Infant Mortality and Desired Fertility: The Case of the Free Health Care Initiative in Sierra Leone

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ABSTRACT Sierra Leone launched the Free Health Care Initiative, which abolished health user fees for pregnant and breastfeeding women and children under five years of age, in 2010. Combining data from the Demographic and Health Survey and a geocoded dataset for the distribution of public health facilities, I design a difference-in-differences study involving birth timing and transportation cost to investigate its impact on infant mortality and desired fertility. I find that the program does not achieve its goal of reducing infant mortality, with the lack of vaccination being a major problem. Notwithstanding the lack of reduction in infant mortality, the program leads to a significant decline in desired fertility, implying that parents may overestimate the program’s benefits and change their expectations of infant mortality accordingly. Heterogeneous effects by household wealth suggest that poor households are more adversely affected by the program than wealthy ones.

KEYWORDS: Health reform; infant mortality; desired fertility; Sierra Leone; Africa

JEL CLASSIFICATION CODES: I18; J13; O12

1. Introduction
Infant and child health are internationally recognized public policy foci, as targeted by the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs). They are not only directly related to infant and child well-being but also have long-term impacts on human capital accumulation and socioeconomic status in adulthood (Behrman & Rosenzweig, 2004; Gensowski, Nielsen, Nielsen, Rossin-Slater, & Wüst, 2019; Maccini & Yang, 2009; Smith, 2009). An obvious measure for improving infant and child health is to provide affordable healthcare for every family. Sierra Leone implemented such a program in April 2010—the Free Health Care Initiative (FHCI)—in response to the very high maternal, infant, and child mortality rates. The FHCI is a system of free healthcare for pregnant and breastfeeding women and children under five years of age.

Since the implementation of the FHCI, the under-five mortality rate in Sierra Leone has fallen significantly from 203.6 per 1,000 live births in 2005 to 153.9 per 1,000 live births in 2011,
and it has decreased further to 105.1 per 1,000 live births in 2018. While some studies attributed the decrease in under-five mortality to the FHCI (Health & Education Advice & Resource Team, 2016; Witter et al., 2018), it should be noted that compared with other countries, the under-five mortality rate in Sierra Leone was still high. In 2018, it was only lower than Somalia, Nigeria, Chad, and the Central African Republic. This implies that the decline in under-five mortality may reflect a time trend similar to most countries, rather than the impact of Sierra Leone’s health reform (Liu et al., 2016).

The fact that the FHCI has been implemented nationwide in all public health facilities and all states simultaneously makes it difficult to find an identification strategy that rigorously investigates the impact of the program. Quantitative studies are therefore limited, with most simply comparing the health outcomes before and after the program (Edoka et al., 2016), which cannot isolate the time trend from the program’s impact. Combining data from the 2013 Sierra Leone Demographic and Health Survey (SLDHS) and a geocoded dataset for the distribution of public health facilities, I design a difference-in-differences (DID) study to explore the impact of the FHCI. The first difference compares infants born before and after the reform. The second difference comes from the density of public health facilities, considering that transportation costs have become a significant barrier since the reform exempting pregnant and breastfeeding women and children under five years of age from medical charges. While the parallel trend assumption test shows the validity of my DID strategy, a limitation of this study is that there is no alternative DID design to cross-check the estimated effects.

Upon investigating the FHCI effect on infant deaths before the age of one, which accounts for 80 per cent of the deaths before the age of five in my sample, the results suggest that the FHCI does not reduce infant mortality. Next, I examine whether the lack of vaccination is a major problem. Recommended vaccinations before the age of one include BCG, polio (three doses), DPT (three doses), and measles. The number of doses given to an infant is summed and standardized by a total of eight doses to measure its vaccination. The results suggest that the FHCI reduces the likelihood of infants getting vaccinated, an effective measure to reduce infant mortality, which offsets the benefits of the FHCI. Therefore, my study builds on a growing body of literature on the impact of health reforms on infant and child health in developing countries (Camacho & Conover, 2013; Cesur, Güneş, Tekin, & Ulker, 2017; Chen & Jin, 2012; Gruber, Hendren, & Townsend, 2014; Powell-Jackson, Mazumdar, & Mills, 2015).

In addition, my study also relates to a large body of literature exploring fertility responses to infant and child mortality. Since Schultz (1969) first establishes a causal relationship between child mortality and fertility, the literature has identified two transmission mechanisms (Ben-Porath, 1976; Kalemli-Ozcan, 2003; Montgomery & Cohen, 1998; Preston, 1978; Sah, 1991; Schultz, 1976). First, the hoarding effect is the fertility response to expected child mortality. It arises from couples in high-mortality settings with more births than the optimal number, with the expectation that some of their children may die in the future. Second, the replacement effect is the fertility response to experienced child mortality. On the one hand, in the absence of contraceptive use, mothers experiencing the death of a child are more likely to become pregnant due to the end of lactational amenorrhea, leading to physiological replacement. On the other hand, to achieve the desired number of surviving children, couples intentionally have additional children in response to the death of their children, leading to volitional replacement.

Most studies with quantitative evidence focus on the replacement effect in developing countries (Kraehnert, Brück, Maio, & Nisticò, 2019; Maglad, 1994; Mauskopf & Wallace, 1984; Olsen, 1980; Palloni & Rafalimanana, 1999) because data on mortality expectations are not routinely collected (Canning, Günther, Linnemayr, & Bloom, 2013), and temporary mortality shocks due to one-time events, such as war and natural disasters, can hardly change expectations about future mortality (Nobles, Frankenberg, & Thomas, 2015). As a presidential flagship program aimed at reducing the mortality rate of children under five years of age, the FHCI, with strong political commitment and public demand (Witter et al., 2018), has the potential to
change mortality expectations, providing an opportunity to investigate the hoarding effect in Sierra Leone.

Before the FCHI, Sierra Leone had experienced a continuous decline in fertility since the 1990s. This downward trend has not changed since the implementation of the FCHI. In 2019, the average number of births per woman was 4.2, well below 5.3 in 2009 and 6.4 in 1999. Using the birth timing of the last child and the density of public health facilities as the two differences in the DID design, I find that the FCHI has indeed reduced the desired number of children reported by women, although it has not reduced infant mortality. How lower desired fertility reported by women will affect actual fertility also depends on whether their husbands agree with them on the desired number of children. If preferences are heterogeneous, reproductive decisions are more likely to be made by household members with greater intrahousehold bargaining power (Rasul, 2008; Thomas, 1990). As polygamy is practiced in Sierra Leone and approximately half of the women in my sample report that their husbands have other wives, husbands are likely to have more bargaining power within each marriage. My estimates point toward no disagreement between women and their husbands about having fewer children. Together, the findings imply that parents overestimate the program’s benefits compared with my estimate and change their expectations of mortality, accordingly, leading to a decline in the insurance demand for children.

The remainder of this paper is organized as follows: Section 2 introduces the background of the FCHI in Sierra Leone. Section 3 presents the conceptual framework to formalize how the FCHI can potentially affect infant mortality and desired fertility. Section 4 describes the data and outlines the identification strategy used. Section 5 discusses the main results and heterogeneous effects by household wealth. Section 6 concludes with implications of the findings for policymaking.

2. Background

In April 2010, the Government of Sierra Leone launched the FCHI, with the main objective of reducing the extremely high mortality rates of mothers and children under five years of age because of poor healthcare services and difficulties in accessing and using those services. While the government was ambitious in implementing the FCHI in all states simultaneously, the preparation period was relatively short. With the publication of a government strategy document entitled ‘Free Healthcare Services for Pregnant and Lactating Women and Young Children in Sierra Leone’ in November 2009, President Koroma announced the exact launch date to the public in a speech at a donors’ conference in London in the same month (Donnelly, 2011). This gave the Ministry of Health and Sanitation (MOHS) only five months to prepare for the forecasted increase in the utilization of healthcare services. Driven by a steering committee and six working groups, the preparatory work involved themes chosen by a group of key stakeholders with the most pressing priorities, including financing, infrastructure, drugs and logistics, monitoring and evaluation, human resources, and communication (Witter, Brikci, et al., 2016).

Funded mainly by the United Kingdom and the United Nations, the FCHI constitutes a package of interventions on both the demand and supply sides. The core intervention is to remove user fees for pregnant and breastfeeding women and children under five years of age. Specifically, the target beneficiaries are exempted from paying any medical charges, including consultation fees, medicines, and medical supplies in all government health facilities as well as in non-governmental organizations and missionary health facilities contracted by the government to provide free healthcare (Edoka et al., 2016). On the supply side, interventions in seven areas (drugs and medical supplies, health workforce, governance, infrastructure, communication with the general public, monitoring and evaluation, and financing) seek to strengthen the health system’s function in response to the forecasted increase in the utilization of healthcare services, namely, (i) the continuous availability of equipment, drugs, and other essential
commodities; (ii) an adequate number of qualified health workers; (iii) strengthened and effective oversight and management arrangements; (iv) adequate infrastructure to deliver services; (v) more and better information, education, and communication to stimulate demand for free high-quality healthcare services; (vi) a comprehensive monitoring and evaluation system; and (vii) sufficient funds to finance the FHCI (Witter et al., 2018).

The FHCI does not substantially change the facility-based healthcare services on the supply side; that is, the target beneficiaries still have to bear the transportation cost to receive services at public health facilities. However, as household out-of-pocket payments accounted for ~70 per cent of the total health expenditure before the implementation of the FHCI (Supplementary Materials Appendix Table 1), the removal of user fees has made healthcare services more affordable to the target beneficiaries, leading to an increase in their utilization. For example, some studies have shown that the FHCI has increased the utilization of public facilities for antenatal care, delivery, and post-natal care by women as well as for vaccination and surgical care for children under five years of age (Edoka et al., 2016; Groen, Kamara, Nwomeh, Daoh, & Kushner, 2013; Jalloh et al., 2019; Witter et al., 2018).

Notwithstanding this systematic health reform, Sierra Leone was unable to meet its MDG4 target—reducing the maternal mortality ratio to 450 per 100,000 births—and MDG5 target—reducing under-five mortality to 95 per 1,000 live births (Government of Sierra Leone, 2016). Given the more ambitious SDG3 target of reducing the global maternal mortality ratio to <70 per 100,000 live births and under-five mortality to at least as low as 25 per 1,000 live births, the FHCI has entered into a new era with significant gaps in various health indicators (WHO, 2017). Interview-based studies and descriptive evidence have pointed out the lack of drugs (Koroma et al., 2019) and diagnostics (Koroma et al., 2017) as major problems, although there have been improvements in the quantity and performance of health workers (Witter, Wurie, & Bertone, 2016). In addition to the medicines being lost or illegally sold for profit, poor infrastructure adds another layer of problems. On the supply side, a lack of electricity, running water, and blood for transfusions make emergency care unreliable. On the demand side, many patients cannot reach health facilities because of tumultuous rivers or flooded dirt roads (Maxmen, 2013).

3. Conceptual framework

3.1. Infant mortality

In economic models where life is not explicitly modeled as a choice variable, death can be expressed as an exhaustive state that occurs when the accumulated health stock fails to exceed a critical value (Sickles & Taubman, 1997). The FHCI can affect infant mortality by changing the health inputs before and after birth. Following Rosenzweig and Schultz (1983), let the health of infant \( j \) born to mother \( i \) at birth be given as the health production function:

\[
H_{ij0} = \Gamma(Z_{ij0}) + \mu_i + \epsilon_{ij0}
\]

where \( Z_{ij0} \) are prenatal inputs; \( \mu_i \) is the health endowment shared by all infants born to mother \( i \), which contains genetic and environmental attributes affecting infant health; and \( \epsilon_{ij0} \) is the stochastic component of health that is observed at the birth of the infant. The production of health after birth is a cumulative process, with prenatal inputs and stochastic events at birth having persistent effects after birth. Letting \( Z_{ij1} \) and \( \epsilon_{ij1} \) denote health inputs and the stochastic component of health after birth, respectively, the health production function is

\[
H_{ij1} = \Gamma(Z_{ij0}, Z_{ij1}, \epsilon_{ij0}) + \mu_i + \epsilon_{ij1}
\]
In the dynamic optimization model, the demand for prenatal inputs \( (Z_{ij0}) \) is a function of prices, income, and health endowment \( (\mu_i) \). In addition to these factors, the demand for inputs after birth \( (Z_{ij1}) \) is also determined by the realized stochastic health disturbances observed at the birth of the child \( (\epsilon_{ij0}) \).

In the context of Sierra Leone, the prices of health inputs for pregnant and breastfeeding women and children under five years of age have been reduced by the free healthcare provided by the FHCI. The decreased prices can stimulate the target beneficiaries’ demand for health inputs before and after birth, leading to improvements in infant health at birth and thereafter. However, two issues may prevent the FHCI from generating benefits. First, when seeking healthcare services, the target beneficiaries must bear transportation costs. Travel time from home to public health facilities as a health endowment \( (\ell_i) \) becomes a source of heterogeneity across families. Second, if the demand for health inputs increases too much, the lack of medical supplies cannot meet the demand.

3.2. Desired fertility

Women’s desired fertility is determined at the start of their childbearing years and modified over time in light of events that can change their expectations of child mortality. Following Kalemli-Ozcan (2003) and Canning et al. (2013), the utility of household \( i \) comes from consumption and the future income of the surviving children, which can be written as

\[
U(C_i, N_i) = U_1(C_i) + U_2(N_ih_iw)
\]

where \( C_i \) is household consumption, \( N_i \) is the number of surviving children, \( h_i \) is the human capital of the surviving children, and \( w \) is the wage rate per unit of human capital that the surviving children will earn. The human capital of children depends on the human capital of the guardians and the parenting time invested by the guardians (denoted by \( h^G_i \) and \( e_i \), respectively), according to

\[
h_i = \phi(h^G_i, e_i)
\]

Assuming a fixed time cost, \( v \in (0, 1) \), for each child. With the number of births \( n_i \), the time left for the household after the time spent on children is deducted as \( 1 - (v + e_i)n_i \). Letting \( m_i \) be the non-labor household income and \( w^G_i \) be the wage rate per unit of human capital the guardians earn, the budget constraint is

\[
C_i = m_i + w^G_i h_i(1 - (v + e_i)n_i)
\]

Let \( q_i \) be the survival probability for each child. With uncertainty, the number of surviving children \( N_i \) is a random variable drawn from a binomial distribution. The probability that \( N_i \) out of \( n_i \) children will survive is:

\[
f(N_i; n_i, q_i) = \binom{n_i}{N_i} q_i^{N_i} (1 - q_i)^{n_i - N_i}
\]

Maximizing expected household utility subject to the budget constraint gives the optimal level of fertility \( n_i^* \) and investment in children’s human capital \( e_i^* \). They depend on the survival rate \( q_i \), the human capital of the guardians \( h^G_i \), and the non-labor household income \( m_i \).

Kalemli-Ozcan (2003) shows that due to uncertainty incorporated through the variation in the survival rate, households engage in a hoarding strategy and overshoot their desired fertility. An exogenous increase in the survival rate (i.e. an exogenous decrease in the mortality rate) can
reduce the insurance demand for children, thereby leading to a decrease in desired fertility and an increase in human capital investment. In the absence of measures of human capital investment in the data, I focus on desired fertility as a response to the change in the expected mortality caused by the FHCI.

4. Data and identification strategy

4.1. Data

Data on child death, child vaccination, and desired fertility are obtained from the 2013 SLDHS, which is the only survey conducted between the implementation of the FHCI in 2010 and the outbreak of Ebola in 2014. It records the complete birth histories of women between the ages of 15 and 49, in which detailed health outcomes, such as vaccination, are reported for children under five years of age at the time of the survey (born between 2008 and 2013). This allows me to identify the birth timing (month and year) for a representative sample of children and their mothers. Since the chance of having a child is much lower for older women, they may be systematically different from younger women in terms of health and family conditions. Hence, I restrict the sample to women who gave their last birth before the age of 40, as suggested by the fact that <2 per cent of women in the SLDHS data gave birth to children at age 40 or older (see Figure 1). This gives me a sample of 7,525 mothers and 8,323 children from 6,452 households. Using the birth month and year as the basic time unit for analysis, the child sample includes children born between July 2008 and September 2012 (see the distribution in Supplementary Materials Appendix Table 2). The last births of the mother sample are between July 2008 and October 2013 (see the distribution in Supplementary Materials Appendix Table 3). Table 1 provides the descriptive statistics on data used for analysis and shows the proportion of individuals treated by the reform for the two samples. While 83 per cent of women’s last children are born after the FHCI, the child sample is more balanced in terms of exposure to the FHCI, with 59 per cent of children born in April 2010 or later.

Information on health facilities was collected and geolocated by Standby Task Force volunteers from open, online sources. Sixty-nine per cent of the public health facilities are covered by data from the MOHS and the District Health Information System. Among the 13 health districts, I exclude Kenema from the analysis because most facilities’ ownership in Kenema is unknown. Although SLDHS also geographically identifies the primary sampling units (PSUs),
their coordinates are randomly replaced to ensure that respondent confidentiality is maintained. Due to this random error, measuring the direct distance from the PSUs to the public health facilities is inaccurate. Hence, I use the density of public health facilities to capture the potential transaction costs for each health district (see Figure 2). With 0.124 public health facilities per square kilometer, the Western Area leads to other districts. While districts in the Southern (0.013–0.017/km²) and Eastern provinces (0.015–0.018/km²) do not have many within-province variations, Koinadugu significantly lags behind Kambia in the Northern Province (0.008 vs. 0.033/km²).

The density of public health facilities may be correlated with other public programs that affect infant health, particularly health and transportation programs. To address potential endogeneity due to omitted investments, I use aid data collected and geolocated by a research lab at William & Mary’s Global Research Institute to capture investments in health,

|                     | Mean   | Standard deviation | Number of observations |
|---------------------|--------|--------------------|-----------------------|
| **Outcome variables** |        |                    |                       |
| Child died before the age of one (0/1 dummy) | 0.093  | 0.291              | 8,323                 |
| Child got vaccinated (number of doses out of total eight doses) | 0.723  | 0.399              | 8,323                 |
| Ideal number of children reported by mother | 5.103  | 2.044              | 7,231                 |
| Husband desires more children (0/1 dummy) | 0.321  | 0.467              | 3,136                 |
| **Child characteristics** |        |                    |                       |
| Born after the FHCI (0/1 dummy) | 0.585  | 0.493              | 8,323                 |
| Girl (0/1 dummy) | 0.500  | 0.500              | 8,323                 |
| First child (0/1 dummy) | 0.240  | 0.427              | 8,323                 |
| Second child (0/1 dummy) | 0.193  | 0.394              | 8,323                 |
| Third child (0/1 dummy) | 0.158  | 0.365              | 8,323                 |
| Fourth child (0/1 dummy) | 0.142  | 0.350              | 8,323                 |
| Fifth child (0/1 dummy) | 0.109  | 0.312              | 8,323                 |
| Sixth child (0/1 dummy) | 0.068  | 0.252              | 8,323                 |
| Birth order >6 (0/1 dummy) | 0.090  | 0.286              | 8,323                 |
| **Mother characteristics** |        |                    |                       |
| Last child born after the FHCI (0/1 dummy) | 0.829  | 0.377              | 7,525                 |
| Birth year | 1985   | 6.558              | 7,525                 |
| No education (0/1 dummy) | 0.648  | 0.478              | 7,525                 |
| Primary education (0/1 dummy) | 0.138  | 0.345              | 7,525                 |
| Secondary education (0/1 dummy) | 0.199  | 0.400              | 7,525                 |
| Higher education (0/1 dummy) | 0.015  | 0.123              | 7,525                 |
| Household head (0/1 dummy) | 0.118  | 0.322              | 7,525                 |
| Head’s wife (0/1 dummy) | 0.534  | 0.499              | 7,525                 |
| Head’s daughter (0/1 dummy) | 0.128  | 0.334              | 7,525                 |
| Head’s daughter-in-law (0/1 dummy) | 0.058  | 0.233              | 7,525                 |
| Other relationships to head (0/1 dummy) | 0.163  | 0.369              | 7,525                 |
| Monogamous marriage (0/1 dummy) | 0.550  | 0.498              | 7,525                 |
| **Household characteristics** |        |                    |                       |
| Poorest households (0/1 dummy) | 0.220  | 0.414              | 6,452                 |
| Poorer households (0/1 dummy) | 0.195  | 0.396              | 6,452                 |
| Middle households (0/1 dummy) | 0.194  | 0.395              | 6,452                 |
| Richer households (0/1 dummy) | 0.225  | 0.417              | 6,452                 |
| Richest households (0/1 dummy) | 0.166  | 0.373              | 6,452                 |
| Have land for agriculture (0/1 dummy) | 0.610  | 0.488              | 6,452                 |
| Number of household members | 6.866  | 3.073              | 6,452                 |
| Age of household head | 42.545 | 13.819             | 6,452                 |
| Female household head (0/1 dummy) | 0.264  | 0.441              | 6,452                 |

*Source:* Own calculation from SLDHS.
transportation, and the rest of all other sectors. The project disbursement is split evenly every year during the project period. In line with the implementation of the FHCI, health aid in all districts except the Western Area increased in 2010 (reported in Table 2). On average, there was a substantial increase in health aid and transportation aid in 2010 (see Supplementary Materials Appendix Figure 1), suggesting that omitting these control variables is likely to bias the estimated effects of the FHCI.

4.2. Identification strategy

The theoretical model of health production discussed in Section 3.1 helps to formalize how family-specific travel time from home to public health facilities as a health endowment can potentially affect health outcomes. A large body of quantitative analyses also links long travel times to increased child mortality in low- and middle-income countries (Karra, Fink, & Canning, 2017; Okwaraji & Edmond, 2012; Schoeps, Gabrysch, Niamba, Sié, & Becher, 2011). In Sierra Leone, qualitative studies have shown that the distance to health facilities and the lack of accessible and affordable vehicles are significant barriers to women and children using the FHCI (Scott, McMahon, Yumkella, Diaz, & George, 2014; Treacy, Bolkan, & Sagbakken, 2018), thus suggesting that in the absence of medical expenses, transportation costs have become the main cost for seeking healthcare services. Hence, although the FHCI was implemented nationwide in April 2010, the variation in the density of public health facilities across districts allowed the addition of another layer of difference based on a comparison in terms of birth timing. This can help to overcome the bias of the time trend in the outcome variables (see Supplementary Materials Appendix Figure 2). The DID specification to be estimated is

\[ Y_{imhdt} = \beta_1 R_{imhdt} * H_d + \beta_2 C_{imhdt} + \beta_3 X_{imhdt} + \beta_4 Z_{hd} + \beta_5 A_d + \mu_t + \lambda_d + \epsilon_{imhdt} \]  

(7)

where \( Y_{imhdt} \) is the health outcome captured by infant mortality or vaccination before the age of one. Specifically, infant mortality is measured by a binary variable for children’s death before the age of one, and vaccination is measured by the number of doses vaccinated out of a total of 2008 F. Xia
| Health district | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  |
|-----------------|-------|-------|-------|-------|-------|-------|
| Kailahun Health aid | 4.656 | 5.312 | 13.817 | 10.241 | 10.435 | 10.403 |
| Transportation aid | 3.617 | 3.617 | 8.149 | 8.149 | 2.724 | 2.724 |
| Other aid | 45.798 | 36.776 | 41.800 | 45.338 | 42.614 | 41.801 |
| Kenema Health aid | 14.081 | 12.875 | 15.050 | 11.501 | 11.923 | 11.806 |
| Transportation aid | 16.324 | 48.862 | 51.609 | 43.785 | 41.733 | 41.679 |
| Other aid | 58.381 | 56.363 | 49.954 | 59.813 | 49.520 | 48.856 |
| Kono Health aid | 11.251 | 11.004 | 12.860 | 2.633 | 3.082 | 3.154 |
| Transportation aid | 6.802 | 6.802 | 11.333 | 11.333 | 5.833 | 6.304 |
| Other aid | 52.344 | 45.841 | 58.347 | 36.407 | 27.921 | 26.883 |
| Bombali Health aid | 9.701 | 10.031 | 15.068 | 6.721 | 7.316 | 6.894 |
| Transportation aid | 16.210 | 16.210 | 21.603 | 21.603 | 21.933 | 21.933 |
| Other aid | 30.565 | 31.420 | 38.067 | 43.664 | 30.196 | 27.766 |
| Kambia Health aid | 4.096 | 4.110 | 5.144 | 5.144 | 2.998 | 2.332 |
| Transportation aid | 6.495 | 6.495 | 9.639 | 8.602 | 5.618 | 5.509 |
| Other aid | 15.509 | 15.133 | 24.208 | 24.757 | 23.224 | 16.042 |
| Koinadugu Health aid | 9.529 | 9.566 | 20.824 | 12.623 | 13.024 | 12.877 |
| Transportation aid | 2.647 | 2.647 | 14.412 | 14.412 | 8.370 | 8.370 |
| Other aid | 55.302 | 49.061 | 59.383 | 57.572 | 53.960 | 51.770 |
| Port Loko Health aid | 9.502 | 10.249 | 10.579 | 10.381 | 10.782 | 10.770 |
| Transportation aid | 30.396 | 64.076 | 72.978 | 51.500 | 49.159 | 48.920 |
| Other aid | 22.453 | 28.729 | 29.606 | 36.798 | 31.555 | 29.644 |
| Tonkolili Health aid | 9.600 | 9.938 | 13.922 | 12.398 | 12.757 | 13.117 |
| Transportation aid | 18.471 | 18.471 | 26.557 | 19.743 | 14.361 | 15.540 |
| Other aid | 32.113 | 36.826 | 38.159 | 37.566 | 26.750 | 25.294 |
| Bo Health aid | 11.581 | 11.962 | 13.506 | 11.256 | 11.851 | 12.361 |
| Transportation aid | 24.217 | 24.217 | 28.260 | 14.633 | 14.924 | 14.924 |
| Other aid | 33.511 | 33.369 | 28.589 | 32.727 | 21.517 | 18.953 |
| Bontha Health aid | 10.051 | 10.057 | 12.144 | 10.200 | 10.766 | 11.233 |
| Transportation aid | 2.647 | 2.647 | 2.647 | 2.647 | 2.647 | 2.647 |
| Other aid | 19.987 | 19.720 | 21.346 | 18.296 | 10.347 | 9.790 |
| Moyamba Health aid | 6.091 | 6.147 | 7.995 | 4.485 | 5.083 | 5.600 |
| Transportation aid | 27.255 | 27.255 | 28.606 | 1.360 | 3.628 | 3.616 |
| Other aid | 36.605 | 42.829 | 43.027 | 46.289 | 18.083 | 18.346 |
| Pujehun Health aid | 2.986 | 3.380 | 6.147 | 3.932 | 4.428 | 4.492 |
| Transportation aid | 1.037 | 1.287 | 1.443 | 0.165 | 0.785 | 1.579 |
| Other aid | 17.786 | 19.089 | 20.512 | 15.241 | 15.714 | 14.165 |
| Western area Health aid | 3.781 | 3.046 | 2.625 | 2.808 | 3.311 | 3.913 |
| Transportation aid | 20.817 | 24.364 | 34.992 | 31.698 | 25.739 | 17.257 |
| Other aid | 74.821 | 87.621 | 86.151 | 77.642 | 69.350 | 66.474 |

Source: AidData. The data source was accessed on December 20, 2021. [http://aiddata.org/research-datasets](http://aiddata.org/research-datasets).
eight doses before the age of one. $R_{tmhdt}$ is the birth timing $t$ (month and year) for child $i$ born to mother $m$ in household $h$ and district $d$. It is a binary variable that is equal to one for children born in April 2010 or later, indicating the difference between children born before and after the FHCI. $H_d$ is the density of public health facilities in district $d$ in 2010, indicating the difference in transportation costs. The interaction of $R_{tmhdt}$ and $H_d$ rather than themselves is included in Equation (7) because they are fully absorbed by birth-timing fixed effects ($\mu_t$) and district fixed effects ($\lambda_d$), respectively. In addition, $\mu_t$ captures the time trend for each cohort born in the same month and year, and $\lambda_d$ also controls for common shocks within a district.

$C_{tmhdt}$ is a vector of infant characteristics, including gender and birth order. $X_{tmhdt}$ is a vector of mother controls, including birth year, education level, relationship to household head, and type of marital status (whether the marriage is monogamous). $Z_{tmhdt}$ is a vector of household attributes including age and gender of household head, household wealth (wealth index and a binary variable for having land for agricultural production), and household size. These three sets of variables control for the initial health condition of infants and their guardian- and family-specific genetic and environmental attributes proposed by the theoretical model discussed in Section 3.1. $A_{dt}$ indicates a vector of aid amounts in different sectors (including health, transportation, and the rest of all other sectors), addressing the potential endogeneity due to omitted investments in each sector. $\varepsilon_{tmhdt}$ is the error term. Standard errors are two-way clustered by the district-specific birth years of children and mothers. The coefficient of interest is $\beta_1$, which captures the differential impact of the FHCI on children’s health outcomes with differential transportation costs.

To ensure that the transportation cost does not affect the health outcomes before the implementation of the FHCI, I exclude individuals born in April 2010 or later and test the parallel trend assumption by modifying Equation (7) as

$$Y_{tmhdt} = \gamma_1 O_{tmhdt} + \gamma_2 C_{tmhdt} + \gamma_3 X_{tmhdt} + \gamma_4 Z_{tmhdt} + \gamma_5 A_{dt} + \mu_t + \lambda_d + \varepsilon_{tmhdt}$$  \hspace{1cm} (8)

where $O_{tmhdt}$ is a binary variable that is equal to one for children born in April 2009 or earlier, and other variables are defined the same as Equation (7). Children born in April 2009 or earlier ($O_{tmhdt}$) are compared with the omitted cohort, including children born within one year before the implementation of the FHCI (between May 2009 and March 2010). By comparing with the omitted cohort born ‘just’ before the FHCI, $\gamma_1$ indicates the existence of a parallel trend if it is small and insignificant.

The specifications that I estimate to investigate the desired fertility are similar to Equations (7) and (8). Assuming that parents exposed to the FHCI update their expectations of infant and child mortality, desired fertility can be changed accordingly based on the theoretical model discussed in Section 3.2. I use the birth timing of the last child to measure parents’ exposure to the FHCI and identify whether their desired fertility is affected. Regarding the control variables, while $\mu_t$, $\lambda_d$, and $A_{dt}$ are still needed for the DID strategy, $C_{tmhdt}$, $X_{tmhdt}$, and $Z_{tmhdt}$ are also important determinants of desired fertility proposed by the theoretical model discussed in Section 3.2.

The main dependent variable is the ideal number of children reported by the mothers. However, it is important to note that older mothers are less likely to change their desired fertility than younger mothers, even if they are exposed to the FHCI. On the one hand, it is difficult to desire more children as the chance of having a child declines with age. On the other hand, it is impossible to desire fewer children if older mothers already have many children. I find that while women under 30 years of age need 1.6–2.9 children to achieve their ideal numbers, the difference between the ideal and actual numbers is <1 for women aged 30 and over (see Figure 3). Hence, women under 30 years of age are the main sample for exploring the impact of the FHCI on mothers’ desired fertility. Finally, to investigate whether there is intrahousehold disagreement between mothers and fathers in terms of desired fertility, the ideal number of children reported by mothers is also replaced with a dependent variable measuring fathers’ desired fertility.
Notably, Sierra Leone is a country with very active inter-regional migration. According to the 2015 population and housing census, 25 per cent of the total population did not live in the district where they were born. The recent in-and out-migration defined by comparing the places of residence over five years is estimated to be 5–7 per cent on average. As inter-regional migratory exchanges are so dynamic in Sierra Leone, children born before the survey may have moved to the current districts with their households from other districts. Consequently, it is rather inaccurate to use the density of public health facilities in current districts to measure the transportation cost at birth and during infancy. To address this issue, I use the inverse share of recent-in migrants as the sample weight (reported in Supplementary Materials Appendix Table 4) for all the estimations, which gives smaller weight to districts with more active inter-regional migration. The unweighted estimates are also reported in Supplementary Materials Appendix Table 5 for comparison.

5. Results

5.1. Infants’ health outcomes

Table 3 presents the results of infant mortality. No statistically significant effect of the FHCI on infant mortality is detected (Column 1). The 95 per cent confidence interval suggests that the change in the conditional mean of infant mortality with respect to the FHCI is estimated to be between −0.08 and 0.52. As the primary interest of this study is to examine the effectiveness of the FHCI aimed at reducing infant mortality rather than investigating whether or not the FHCI has any impact, testing \( \beta_1 \leq 0 \) can provide more direct evidence than testing \( \beta_1 = 0 \). Therefore, I further conduct a one-sided test with the null hypothesis of \( \beta_1 \leq 0 \), which is rejected at a significance level of 10 per cent, indicating that the FHCI does not achieve its goal. This result is robust to controlling for aid in more sectors (see Column 2). Finally, the parallel trend assumption is tested in Column 3, suggesting that the impact of the transportation cost on the oldest cohort is not significantly different from that on the cohort born within one year of the implementation of the FHCI.

One possible reason why the FHCI fails to reduce infant mortality is that medical supplies cannot meet the growing demand, leading to a decline in the quality of healthcare services (Koroma et al., 2017, 2019; Maxmen, 2013). I try to elucidate this issue by providing evidence...
on infant vaccination and exploring whether vaccination is an important channel through which the FHCI affects infant mortality. The relevant results are presented in Table 4.

Columns 1–3 of Table 4 present the results of infant vaccination. My estimate in Column 1 indicates a significant decline in the vaccination rate by 1.07, which is robust to controlling for aid in more sectors (Column 2). This means that the vaccination rate would decline by 12 per cent if the density of public health facilities increases from the lowest 0.008/km² to the highest 0.124/km² in the sample. The estimates in Column 3 support the parallel trend, suggesting that the transportation cost only affects children born after the FHCI, but not any cohort born before the FHCI. Columns 4–6 of Table 4 present the results showing how vaccination affects infant mortality and whether the FHCI reduces infant mortality once the vaccination channel is closed. First, I find that vaccination significantly reduces infant mortality by 46 per cent (Column 4). This estimate is robust to controlling for aid in more sectors (see Column 5). In addition, testing the parallel trend does not affect the vaccination-induced mortality reduction (Column 6). Second, my estimate in Column 4 indicates a significant decline in the mortality rate by 0.26 once the vaccination channel is closed, which is robust to adding variables for aid in more sectors (Column 5). This means that excluding the impact transmitted by vaccination, the mortality rate would decline by 3 per cent if the density of public health facilities increases from the lowest 0.008/km² to the highest 0.124/km² in the sample. The parallel trend is supported by the finding that there is no significant difference between the oldest cohort and the cohort born within one year of the implementation of the FHCI in terms of transportation cost (Column 6). Taken together, the results in Table 4 support my hypothesis that the lack of vaccination is an important factor in FHCI’s failure to reduce infant mortality.

5.2. Desired fertility

Table 5 presents results for the ideal number of children reported by mothers. With an estimate of −3.74, I find that women under 30 years of age desired fewer children if they are intensively exposed to the FHCI (Column 1), which is robust to controlling for aid in more sectors (Column 2). This means that women would desire 0.43 fewer children if the density of public health facilities increases from the lowest 0.008/km² to the highest 0.124/km² in the sample. The estimates in Column 3 support the parallel trend, suggesting that there is no differential impact in terms of the transportation cost for cohorts born before the FHCI. Conversely, no
Table 4. Infant vaccination and its role reducing infant mortality

| Infant vaccination | Infant mortality |
|--------------------|------------------|
| (1)                | (2)              | (3)           | (4)           | (5)           | (6)           |
| Born in April 2010 or later* | Density of public health facilities |
|                     | -1.068*** (0.258) | -1.064*** (0.264) | -0.264* (0.136) | -0.272** (0.127) |
| Born in April 2009 or earlier* | Density of public health facilities |
|                     | -0.174 (0.270) |                                 | -0.037 (0.208) |
| Vaccination         |                   |                   | -0.455*** (0.021) | -0.455*** (0.021) | -0.395*** (0.026) |
| Child controls      | Yes               | Yes               | Yes             | Yes           | Yes           |
| Mother controls     | Yes               | Yes               | Yes             | Yes           | Yes           |
| Household controls  | Yes               | Yes               | Yes             | Yes           | Yes           |
| Health aid          | Yes               | Yes               | Yes             | Yes           | Yes           |
| Transportation aid  | Yes               | Yes               | Yes             | Yes           | Yes           |
| Other aid           | No                | Yes               | Yes             | Yes           | Yes           |
| Observations        | 8,323             | 8,323             | 3,452           | 8,323         | 8,323         |
| R-squared           | 0.134             | 0.134             | 0.190           | 0.377         | 0.377         |

Notes: The dependent variable is the number of doses vaccinated out of the total eight doses. Child controls include timing of birth (birth year and birth month), gender, birth order, and singleton. Mother controls include birth year, education level, relationship to the household head, and type of marital status. Household controls include household wealth, household size, and gender and age of the household head. The health district fixed effects are controlled for throughout. Robust standard errors in parentheses are two-way clustered by the district-specific birth years of children and mothers. **p < 0.01, *p < 0.05, *p < 0.1.
Table 5. Mothers’ desired fertility

|                                      | Age < 30 | Age ≥ 30 |
|--------------------------------------|----------|----------|
|                                      | (1)      | (2)      | (3)      | (4)      | (5)      | (6)      |
| Last child born in April 2010 or     |          |          |          |          |          |          |
| later*Density of public              |          |          |          |          |          |          |
| health facilities                   | -3.735** (1.743) | -3.678** (1.832) | 2.126 (3.576) | 2.158 (3.494) |
| Last child born in April 2009 or     |          |          |          |          |          |          |
| earlier*Density of public            |          |          |          |          |          |          |
| health facilities                   |          |          |          |          |          |          |
| Child controls                       | Yes      | Yes      | Yes      | Yes      | Yes      | Yes      |
| Mother controls                      | Yes      | Yes      | Yes      | Yes      | Yes      | Yes      |
| Household controls                   | Yes      | Yes      | Yes      | Yes      | Yes      | Yes      |
| Health aid                          | Yes      | Yes      | Yes      | Yes      | Yes      | Yes      |
| Transportation aid                  | Yes      | Yes      | Yes      | Yes      | Yes      | Yes      |
| Other aid                           | No       | Yes      | Yes      | No       | Yes      | Yes      |
| Observations                         | 4,287    | 4,287    | 571      | 2,944    | 2,944    | 670      |
| R-squared                            | 0.205    | 0.205    | 0.323    | 0.191    | 0.191    | 0.269    |

Notes: The dependent variable is the ideal number of children reported by mothers. Child controls include timing of birth (birth year and birth month), gender, birth order, and singleton. Mother controls include birth year, education level, relationship to the household head, and type of marital status. Household controls include household wealth, household size, and gender and age of the household head. The health district fixed effects are controlled for throughout. Robust standard errors in parentheses are two-way clustered by the district-specific birth years of children and mothers. **p < 0.05.
A statistically significant effect of the FHCI on desired fertility is detected for women aged 30 and over (Column 4). This is unsurprising as older women are less flexible to adjust desired fertility because of the age constraint and their existing children. The 95 per cent confidence interval suggests that the change of the conditional mean of the ideal number of children reported by mothers with respect to the FHCI varies widely, with an estimate between −5.00 and 9.26. This result is robust to controlling for aid in more sectors (Column 5) and passes the parallel trend test (Column 6). As my estimate suggests that the FHCI does not reduce infant mortality (Table 3), if young women’s perception of the FHCI impact is in line with my estimate, there would be no change in terms of the insurance demand for children. Therefore, the reduction in desired fertility indicates that compared with my estimate, young women overestimate the benefits of the FHCI.

As reproductive decisions can also be affected by husbands’ preferences, thereby leading to a change in actual fertility, Table 6 explores whether young women’s husbands desire more children than they do. As my estimates are negative but statistically insignificant throughout, I test the null hypothesis of $\beta_1 \geq 0$. The underlying logic of using the one-sided test is that rather than testing whether the FHCI changes the likelihood of husbands desiring more children than their wives, my primary interest is to investigate whether the FHCI increases the likelihood, which can translate into intrahousehold disagreement since wives have been shown to desire fewer children (Table 5). The null hypothesis is rejected at a significance level of 10 per cent, indicating that husbands are unlikely to disagree with their wives about having fewer children. Finally, the parallel trend assumption tested in Column 6 suggests that there is no differential impact in terms of the transportation cost for cohorts born before the FHCI.

### 5.3. Heterogeneous effects of household wealth

As the existing studies find that the FHCI benefits women from wealthy households more than those from poor households (Jalloh et al., 2019; van Duinen et al., 2021), I also investigate how
Table 7. Heterogeneous effects by household wealth.

|                                | Infant mortality | Infant vaccination | Vaccination as a channel to reduce infant mortality | Ideal number of children | Husbands desire more children |
|--------------------------------|-----------------|-------------------|---------------------------------------------------|--------------------------|-----------------------------|
|                                | (1)             | (2)               | (3)                                               | (4)                      | (5)                         |
| Born in Apr. 2010 or later*Density of PHF |                 |                   |                                                   |                          |                             |
| Poor                           |                 |                   |                                                   |                          |                             |
| 1.160*** (0.289)               |                 |                   |                                                   |                          |                             |
| Born in Apr. 2010 or later*Density of PHF*Poor |                 |                   |                                                   |                          |                             |
| Vaccination                    |                 |                   |                                                   |                          |                             |
| 0.474*** (0.020)               |                 |                   |                                                   |                          |                             |
| Notes:                         |                 |                   |                                                   |                          |                             |

Notes: The binary variable for poor households, the interaction between the binary variable for children born in April 2010 or later, the binary variable for poor households, and the interaction between the density of public health facilities and the binary variable for poor households are controlled for throughout. Child controls include timing of birth (birth year and birth month), gender, birth order, and singleton. Mother controls include birth year, education level, relationship to the household head, and type of marital status. Household controls include household wealth, household size, and gender and age of the household head. The health district fixed effects are controlled for throughout. Robust standard errors in parentheses are two-way clustered by the district-specific birth years of children and mothers. ***p < 0.01, **p < 0.05, *p < 0.1.
the FHCI affects wealth-related health inequalities. Table 7 presents the results from estimating Equation (7) with the binary variable for poor households interacting with FHCI-related variables (i.e. \( R_{\text{unhd}}, H_d \), and their interaction). The result in Column 2 suggests that the FHCI reduces the vaccination rate for infants in wealthy households by a magnitude far below the average (0.67 vs. 1.07 for all households in Table 4). Conditional on the vaccination status (Column 3), the impact on infant mortality for wealthy households is also larger than the average (0.40 vs. 0.26 for all households in Table 4). Conversely, poor households were more adversely affected by the FHCI than wealthy ones. If the density of public health facilities increases from the lowest 0.008/km² to the highest 0.124/km² in the sample, the estimated difference between poor and wealthy households is 13 per cent for infant mortality (Column 1), 12 per cent for the vaccination rate (Column 2), 8 per cent for infant mortality conditional on the vaccination status (Column 3), and 0.66 for the ideal number of children reported by women under 30 years of age (Column 4).

6. Conclusion

Using a DID design that considers transportation costs, this study attempts to provide an assessment of the FHCI. While the test of the parallel trend assumption shows the validity of my DID strategy, as I do not have alternative DID designs to cross-check the estimated effects, future studies with different designs can help to further examine the internal validity of this study. From a methodological perspective, my estimation strategy can also be applied to other sub-Saharan African countries with transportation barriers to evaluate health policies implemented nationwide, such as the removal of user fees in Benin (Dossou et al., 2018), Burundi (Nimpagaritse & Bertone, 2011), Mali (El-Khoury, Hatt, & Gandaho, 2012), and Zambia (Lépine, Lagarde, & Le Nestour, 2018).

In the case of Sierra Leone, three policy implications can be drawn from the results. First, I find that the FHCI fails to achieve its goal of reducing infant mortality, with the lack of vaccination being a major problem. This emphasizes the need to strengthen the ‘supply side’ interventions. Second, although the FHCI does not reduce infant mortality, it seems to have changed parents’ expectations of infant mortality, which translates into a decline in desired fertility, thus supporting the existence of the hoarding strategy. The reduction in insurance demand for children points toward the potential long-term loss that households may face because of overestimating the benefits of the FHCI. Therefore, it is important to provide information on the effects of FHCI implementation from different perspectives. Finally, while the universal coverage of pregnant and breastfeeding women and children under five years of age is in line with the global movement (WHO, 2010), in the presence of the challenge of sustainability that is largely dependent on domestic financing (Witter et al., 2018), poor mothers and children may need to be given priority, which is supported by the finding that the FHCI affects poor households more adversely than wealthy ones.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes

1. The MDG4 is to reduce child mortality. Relevant information is available at https://www.undp.org/content/undp/en/home/sdgoverture/mdg_goals/mdg4/. The SDG3 is good health and well-being. Its targets related to infant and child health are available at https://www.un.org/sustainabledevelopment/health/. Both data sources were accessed on December 20, 2021.

2. The under-five mortality data from UNDP are available at http://hdr.undp.org/en/data#. They were accessed on December 20, 2021.
3. The under-five mortality data from UNDP are available at http://hdr.undp.org/en/data#. They were accessed on December 20, 2021.

4. The fertility data from the World Bank are available at https://data.worldbank.org/indicator/SP.DYN.TFRT.IN?end=2019&locations=SL&start=1960. They were accessed on December 20, 2021.

5. The document can be found at https://unipris.unmissions.org/sites/default/files/old_dnn/free_servicesframewk_nov09.pdf, accessed on December 20, 2021.

6. More information on Standby Task Force can be found at https://standbytaskforce.wordpress.com/, accessed on December 20, 2021.

7. Sierra Leone is divided into 13 health districts corresponding to its administrative districts, except for the Western Area Rural and the Western Area Urban, which are combined into the Western Area Health district.

8. In my sample, mortality before the age of one comprises 80% of the deaths before the age of five. Recommended vaccinations before the age of one are BCG, polio (three doses), DPT (three doses), and measles. The number of doses given to a child is added up and standardized by the total of eight doses.

9. I compare only two cohorts born before April 2010 because the sample size of children born in each month of each year is too small to conduct an event study by birth timing (see Supplementary Materials Appendix Table 2).

10. Controls for the last child’s characteristics in this specification.

11. Although the Western Area with rich medical resources is the most attractive place for migrants (20% of recent in-migrants), some districts with less medical resources also attract a large proportion of migrants (Supplementary Materials Appendix Table 4). For example, 8% of Bo’s residents were rent in-migrants, probably because it is an early administrative and educational center.

12. There is no ideal number of children reported by husbands in the dataset. Hence, I use a variable indicating whether the husband desires more children than his wife to capture the intrahousehold disagreement about desired fertility. This dependent variable gives me a husband sample smaller than the mother sample.

13. The binary variable for the poor household is equal to one if the household is the poorest, the poorer, or in the middle, according to the wealth index. It is equal to zero if the household is the wealthiest or the wealthier according to the wealth index. The five categories of household wealth are reported in Table 1. While $R_{\text{adult}}$ and $H_d$ are fully absorbed by birth-timing fixed effects ($\mu_t$) and district fixed effects, respectively, their interactions with the binary variable for the poor household are not. So in addition to the three-term interaction between $R_{\text{adult}}*H_d$ and the binary variable for the poor household, $R_{\text{adult}}$ and $H_d$ are also interacted with the binary variable for the poor household, respectively.

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