income countries, including Sub-Saharan African countries. These previous studies include the effect of education on fertility (Behrman, 2015a; Duflo, Dupas, & Kremer, 2015), knowledge about HIV/AIDS (Agüero & Bharadwaj, 2014; Behrman, 2015; Tsai & Venkataramani, 2015), child mortality (Grépin & Bharadwaj, 2015; Makate & Makate, 2016), and nutrition (Makate & Makate, 2018). Further, the validity tests also conducted in this study showed no signs of manipulation in the assignment variable, and there are no discontinuities found in the other explanatory variables used in the model. The evidence strengthens the reliability of our RDD estimates.

In a comprehensive manner, our causal inferences indicate that retaining young girls in school can serve as a potential approach for enhancing the nutritional outcomes and dietary diversity of children. Based on these findings, we support previous studies which show that providing education to women can have various and long-lasting effects that go beyond educational settings (Behrman, 2015). Therefore, it is crucial to promote female enrollment in school, especially in a country where our data shows a 77.5% dropout rate. Poor nutrition among children incurs economic costs (United Nations. Economic Commission for Africa, 2014). According to the 2018 report from USAID, the economic impact of undernutrition in Kenya is estimated to be over US $38.3 billion in terms of gross domestic product (GDP) losses. Additionally, our findings demonstrate a significant impact, given the few years of education (6.6 years). Although several studies indicate that there is a specific threshold of maternal schooling required to enhance these outcomes Makoka (2013), others propose that there is no specific "threshold" advantage and that even minimal improvement in education level enhances the survival of children (Aslam & Kingdon, 2012).

The empirical work in the past has examined how a mother's education is associated with several factors that contribute to child health and nutrition (Makate & Makate, 2018). The current study has also revealed some significant pathways. Our research indicates that maternal education has a significant influence on the dietary diversity and nutrition of children. Factors like the mother's fertility behavior, assortative mating, healthcare use, information access, cognitive ability, and participation in the labor force are likely to mediate this influence. Rahman, Razmy, & Rizath (2017) highlighted the negative effects of teenage pregnancies on nutrition and birth outcomes in Kenya. Our research also demonstrates that education empowers women to postpone their first childbirth, thereby delaying the probability of teenage pregnancies and mitigating their negative consequences. On the other hand, education also empowers women to decrease their fertility patterns. Further, our study indicates that women with higher levels of education are more inclined to enhance their utilization of prenatal care, which in turn has a direct impact on the overall health of their children. The outcome is expected because pregnant women are more prone to receiving comprehensive and suitable educational guidance regarding proper nutrition, lifestyle, adequate rest, exclusive early breastfeeding, the risks associated with smoking and alcohol consumption during pregnancy, parenting abilities, family planning, birth intervals, feeding methods, and where to seek additional healthcare if necessary (Lincetto et al., 2006). Moreover, the results of the study indicate that the practice of assortative mating and the employment status of women have a significant impact on enhancing the health of children. Finally, education also empowers mothers to get knowledge through television and newspapers and to improve their literacy level.

5.1. Larger two-stage least squares estimates

The effect of a mother's education on a child's nutrition is considerably greater in all instrumental variable (IV) estimates reported in this research compared to what the ordinary least squares (OLS) estimates indicate. This finding aligns with prior empirical research (Günes, 2015; Makate & Makate, 2018; Makate & Nyamuranga, 2023). Certainly, there are multiple potential reasons for this phenomenon, which explains why the 2SLS estimates may be greater than the OLS estimates.

Firstly, the reported variation in the estimates can be explained by the fact that the OLS estimates failed to account for the potential endogeneity bias. Secondly, it is worth noting that the 2SLS estimator measures the local average treatment effect (LATE), which is different from the average treatment effect (ATE) that the OLS estimator focuses on (Angrist, Imbens, & Rubin, 1996). Thirdly, if the instrumental variable (IV) estimate assumes that school reform is the sole determinant of variation in education, the estimated impact of education may be subject to bias and might overestimate the true effect of education reform. Nonetheless, the results could also be attributed to other nationwide alterations in development or the degree to which the school system has effectively adjusted to revisions in curriculum that have occurred since achieving independence. For instance, governmental peace and stability following independence may have a potential impact on the enhancement of school enrollment. Furthermore, following the attainment of independence, modifications were implemented to the educational syllabus, facilitating the incorporation of food and nutrition subjects into the educational curriculum as suggested in the 2009 national school health policy. Consequently, the impact may indicate the level of success the education system has achieved in acquiring nutrition principles in classrooms over a period of time (Makate, 2016). Lastly, the discrepancy noticed in the case of Kenya may be attributed to the recognition that the schooling system before reform was voluntary, thus it is distinct from the calculation made when schooling is compulsory. It is plausible that children with outstanding abilities may have been deprived of primary schooling before the implementation of the reform. The greater magnitude of the LATE impact could potentially be attributed to the self-selection mechanism. Nevertheless, it is possible that high-achieving pupils choose to attend primary school when tuition costs become free as a result of educational reform, while low-achieving students may have chosen not to attend despite the absence of school fees, as indicated by other research (Chimombo et al., 2000). Therefore, the 2SLS estimates may be indicative of the total impact of the high-achieving pupils. These are the possible reasons that explain the larger Local Average Treatment Effect (LATE). Many researchers argue that the preference is to report Local Average Treatment Effects (LATE) when examining the impact of education reform. This is because the reform was implemented gradually in Kenya rather than a "big bang" approach as observed in some other African countries contexts (Behrman, 2015).

5.2. Study limitations

This study has certain limitations:

First, the use of cross-sectional data poses a challenge in examining the potential impact of maternal education on the nutritional status and dietary diversity of children, as it limits our ability to study any potential dynamics[32]. Second, we recognize the potential for bias resulting from other developmental projects that were carried out in Kenya after gaining independence. Nevertheless, we contend that these changes are unlikely to have had the same cohort-specific impacts as the education policy in Kenya and, therefore are unlikely to impact our empirical estimates.

Third, it's important to note that our analysis only considers the group of children who were still alive as observed at the survey date. Therefore, we cannot take into account the nutrition outcomes for children who have passed away (deceased children), which could potentially introduce a source of selection bias. KDHS does not have information on the anthropometric measures of deceased children[33], so we cannot respond to this problem. Fourth, it's worth noting that our measure of children's dietary diversity aligns with commonly recommended methods (FAO, 2021). However, it's important to acknowledge that there may be some potential for error in its measurement. This is due to the fact that the data is based on self-reported information from mothers regarding the particular foods their children consumed during the 24-hour survey period.

Fifth, our estimates are specific to the context of Kenya. Future studies could potentially explore additional, broader contexts across space and time. Lastly, it is crucial to address the fact that child nutrition is influenced by various factors beyond the ones examined in this analysis. Therefore, a thorough investigation of other pathways is also necessary to understand how a mother's education can impact feeding and nutrition outcomes. In spite of such limitations, the current study contributes to the rising evidence on the impact of women's education on dietary diversity and nutrition outcomes in Sub-Saharan Africa.

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[32] It is important to study analyses of this nature in the context of panel data, as it enables us to examine dynamic impacts and intergenerational links between schooling and child nutrition (Makate & Makate, 2018).

[33] The availability of anthropometric data for deceased children provides a more comprehensive viewpoint and enables us to thoroughly assess the influence of schooling on nutritional outcomes in Kenya (Makate & Makate, 2018).

6. Conclusion and policy implication

The current study furnishes empirical evidence that maternal education enhances the nutritional outcomes and dietary diversification of children in Kenya. By examining frequently used metrics like height-for-age, weight-for-age, and dietary diversity score, we find the positive effects of a mother's education on her children's nutritional health status. Additionally, we determine that a mother's education decreases the likelihood of the child experiencing stunted growth and being underweight. We also analyze several underlying pathways for their effects on child nutritional status and the heterogeneous impacts of a mother's education based on the child's gender. Focusing on women’s education can lead to positive outcomes for their children, such as promoting normal growth and preventing adverse health consequences. Subsequently, it promotes healthy development in the early stages of a child's life. Further, our findings emphasize the significance of maternal education in improving the socioeconomic situation in low-income countries as it also has a long-lasting impact on individuals' lives. Hence, government initiatives aimed at enhancing educational opportunities for young women would have the potential to not only improve child health in the short term but also provide long-term economic advantages. This is because healthy children will eventually grow up to become educated and productive adults themselves. In addition, our research also indicates that enhancing women's access to education could contribute to the attainment of Sustainable Development Goals: 2 (zero hunger), 3 (good health and well-being), 4 (quality education), and 5 (gender equality). Although our study has certain known limitations, it significantly enhances the current state of the literature on the causal impact of education on child nutrition outcomes and dietary diversity, particularly in sub-Saharan Africa, where research has been lacking.

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Appendix A: Tables

Table 1: Descriptive statistics for the variables selected in the analysis and t-test differences in means

	Overall cohorts (1985-1992)		Treatment cohorts (1989-1992)		Control cohorts (1985-1988)		
	Aged 11-18 years in 2003		Aged 11-14 years in 2003		Aged 15-18 years in 2003		Mean difference
Variables	Mean	SD	Mean	SD	Mean	SD	P-value
<u>Mother-level variables</u>							
Years of schooling	6.615	4.707	6.737	4.605	6.497	4.802	***
No education	0.251	0.434	0.236	0.425	0.266	0.442	***
Incomplete primary	0.213	0.409	0.215	0.410	0.211	0.408	
Complete primary	0.225	0.417	0.227	0.414	0.222	0.419	*
Incomplete secondary	0.087	0.282	0.098	0.298	0.076	0.266	***
Complete secondary	0.121	0.326	0.129	0.335	0.113	0.317	***
Higher education	0.102	0.302	0.106	0.308	0.097	0.295	*
Age at survey date	28.344	4.309	26.598	3.945	30.044	3.953	***
Age in 2003	14.466	2.251	12.496	1.178	16.385	1.091	***
Age at first birth	19.597	3.643	19.270	3.381	19.915	3.854	***
Female-headed house	0.280	0.448	0.285	0.447	0.274	0.448	*
Wealth index (1-5)	2.577	1.457	2.603	1.477	2.549	1.436	**
Reads newspaper	0.083	0.276	0.087	0.282	0.078	0.268	*
Watches television	0.310	0.463	0.314	0.464	0.304	0.461	**
Literate women	0.699	0.459	0.718	0.450	0.681	0.466	***
Employed	0.513	0.50	0.539	0.499	0.489	0.50	***
Number of women	10710		5446		5264		
<u>Child-level variables</u>							
Child is female	0.495	0.50	0.491	0.50	0.499	0.50	
Age in months	29.412	16.924	28.533	16.896	30.268	16.908	***
Child under five	1.694	0.730	1.71	0.737	1.679	0.723	***
Any prenatal care	4.737	3.131	5.029	3.25	4.444	3.011	***
Height-for-age z-score	-1.031	1.358	-1.006	1.347	-1.056	1.368	**
Stunting	0.227	0.417	0.215	0.417	0.239	0.418	***
Weight-for-age z-score	-0.738	1.151	-0.720	1.142	-0.756	1.159	*

Underweight	0.129	0.335	0.122	0.333	0.136	0.336	***
Dietary diversity score	1.987	2.074	2.041	2.045	1.934	2.106	*
Number of children	15054		7634		7420		
Geographical variables							
Coast province	0.120	0.325	0.124	0.329	0.117	0.321	
North eastern province	0.096	0.294	0.093	0.291	0.098	0.298	
Eastern province	0.147	0.354	0.144	0.351	0.15	0.357	
Central province	0.073	0.261	0.067	0.249	0.08	0.271	***
Rift valley province	0.326	0.469	0.337	0.473	0.316	0.465	***
Western province	0.084	0.277	0.079	0.269	0.089	0.285	**
Nyanza province	0.129	0.335	0.133	0.340	0.124	0.329	*
Nairobi province	0.024	0.154	0.023	0.151	0.025	0.157	
Urban resident	0.342	0.474	0.345	0.473	0.339	0.475	

Notes: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level. All data is extracted from the children-recode data files (KR) and merged with the household members data files (PR) of the Kenya Demographic Health Survey (KDHS) 2014 and 2022. SD = standard deviation. Descriptive statistics are weighted to be nationally representative of the Kenyan general population.

Table 2: The effect of the 2003 education reform on maternal education in Kenya

First stage of 2sls Estimates	Years of Schooling
Age below 14 years in 2003	0.240**
	(0.103)
Observations	15,054
Mean of the dependent variable	6.615

Notes: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level. The reported estimated coefficients are from regression analysis. Robust standard errors are shown in parentheses and clustered at the enumeration area level. The reported estimates are based on the sample of women aged 11-18 years in 2003.

Table 3: The effect of maternal education on child nutritional outcomes and dietary diversity in Kenya

	(1)	(2)	(3)	(4)	(5)
Regression Specifications	HAZ	Stunting	WAZ	Underweight	Dietary diversity score
OLS Estimates					
Years of schooling	0.010**	-0.003**	0.031***	-0.007***	0.027***
	(0.004)	(0.001)	(0.003)	(0.001)	(0.009)
Observations	14,267	14,267	14,287	14,287	4,523
2SLS Estimates (IV)					
Years of schooling	0.133***	-0.049***	0.187***	-0.035***	0.308***
	(0.051)	(0.014)	(0.044)	(0.013)	(0.109)
Observations	14,267	14,267	14,287	14,287	4,523
First stage F-statistics	26.77	26.77	26.54	26.54	16.95
P-value	0.000	0.000	0.000	0.000	0.000
Mean of the dependent variable	-1.031	0.227	-0.738	0.129	1.987

Notes: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level. Robust standard errors are shown in parentheses and clustered at the enumeration area level. The reported estimates are based on the sample of women aged 11-18 years in 2003. All specifications include controls for linear age slopes on either side of the age 14 threshold, a binary indicator for child gender (=1 if female), a child's age in months and its square, the total number of children under the age of five in the household, the mother's age and its square, a binary indicator for female-headed households, province fixed effects, indicators for household wealth quintiles (1-5), binary indicator for urban residence (=1 if urban residence), and survey year fixed effects.

Table 4: The effect of maternal education on child nutritional outcomes and dietary diversity in Kenya-robustness checks across smaller and larger bandwidths

	(1)	(2)	(3)	(4)	(5)
2SLS Estimates(IV)	HAZ	Stunting	WAZ	Underweight	Dietary diversity score
Aged 12-17 in 2003					
Years of schooling	0.139***	-0.055***	0.192***	-0.041***	0.278***
	(0.053)	(0.016)	(0.047)	(0.015)	(0.101)
Observations	10,785	10,785	10,799	10,799	3,335
First stage F-statistics	19.80	19.80	19.56	19.56	11.21
P-value	0.000	0.000	0.000	0.000	0.000
Mean of the dependent variable	-1.023	0.222	-0.718	0.127	1.948
Aged 10-19 in 2003					
Years of schooling	0.128***	-0.042***	0.180***	-0.030***	0.227**
	(0.049)	(0.012)	(0.042)	(0.011)	(0.098)
Observations	17,565	17,565	17,586	17,586	5,556
First stage F-statistics	33.34	33.34	33.12	33.12	19.87
P-value	0.000	0.000	0.000	0.000	0.000
Mean of the dependent variable	-1.039	0.226	-0.733	0.13	1.983

Notes: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level. Robust standard errors are shown in parentheses and clustered at the enumeration area level. All specifications include controls for linear age slopes on either side of the age 14 threshold, a binary indicator for child gender (=1 if female), a child's age in months and its square, the total number of children under the age of five in the household, the mother's age and its square, a binary indicator for female-headed households, province fixed effects, indicators for household wealth quintiles (1-5), a binary indicator for urban residence (=1 if urban residence), and survey year fixed effects.

Table 5: The effect of maternal education on child dietary diversity in Kenya- robustness check-excluding those children whose dietary diversity is zero

Regression Specifications	Dietary diversity score
OLS Estimates	
Years of schooling	0.049***
	(0.009)
Observations	2,866
2SLS Estimates (IV)	
Years of schooling	0.233*
	(0.135)
Observations	2,866
First stage F-statistics	6.661
P-value	0.001
Mean of the dependent variable	3.126

Notes: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level. The estimates presented in this table exclude those children whose dietary diversity is zero. Robust standard errors are shown in parentheses and clustered at the enumeration area level. The reported estimates are based on the sample of women aged 11-18 years in 2003. All specifications include controls for linear age slopes on either side of the age 14 threshold, a binary indicator for child gender (=1 if female), a child's age in months and its square, the total number of children under the age of five in the household, the mother's age and its square, a binary indicator for female-headed households, province fixed effects, indicators for household wealth quintiles (1-5), binary indicator for urban residence (=1 if urban residence), and survey year fixed effects.

Table 6: Heterogeneity in the effect of maternal education on child nutritional outcomes and dietary diversity in Kenya

	(1)	(2)	(3)	(4)	(5)
2SLS Estimates(IV)	HAZ	Stunting	WAZ	Underweight	Dietary diversity score
<u>Girl Child sample</u>					
Years of schooling	0.103**	-0.040**	0.165***	-0.031***	0.302**
	(0.045)	(0.018)	(0.050)	(0.012)	(0.165)
Observations	7,042	7,042	7,053	7,053	2,204
First stage F-statistics	21.93	21.93	21.62	21.62	10.40
P-value	0.000	0.000	0.000	0.000	0.000
Mean of the dependent variable	-0.922	0.195	-0.668	0.117	1.981
<u>Boy Child sample</u>					
Years of schooling	0.139**	-0.060**	0.197***	-0.040***	0.342***
	(0.070)	(0.026)	(0.046)	(0.015)	(0.119)
Observations	7,225	7,225	7,234	7,234	2,319
First stage F-statistics	15.53	15.53	15.51	15.51	13.01
P-value	0.000	0.000	0.000	0.000	0.000
Mean of the dependent variable	-1.138	0.253	-0.785	0.14	1.974

Notes: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level. Robust standard errors are shown in parentheses and clustered at the enumeration area level. The reported estimates are based on the sample of women aged 11-18 years in 2003. All specifications include controls for linear age slopes on either side of the age 14 threshold, a binary indicator for child gender (=1 if female), a child's age in months and its square, the total number of children under the age of five in the household, the mother's age and its square, a binary indicator for female-headed households, province fixed effects, indicators for household wealth quintiles (1-5), a binary indicator for urban residence (=1 if urban residence), and survey year fixed effects.

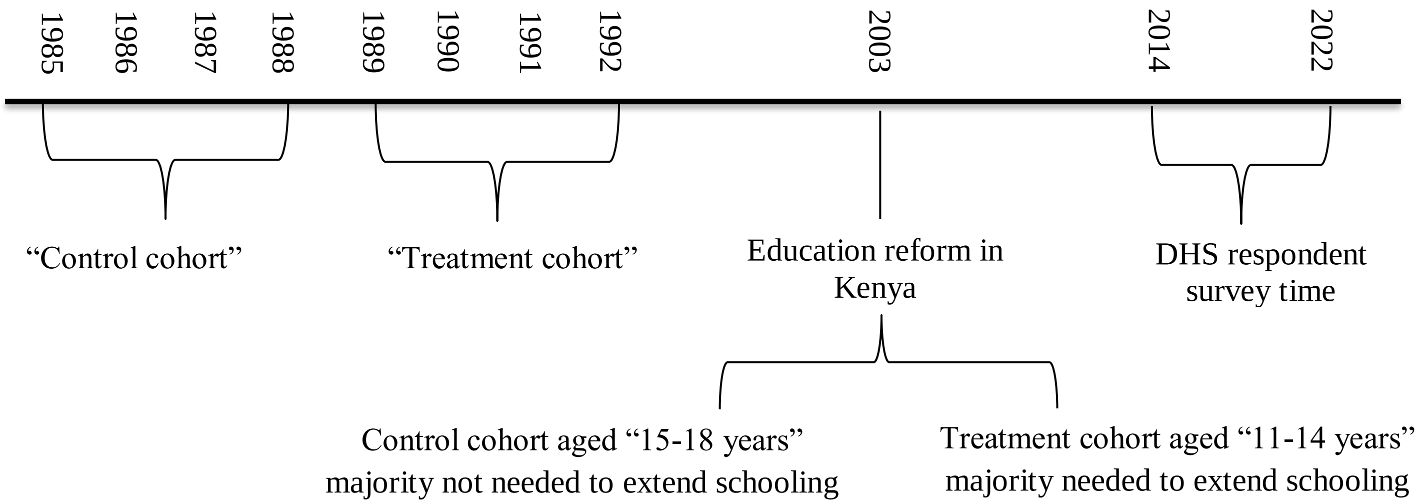
Table 7: Pathways through which mother's education impact child nutritional outcomes and dietary diversity in Kenya

	Age at first birth	Children under five	Father's year of schooling	Any prenatal care
Years of schooling	2.188***	-0.035*	0.723***	0.631***
	(0.589)	(0.018)	(0.205)	(0.170)
Observations	14,763	14,763	5,422	14,763
First stage F-statistics	20.12	20.12	16.75	20.12
P-value	0.000	0.000	0.001	0.000
Mean of the dependent variable	19.597	1.694	7.088	4.737
	Reads newspaper	**Watches television**	**Literate women**	**Employed**
Years of schooling	0.036*	0.037*	0.058*	-0.131***
	(0.022)	(0.022)	(0.034)	(0.050)
Observations	14,755	14,759	14,763	10,284
First stage F-statistics	20.19	20.19	16.33	17.26
P-value	0.000	0.000	0.001	0.000
Mean of the dependent variable	0.083	0.310	0.699	0.513

Notes: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level. Robust standard errors are shown in parentheses and clustered at the enumeration area level. The reported estimates are based on a sample of women aged 11-18 years in 2003. All specifications include additional controls, as described in the previous table of main estimates.

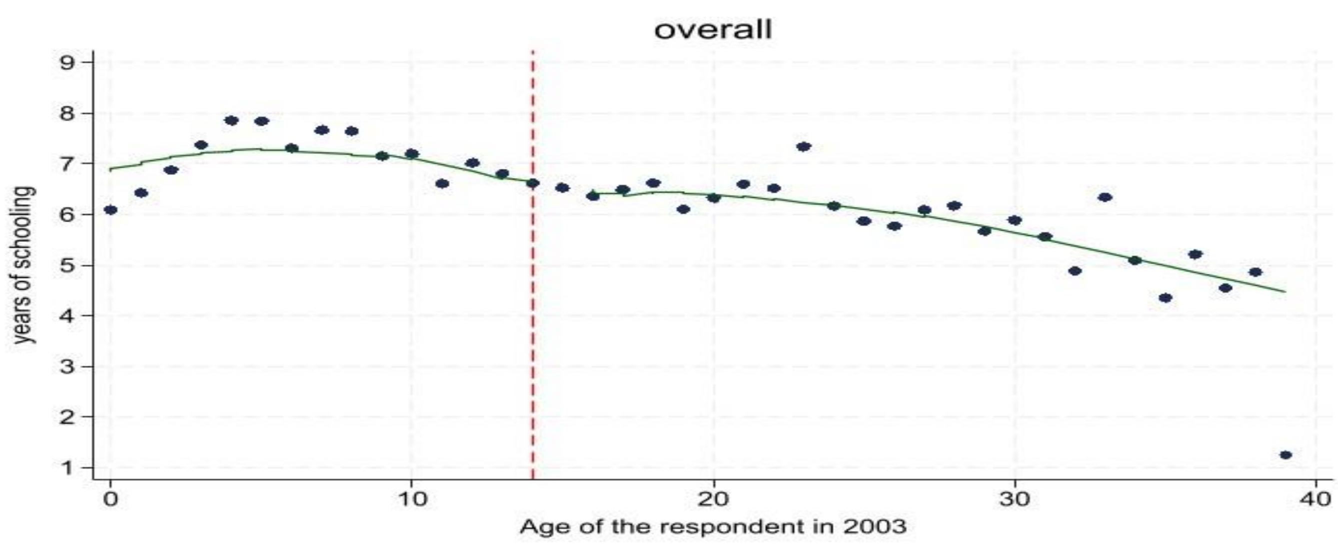
Appendix B: Figures

Figure 1: Timeline of events



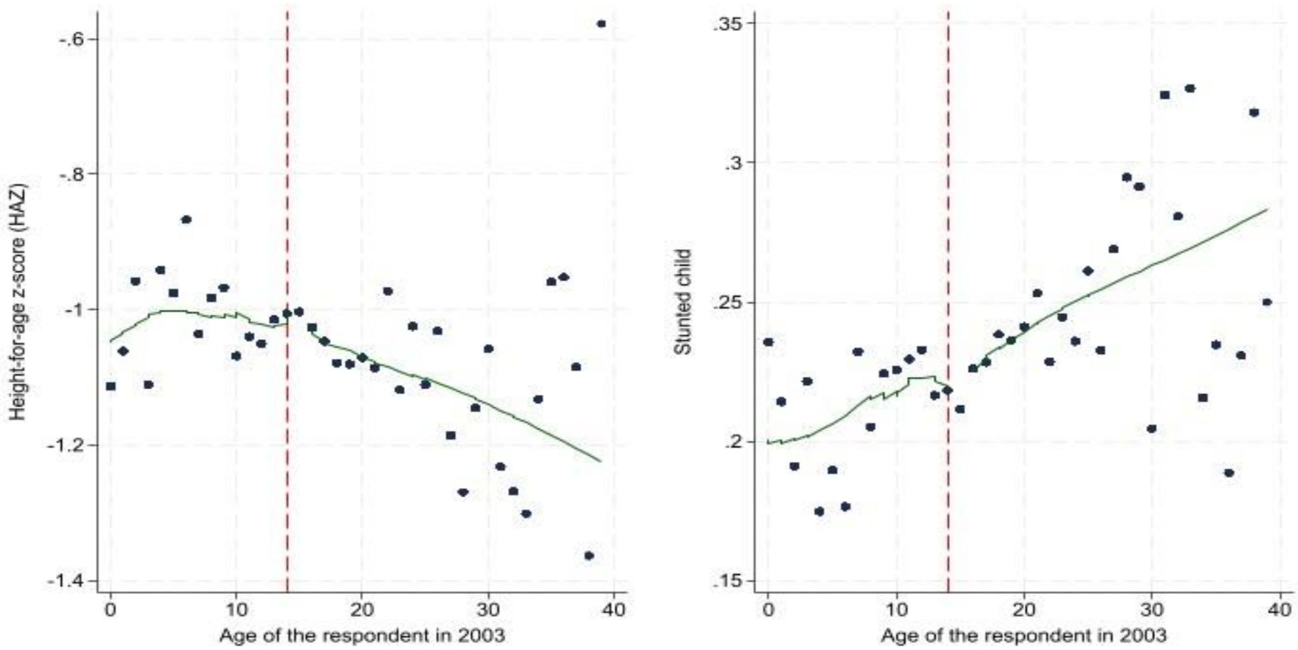
Source: authors' own elaboration

Figure 2: The impact of the 2003 education reform on maternal education in Kenya



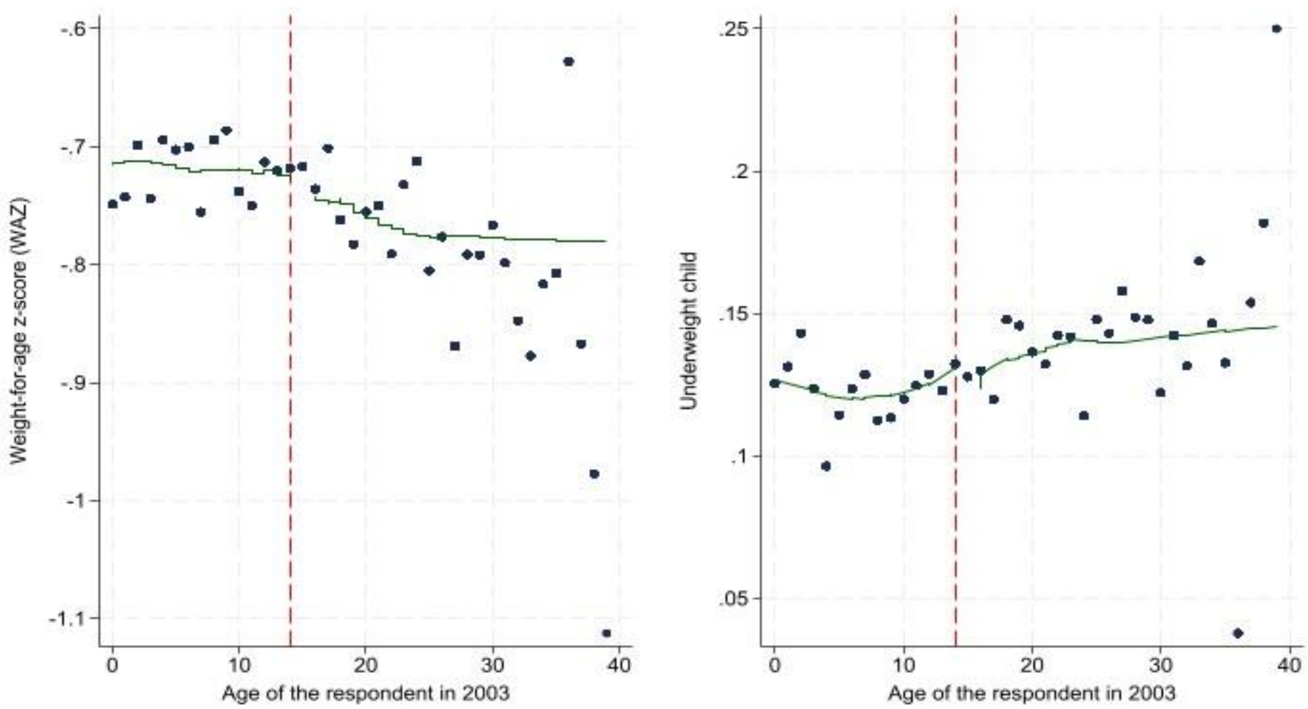
Notes: Each dot shows the average years of schooling for each age cohort with a local polynomial smoothing line plot for the treatment cohort (age 14 years and below in 2003) and control cohort (age 14 years and above in 2003). The vertical dotted line shows the discontinuity in years of schooling around the threshold of age 14 (in 2003). Source: authors' own elaboration using the Kenya Demographic Health Survey (KDHS) 2014 and 2022.

Figure 3: The impact of the 2003 education reform on height-for-age and child stunting in Kenya



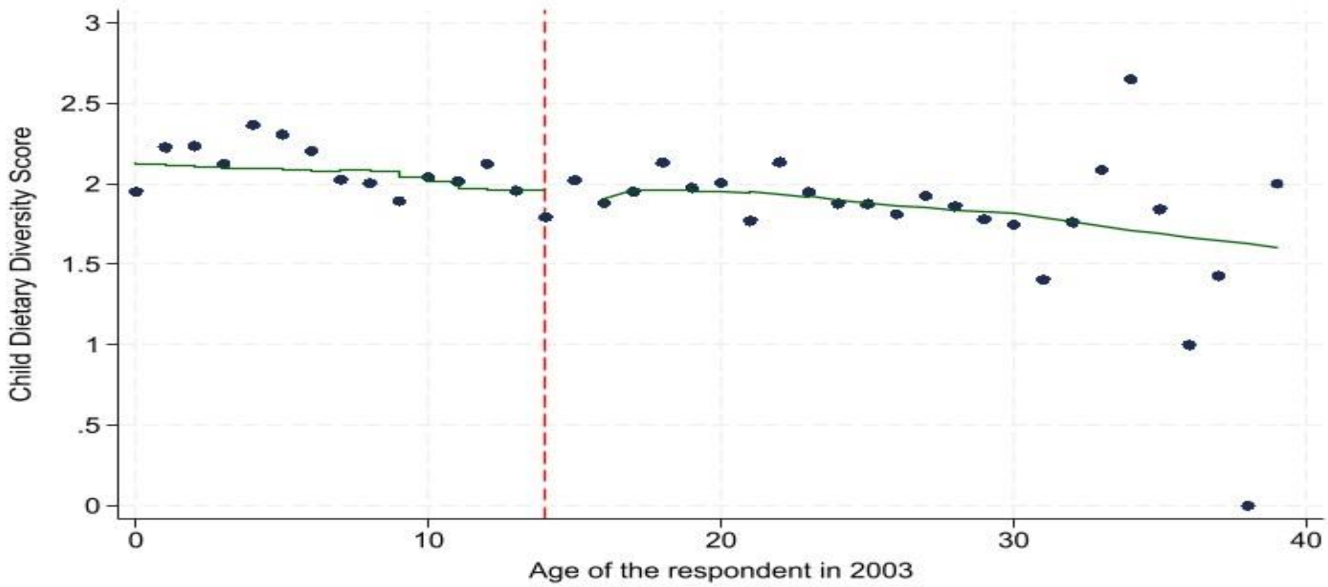
Source: authors' own elaboration using the Kenya Demographic Health Survey (KDHS) 2014 and 2022.

Figure 4: The impact of the 2003 education reform on weight-for-age and child underweight in Kenya



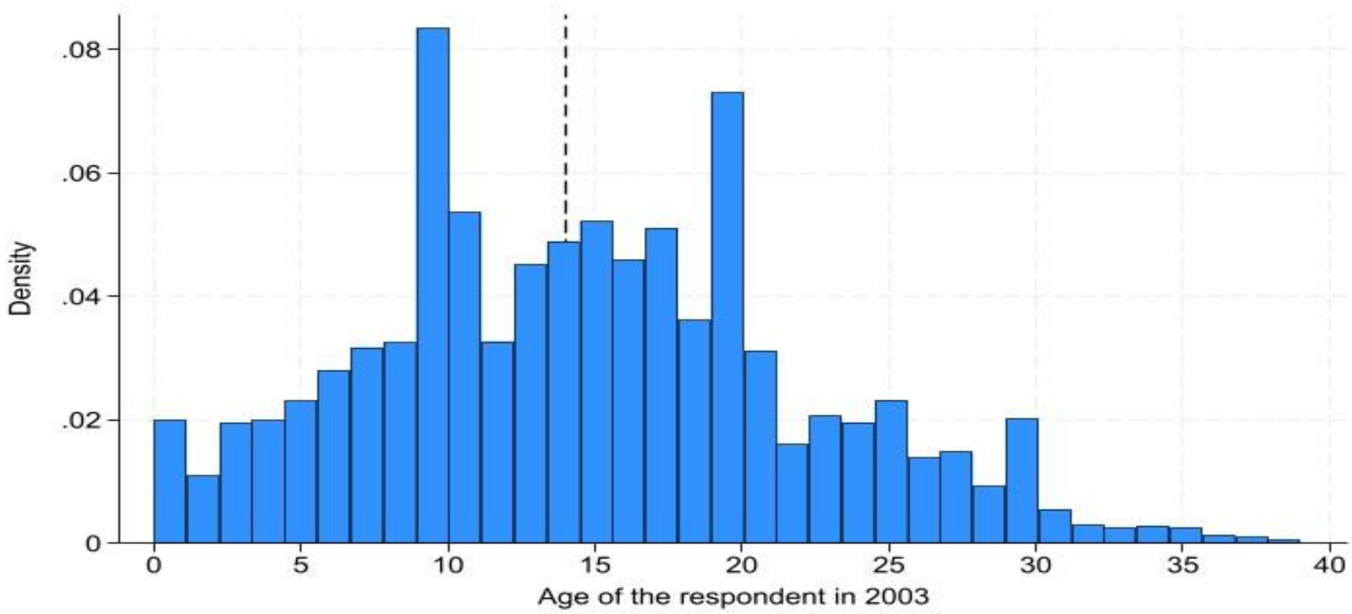
Source: author's own elaboration using the Kenya Demographic Health Survey (KDHS) 2014 and 2022.

Figure 5: The impact of the 2003 education reform on child dietary diversity in Kenya



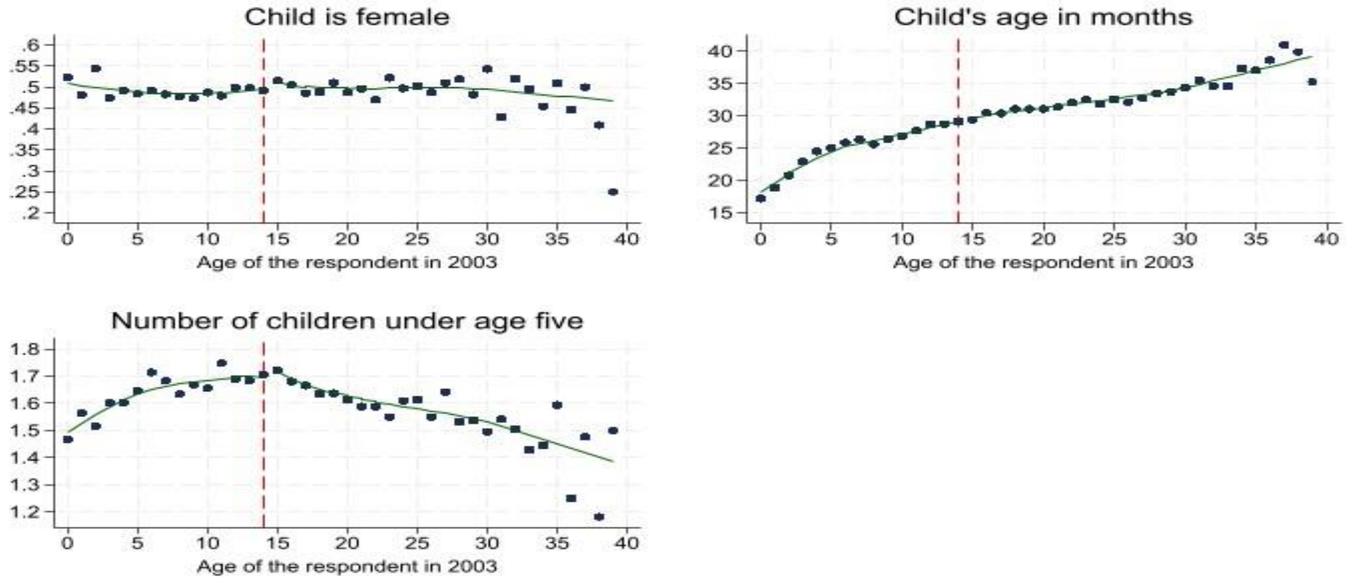
Source: authors' own elaboration using the Kenya Demographic Health Survey (KDHS) 2014 and 2022.

Figure 6: Histogram plot of the respondent's age in 2003 (running variable) to check for bunching/manipulation/potential discontinuities at the age 14 threshold



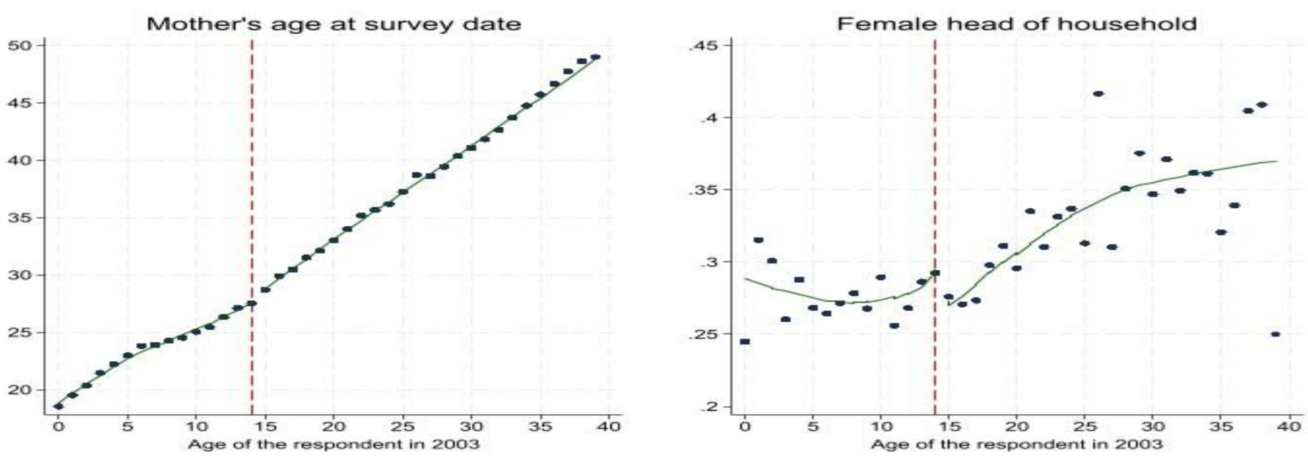
Source: authors' own elaboration using the Kenya Demographic Health Survey (KDHS) 2014 and 2022.

Figure 7: Smoothness of the explanatory variables used in the analysis: child-level variables



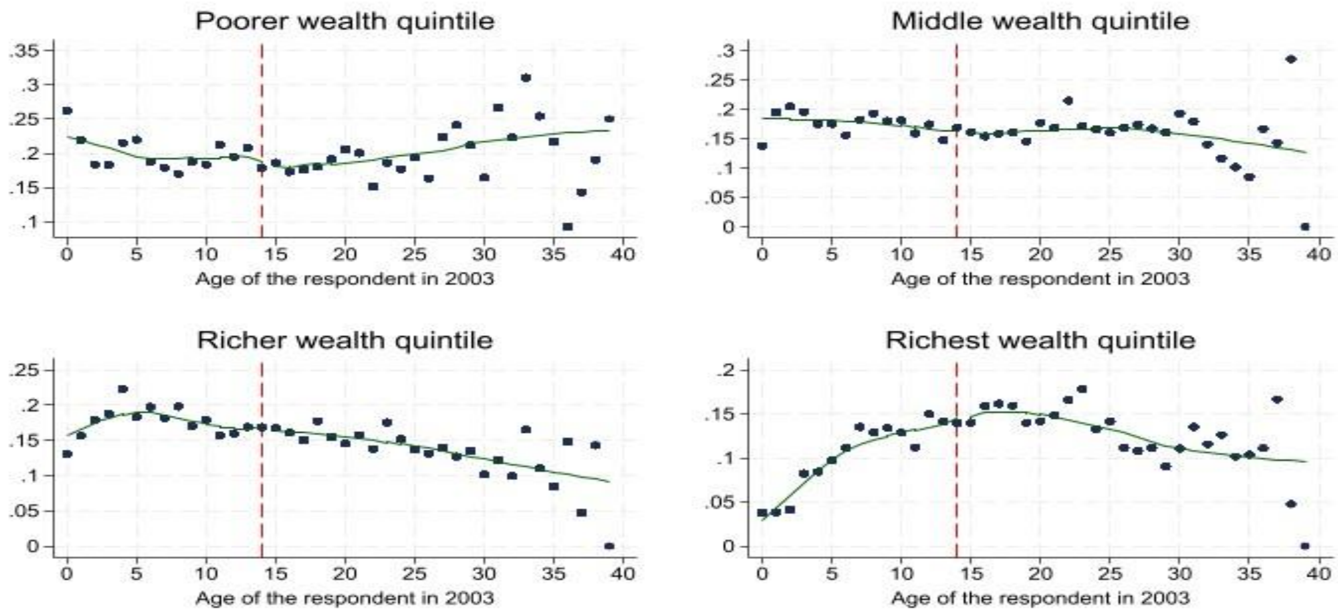
Notes: Figure 8 shows the graphs assessing the smoothness of the explanatory variables at the child-level used in the regression models to determine the possible discontinuities of these variables that are impacting our empirical estimates in the analysis over the years of schooling. Source: authors' own elaboration using the Kenya Demographic Health Survey (KDHS) 2014 and 2022.

Figure 8: Smoothness of the explanatory variables used in the analysis: mother-level variables



Notes: Figure 9 shows the graphs assessing the smoothness of the explanatory variables at the mother-level used in the regression models to determine the possible discontinuities of these variables that are impacting our empirical estimates in the analysis over the years of schooling. Source: authors' own elaboration using the Kenya Demographic Health Survey (KDHS) 2014 and 2022.

Figure 9: Smoothness of the explanatory variables used in the analysis: mother-level variables (wealth quintile)



Notes: Figure 10 shows the graphs assessing the smoothness of the explanatory variables at the mother-level (Wealth Quintile) used in the regression models to determine the possible discontinuities of these variables that are impacting our empirical estimates in the analysis over the years of schooling. Source: authors' own elaboration using the Kenya Demographic Health Survey (KDHS) 2014 and 2022.