Intergenerational Child Mortality Impacts of Deworming: Experimental Evidence from Two Decades of the Kenya Life Panel Survey

Michael Walker[1]** Alice Huang[1]**
Suleiman Asman[2] Sarah Baird[5]
Lia Fernald[1] Joan Hamory[4]
Fernando Hoces de la Guardia[1] Satoshi Koiso[1]
Michael Kremer[3] Matthew N Krupoff[1]
Michelle Layvant[1] Eric Ochieng[2] Pooja Suri[1]
Edward Miguel[1]*

[1]University of California, Berkeley
[2]Innovations for Poverty Action, Kenya
[3]University of Chicago
[4]University of Oklahoma
[5]George Washington University

**Denotes joint first authorship
*To whom correspondence should be addressed:
E-mail: emiguel@berkeley.edu.

1. Summary/Abstract

Background. There is limited causal evidence on the intergenerational transmission of health status, particularly in low- and middle-income countries (LMICs). This study assesses the impacts of a Kenyan school-based deworming intervention on the mortality of recipients' children.

Methods. The causal impacts of a randomized school-based deworming intervention in Kenya on the mortality of recipients' children are estimated by combining information from the deworming experiment with a 23-year longitudinal data set (1998 to 2021) containing detailed follow-up information on both the original program participants (N = 6,523), treated between 1998-2003, and their children (N = 14,172). The panel nature of these data allows us to explore four leading candidate mechanisms for intergenerational transmission of health

status: parent living standards and residential choice, education, fertility patterns, and use of health care. The internal rate of return (IRR) for school-based deworming is estimated by valuing the benefits of averted child deaths.

Findings. School-based deworming reduced the under-5 mortality rate (U5MR) for children of individuals in the treatment group by 18 deaths per 1000 live births (p-value = 0.03), corresponding to a reduction of 24% relative to the control group mean. The infant mortality rate (under-1, IMR) was lowered by 6 deaths per 1000 births (or by 15%, p-value = 0.26). Analysis of potential mechanisms suggests that some combination of improvements in living standards, increased urban residence, higher schooling attainment, delayed fertility, and greater use of health care in the parent generation contributed to the reduction. Deworming is estimated to generate a large return on investment in terms of reduced child deaths, with an annualized social IRR of at least 41.5%.

Interpretation. The results provide novel experimental evidence on the impacts of child health investments on the survival outcomes of the next generation in an LMIC setting. Quantifying these benefits allows for improved understanding of the long-run cost-effectiveness of child health programs. This study provides further evidence that school-based deworming treatment can be cost-effective and that age-specific health investments are essential for development.

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2. Introduction

The persistent burden of deaths among young children is a major global public health challenge, particularly in low and middle-income countries (LMICs), and has motivated numerous studies on the determinants of child health and mortality [28, 5]. The leading causes of infant mortality (IMR) and under-five mortality (U5MR) in these contexts include preterm birth complications, infectious diseases, and intrapartum-related events, pointing to the importance of parent and household characteristics and behaviors [20, 29]. Past studies find that IMR is most strongly correlated with biodemographic factors (e.g., birth order, birth spacing) while U5MR is most strongly correlated with socioeconomic, environmental, and hygienic factors [23, 12, 17, 13]. Indeed, differential patterns of child mortality reduction across countries suggest that multi-sectoral approaches are most effective in addressing critical health determinants [19, 5]. However, relatively few studies have causally estimated the impact of these hypothesized mechanisms and the intergenerational transmission of child health in LMICs and especially in Sub-Saharan Africa (SSA), with some notable exceptions (e.g., [13, 2]).

This study examines the intergenerational transmission of health in the context of a school-based deworming intervention (the Primary School Deworming Project, PSDP) in Kenya. Intestinal helminth infections remain one of the most widespread parasitic infections globally and have adverse health and nutritional consequences for children including stunting, anemia, and increased susceptibility to other infections ([27, 26]). At present, the World Health Organization (WHO) recommends providing mass school-based deworming treatments in regions with infection prevalence over 20% at baseline, noting population-wide health gains and cost-effectiveness of this approach [24]. Recipients of the PSDP were aged 8-15 at baseline, falling within the "adolescent growth spurt" phase with greater requirements on nutrition and good diet [7]. Several studies analyze the short- and long-run impacts of deworming (e.g., [22, 30, 11, 25, 4, 14, 10]). [4] and [14] assess the validity of the PSDP's research design and study its

long-term effects, using up to four rounds of follow-up data (20 years post-treatment), and document meaningful impacts on a range of adult outcomes, including education, health, and economic living standards.

This study estimates the effects of deworming treatment on the subsequent generation's mortality outcomes during childhood. This analysis explores leading mechanisms for the intergenerational transmission of health status: parent living standards and residence, education, fertility patterns, and use of health care. Characterizing these overall effects and associated mechanisms contributes to understanding persistence of health disparities across generations and intergenerational economic mobility in society more broadly [6, 8, 16, 1, 3].

2.1. Research in Context

Evidence before this study While many countries have experienced declines in the IMR and U5MR in recent decades (including Kenya, the study country), infant and child mortality continues to be a significant issue in LMICs. We searched PubMed for full articles published up to March 29, 2022, using the search terms "intergenerational" and "child mortality" or "infant mortality", and the search identified 142 results. Of these results, only one study claims to provide causal evidence on the intergenerational transmission of child health status. Existing research suggests that declines in infant and child mortality are associated with favorable biodemographic, socioeconomic, hygienic, family and community factors, but this work is largely non-experimental in nature and hence risks confounding. More evidence, and particularly causal evidence using longitudinal (panel) data on both parents and their children, is critical in identifying the impact of parental factors on child health and understanding the causes of intergenerational persistence of health status.

Added value of this study Using a randomized health intervention and rich panel data, this study 1) estimates the causal effect of school-based deworming on the subsequent generation's IMR and U5MR, 2) identifies plausible mechanisms for the observed reductions in child mortality, and 3) quantifies the economic value of increased child survival. The study leverages a 23-year lon-

gitudinal survey (1998 to 2021) that tracks both intervention participants and their children. In contrast to previous work, this study utilizes detailed survey data and experimental variation in deworming to estimate the causal relationship between improved child health in one generation and a key health outcome (child survival) among their children in an African context.

Implications of all the available evidence The findings contribute to understanding the impacts of age-specific deworming (and possibly other child health investments) on a broad range of long-run socioeconomic and health outcomes. This study specifically examines the impacts of deworming on child mortality in the next generation, a dimension that has not (to our knowledge) been previously examined. Prior work has demonstrated very high cost-effectiveness of deworming treatment in terms of later labor market returns, and this study's findings also indicate significant additional gains in terms of improved child survival of the next generation decades later.

3. Methods

Study design. The PSDP took place in Busia District (now Busia County) in western Kenya from 1998-2003. This rural, largely agrarian area had high baseline intestinal helminth infection rates (over 90%) [22]. In 1998, a non-governmental organization (NGO) launched the PSDP in 75 schools enrolling over 32,000 pupils. Schools were experimentally assigned into one of three groups via list randomization, with 25 schools assigned to each. The schools were first stratified by administrative subunit (zone), zones were listed alphabetically within each geographic division, and schools were ordered by pupil enrollment within each zone, with every third school then assigned to a given program group. Previous studies confirm the validity of the research design and document that the groups were well-balanced along a wide range of baseline characteristics [22, 4]. This study is registered on the American Economic Association's Randomized Controlled Trials Registry (AEARCTR-0001191).

The program was phased in across groups: Group 1 schools began treat-

ment in 1998, Group 2 schools in 1999, and Group 3 schools in 2001 (Figure 1; see also Appendix Appendix B). Children in Groups 1 and 2 were thus on average assigned to 2.41 additional years of deworming treatment and serve as the treatment group in this analysis, while Group 3 serves as the control group (as in [4, 14]). Take-up of the deworming drugs was high: around 75% for the treatment group and under 5% for the control group [22].

Data collection. The Kenya Life Panel Survey (KLPS) began in 2003 to track a representative sample of approximately 7500 students enrolled in grades 2 to 7 in the PSDP schools at baseline, and is thus largely representative of primary school students in the study area in 1998. Four rounds of KLPS surveys have been collected over the period 1998-2021 (see Figure 1).

Each KLPS round has collected information on fertility and child health, and we use self-reported survey data on births and survival status to construct child and infant mortality measures consistent with Demographic and Health Surveys [9]. The primary infant and child mortality outcomes pool reported live births (for female respondents and the partners of male respondents) across KLPS survey rounds. A child is considered to have experienced under-5 (under-1) mortality if the child was born alive and is reported by the parent to have died before the age of 5 years (1 year), and is only included in the sample if data is collected at least 5 years (1 year) since their birth year.

KLPS data also include measures that allow us to investigate four types of mechanisms for the intergenerational transmission of health: (i) living standards and residence choice (namely, consumption, individual earnings and urban residence), (ii) education (any secondary school attendance and total years of completed schooling), (iii) fertility patterns (age at first birth and number of live births), and (iv) use of health care (indicators for receiving antenatal care (ANC) and institutional delivery). Summary statistics for these measures and details on their construction are available in Appendix C.

Statistical analysis. All statistical analyses were conducted in Stata [version 16]. To estimate the effects of deworming on IMR and U5MR, we use a linear proba-

bility model where the dependent variable is a child mortality measure; we also estimate logistic and probit regression models to check robustness. As described above, the treatment variable is an indicator for whether the parent attended a school in deworming groups 1 or 2, which were assigned to 2.41 more years of deworming than group 3. Regression covariates include a set of respondent and child-level covariates (following [4] and [14]), namely the PSDP participants' baseline school characteristics (average test score, population, number of students within 6 km, and administrative zone indicators), respondents' baseline characteristics (grade and gender), indicators for KLPS survey calendar month (within wave and round), and indicators for participation in the control group of other randomized interventions implemented later in the panel (see Appendix B). We also include year of birth fixed effects for child mortality estimates. Standard errors are clustered at the school level to allow for correlation in outcomes both within schools and across survey rounds. The estimates are weighted to maintain representativeness of the baseline PSDP population and take into account the tracking design of the KLPS (as in [4]) (see Appendix B, Appendix C, and table notes). A similar approach is taken when studying mechanisms, with adjustments for data availability by survey round (see Appendix C). We conduct subgroup analysis by recipients' gender and age to estimate heterogeneous effects and also examine deworming impacts on hypothesized channels, taking a similar approach as above.

Cost-Benefit Analysis. To quantify the monetary value of the reduction in under-5 mortality, we conduct cost-benefit analysis to estimate the internal rate of return (IRR) for deworming. The social rate of return for deworming treatment provides an estimate of the economic value of the benefits of deworming relative to the costs of providing treatment. School-based deworming is relatively inexpensive, and we use recent cost estimates from school-based deworming in Kenya (see Appendix D.1 for details). Valuing health gains is more challenging; there is an extensive literature estimating disability-adjusted life years (DALYs). We take two approaches to identify a willingness to pay

per DALY averted: the first uses the stated preference of Kenyan households' willingness to pay to avoid child health problems, and the second uses revealed preference measures (which are typically lower than stated preferences). We combine the estimated willingness to pay to avert a DALY figures with information on the time series of births in the sample, the estimated U5MR reduction (from Table 1), and the average value of life in terms of DALYs, to generate benefits over time.

Role of Funding Source. The sponsors of the study had no role in data analysis, interpretation, or write-up.

Ethics Review. Human subjects approval was obtained from the University of California, Berkeley and Maseno University in Kenya.

4. Results

4.1. Intergenerational Child Mortality Impacts

Figure 1 shows the study timeline. As of the 23-year follow-up, we find no statistically significant difference in attrition between the intervention and control groups (Table A.1). High round-specific and overall tracking rates (86.5% surveyed in a follow-up round) also indicate that the results remain largely representative of the original study population.

The deworming intervention decreased the U5MR and IMR for the children of beneficiaries by 18 deaths per 1000 births and 6 deaths per 1000 births, respectively (statistical significance presented below). Across child year of birth (1998-2016), under-5 mortality is lower among the children of the treated group in most years (figure 2). For both the treatment and control groups, children born in later cohorts experienced declines in mortality, reflecting population-level declines in the Kenyan U5MR and IMR over the period.

Table 1 presents these results in regression form. The average treatment effect for deworming on intergenerational child mortality represents a reduction of 24% (p-value = 0.03), relative to the control mean of 76 deaths per 1000 births

(table 1). Effect magnitudes and statistical significance levels are nearly identical using logistic and probit regression models (appendix table A.4). Similarly, deworming leads to an average reduction in intergenerational infant mortality of 15% (p-value = 0.26, not statistically significant), relative to the control mean of 40 deaths per 1000 births (table 1).

The data allows for analysis of heterogeneous effects by parents' gender and age (specifically, older versus younger than the median baseline age of 12 years old). The deworming effects are somewhat larger in magnitude among female recipient parents, although effects across gender groups are not significantly different (table 1). Relative to control group females, deworming treatment reduced intergenerational child mortality for treated females by 20 deaths per 1000 births (p-value = 0.03), an average reduction of 27% (table 1). The effects of deworming on intergenerational child mortality are larger among older parents (appendix table A.2). Specifically, deworming reduces intergenerational child mortality among treated older parents by 27 deaths per 1000 births (p-value = 0.01), an average reduction of 34% relative to older parents in the control group, and the difference between older and younger parents is statistically significant (appendix table A.2).

4.2. Mechanisms

Several channels appear to contribute to the causal impact of deworming on the survival of children in the subsequent generation, focusing on four main channels prominent in existing research (see figure 3). Deworming treatment is positively correlated with each of these four channels (e.g., for fertility patterns, deworming is positively correlated with reductions in total number of children), and these channels are in turn negatively correlated with intergenerational child mortality, although not all correlations are statistically significant.

Table 2 presents the long-run causal impact of deworming on the four main channels in regression form. The living standard results presented reproduce the longitudinal analysis from [14] and pool data across KLPS rounds 2 to 4, when most respondents were between 19 years and 35 years old. Total household per

capita consumption expenditures up to 20-years post treatment are higher by USD PPP 305 (p-value = 0.06) among the treated group, which represents a 14% increase relative to the control mean. Column (2) also documents higher annual individual earnings among deworming recipients, although the results are not statistically significant for the full sample. Treated individuals are 4 percentage points (p-value = 0.03) more likely to reside in urban areas as adults, and this effect is particularly large among male parents (a 13% increase in urban residence relative to control male parents).

Deworming treatment also has positive effects on recipients' education outcomes (see Columns (4-5)). Among the full sample, individuals who received deworming treatment attained 0.25 more years of schooling (p-value = 0.17) and were more likely to have attended secondary school. These estimated effects are somewhat larger among female parent recipients: among treated females, deworming treatment increased school attainment by 0.43 years (p-value = 0.08) and increased the likelihood of secondary school attendance by 7.6% (p-value = 0.05), relative to females in the control group.

The data also suggest that deworming treatment leads to some modest changes in fertility patterns, including age of first birth and total number of children (see Columns (6-7)). Among the treated group, age at first birth is higher by 0.42 years (p-value = 0.06), relative to the control mean of 22.7 years. Among male parent recipients, deworming increased the age at first birth by 0.52 years (p-value = 0.05), relative to the mean age of 24.3 years among male parents in the control group. Individuals in the treatment group also had slightly fewer total children on average although this estimate is not statistically significant.

A final measured pathway is use of health care: on average, deworming treatment increases recipient parents' likelihood of receiving ANC by 1.3 percentage points (p-value = 0.01) and institutional delivery (see Columns (8-9)). Treated female parents are 1.7 percentage points more likely to receive ANC (p-value = 0.02) and 5 percentage points more likely to use institutional delivery (p-value = 0.03) relative to the female parents in the control group.

4.3. Cost Benefit Analysis

Using stated and revealed preference approaches, the estimated willingness to pay per DALY averted is USD PPP 3611 and 67, respectively. Figure 4 presents the costs and implied intergenerational health benefits graphically, on a log scale. In earlier years, deworming treatment costs are incurred, and child survival benefits are smaller given the low overall birth rates. In later years, higher birth rates lead to increased benefits in terms of child survival, which through 25 years post treatment, amount to USD PPP 394 and 7 on average under the stated and revealed preference approaches, respectively. The annualized social IRR for intergenerational mortality benefits under stated preference and revealed preference is 124.6% and 41.5%, respectively. Assuming a discount rate of 5%, the net present value from intergenerational mortality benefits is positive for both stated and revealed preference approaches, at USD PPP 4658 and 85 respectively, with respect to the deworming drug treatment costs.

These calculated benefits only include the reduction of intergenerational child mortality and do not incorporate other treatment gains (e.g., those in consumption and earnings [14]). Furthermore, we assign the intergenerational child survival benefits to five years after the child's birth. For both of these reasons (and others articulated in the appendix), the partial cost-benefit analysis here provides a highly conservative estimate for the overall return to deworming.

5. Discussion

This study provides novel causal evidence on the impact of a randomized child health intervention on intergenerational child survival outcomes. We document that the children of deworming recipients were more likely to survive to age 5. We also estimate deworming impacts on four leading channels potentially linking deworming to intergenerational child mortality–adult living standards and residence choice, education outcomes, fertility patterns, and use of health care–and it seems likely that some combination of these channels, and possibly

others, account for the overall child survival effect. The findings on mechanisms also corroborate previously hypothesized channels (e.g., maternal education).

It should also be noted that we do not conduct a full causal mediation analysis due to data limitations and methodological concerns [21]. A timing mismatch between the measurement of the mechanisms (sometimes only collected in later KLPS survey rounds) and intergenerational child mortality, for instance, make it difficult to establish tight causal claims. Furthermore, given that the hypothesized mechanisms were not themselves randomized in the original study design, mediation analysis may lead to biased inference.

The point estimate on intergenerational infant (under-1) mortality is negative, and the proportional reduction in infant mortality is broadly in line with the reduction in under-5 mortality, but the infant mortality effect is not statistically significant. Several factors may explain differences between the IMR and U5MR results. Previous studies suggest that different pathways are more important in explaining intergenerational infant versus under-5 mortality. Importantly, deworming led to improvements in adult socioeconomic and education outcomes, which are more commonly associated with U5MR [23]. [4] also finds that deworming reduces the likelihood of miscarriage. Somewhat speculatively, this suggests that additional children who may be less healthy are being born in the treated group; if these children are more susceptible to neonatal infections, the leading cause of infant mortality globally [20], this would dampen the treatment effect in infant mortality.

The relative impacts on the various proposed channels linking deworming to intergenerational child survival also differ depending on recipients' gender or age at baseline. For instance, the deworming effects on education outcomes and use of health care are particularly large among female parent recipients, which suggests that for female parents, deworming may reduce intergenerational child mortality predominantly via increases in years of schooling and use of ANC and institutional delivery. Similarly for parent recipients above the median age in the sample, deworming had particularly large positive impacts on economic living standards, and this subgroup also shows more pronounced reductions in

under-5 child mortality.

Additionally, cost-benefit analysis for deworming suggests that the benefits of increased intergenerational child survival alone far outweigh the costs of treatment. It should be noted that the high calculated social IRRs here are consistent with previous analysis on the marginal value of public funds invested in numerous child health, education, and nutritional programs [15].

In general, rigorous evaluations of the long-term and intergenerational impacts of childhood health investments are rare in LMICs due to a lack of longitudinal data that tracks both adults and their children and the well-known difficulties inherent in designing credible strategies to address omitted variables and confounding. In contrast, this study leverages the unusual combination of experimental evidence and a longitudinal survey among the original respondents and their children.

Limitations of this study include an inability to decompose the overall effect of deworming on intergenerational child survival across the measured channels. While the experimental design allows for the identification of plausible mechanisms, it is difficult to disentangle the relative weight and interaction of these mechanisms in reducing child mortality. Mechanisms matter, because beyond implementing child health interventions (like deworming), it is important to understand where policy should focus to improve child survival and health outcomes. Furthermore, the heterogeneous deworming impacts on potential mechanisms among gender and age subgroups suggests that the study population matters. Thus, an important avenue for future research is to determine which multi-sectoral approaches are most effective, and for whom.

Another factor to consider is external validity: the KLPS is not a nationally-representative sample but rather drawn from students attending rural primary schools in Busia, Kenya in 1998. This smaller sample, however, is the price to pay for experimental variation in the child health intervention. Furthermore, the limited sample size allowed for the gathering of multiple rounds of rich survey data with low rates of sample attrition, which enables us to analyze how adult life changes translate into child survival outcomes, including via the hypothesized

mechanisms discussed above. Despite not being nationally-representative, the KLPS sample appears to be fairly typical of other SSA settings (see Appendix B). Furthermore, given the high prevalence of intestinal helminth infections in SSA and globally, the findings on the causal intergenerational impacts of deworming are relevant in many other settings.

These findings suggest that deworming treatment has implications not only for reducing infection rates among the current generation, but also potentially far-reaching implications on improving child survival outcomes of the subsequent generation. Furthermore, transmission of intergenerational child health could occur on multiple fronts, and multi-sectoral public policy approaches may be key to reducing infant and child mortality. Finally, cost-benefit analysis suggests that deworming is highly cost-effective. Taken together, the results provide causal evidence of the intergenerational transmission of health and highlight the wide range of assumptions under which subsidies for deworming would be justified.

Contributors

EM and MK conceived the original PSDP study. AS and EO supervised data collection in Kenya. JH, EM, MW, SB, and LF conceived the analysis on the long-run effects of deworming. EO, PS, MNK, and ML engaged in data curation, visualization, and analysis, which involved adapting the statistical methods to the intergenerational child mortality data, with supervision from EM and MW. SK and FH conducted the cost-benefit analysis, with supervision from EM, MW, and AH. AH and MW wrote the original draft, and all authors worked to review and revise the manuscript.

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Figure 1: Primary School Deworming Project (PSDP) and Kenya Life Panel Survey (KLPS) Timeline

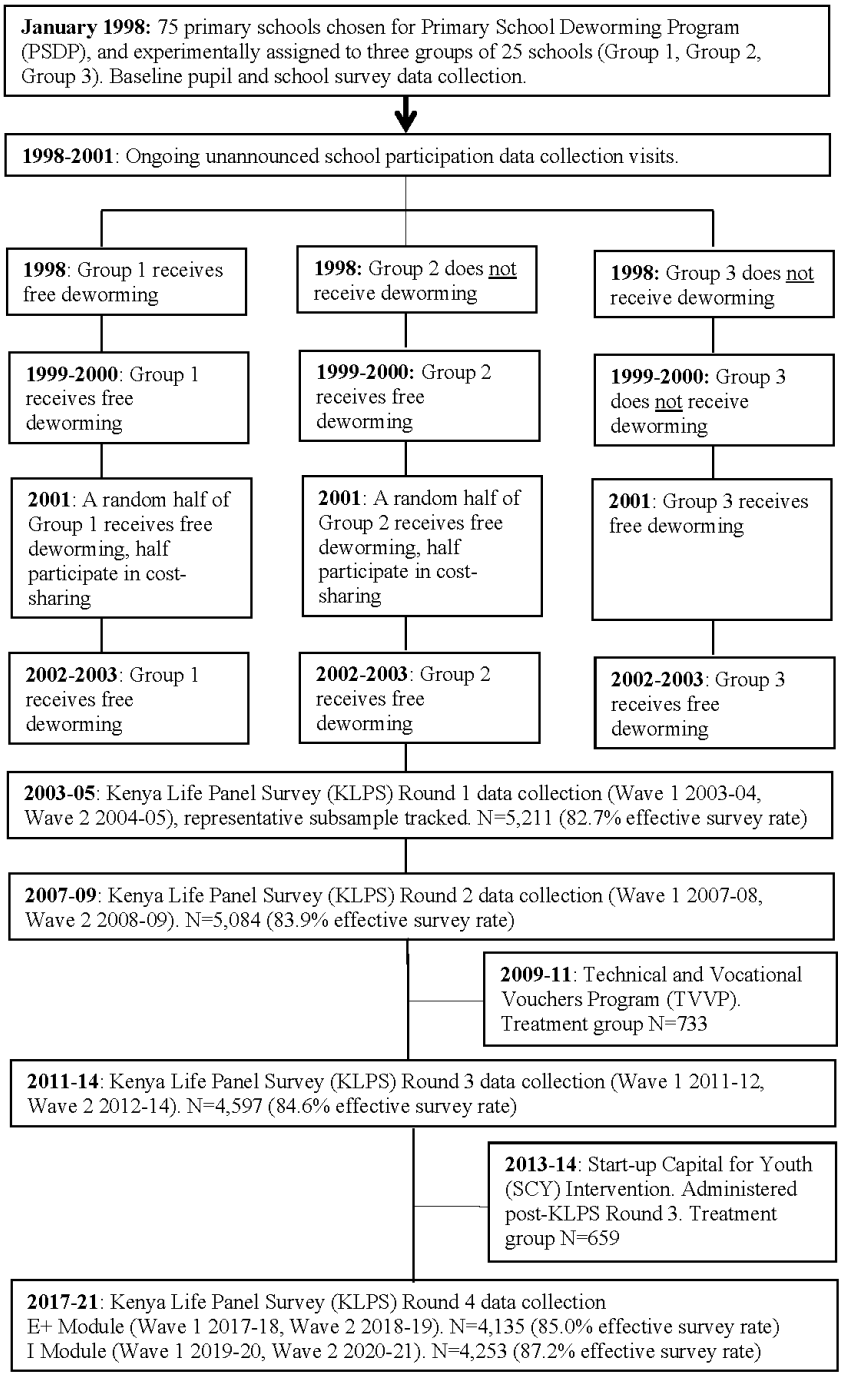
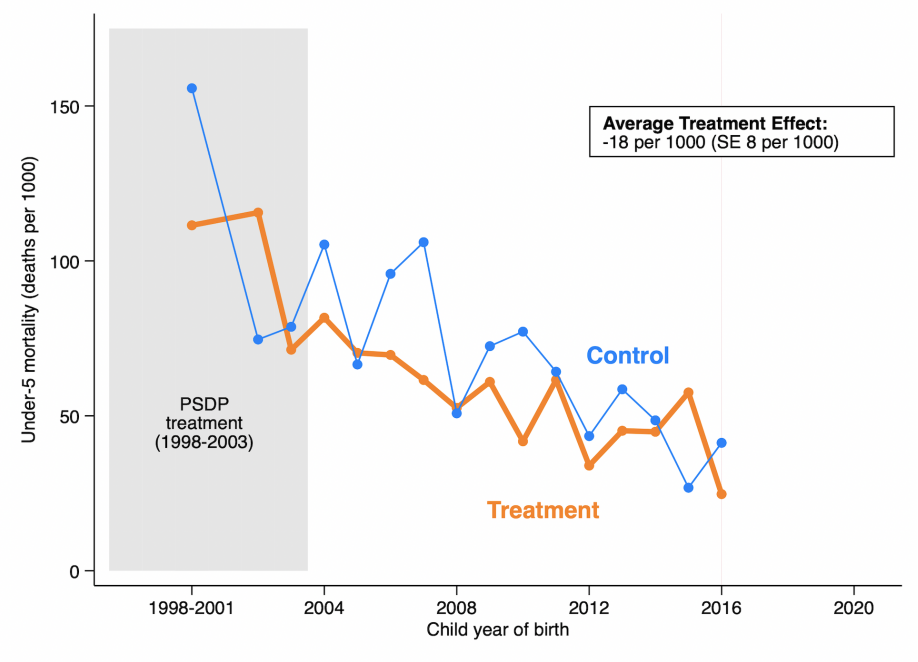
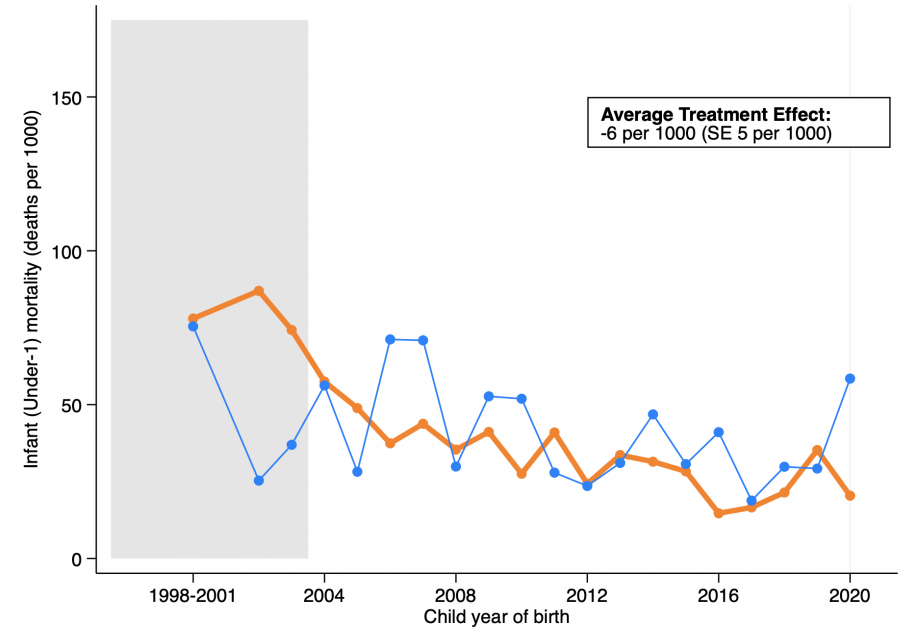


Figure 2: Intergenerational Deworming Impacts on Child Mortality, for Parent Deworming Treatment group vs Control group



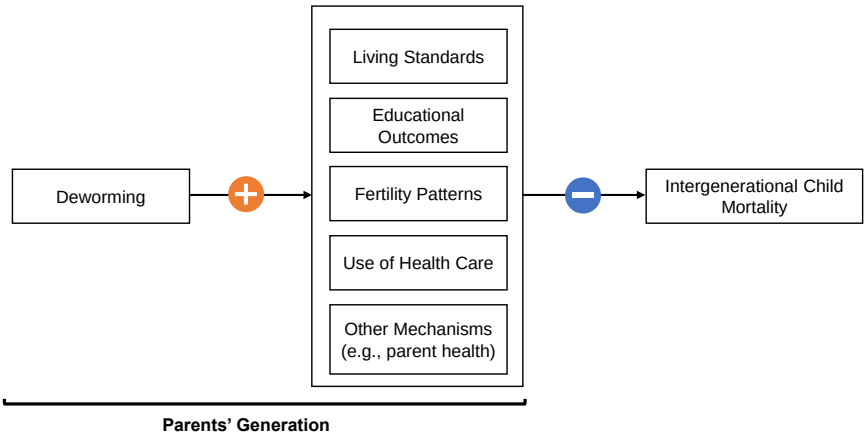
(a) Panel A: Under-5 mortality over time (1998-2016)



(b) Panel B: Infant (under-1) mortality over time (1998-2020)

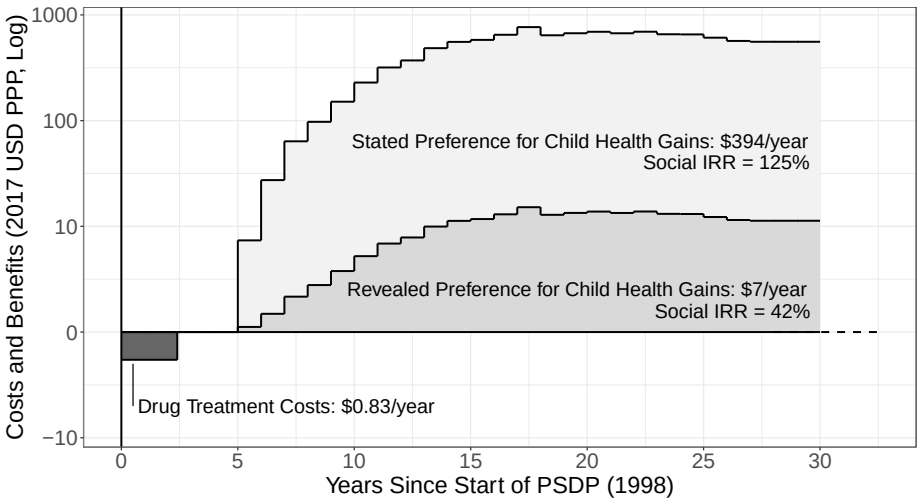
Note: Figure 1 shows the difference in the mortality rates by year between treatment and control. The orange line shows the mortality rates for the treatment, and the blue line shows the mortality rates for the control. Panel A shows under-5 mortality which for a given year is calculated as the share of children born in that year who die before the age of 5, scaled to be deaths per 1000 births. The data is trimmed at 2016, shown by a vertical line, so that all children are observed for at least 5 years. Panel B shows under-1 mortality. The Under-1 mortality rate is calculated as the share of children born in that year who die before the age of 1, scaled to be deaths per 1000 births. The data is trimmed at 2020 so that all children are observed for at least 1 year. The grey shaded area denotes the PSDP project years from 1998-2003. The sample is weighted using the average round-specific PSDP analytical weights.

Figure 3: Hypothesized Mechanisms for Intergenerational Child Mortality Effects from Deworming



Notes: This figure presents potential causal mechanisms from deworming intervention to intergenerational child mortality. The mechanisms analysis focuses on the upper four main channels: recipients' adult living standards and residential choice, education outcomes, fertility patterns, and use of health care. See the first row of Table 2 for the results of the correlation analysis. The analysis hypothesizes that the deworming treatment positively influences these four mechanism channels; in turn, these channels are negatively related to intergenerational child mortality (i.e., lead to reduced intergenerational child mortality). Other mechanisms beyond those measured in this study may also contribute to the causal impact of deworming on intergenerational child mortality.

Figure 4: Valuing the Benefits of Intergenerational Deworming Impacts on Child Mortality



Notes: This figure presents the deworming drug treatment costs and intergenerational mortality benefits of deworming over time, and calculated social IRR. For compatibility purposes, the costs and benefits in the figure are reported in 2017 USD PPP terms as used in [14]. The y-axis uses a common logarithmic scale to show the intergenerational mortality benefits and the costs clearly. For the sake of readability, costs and benefits are presented in terms of log(1+Value), which costs then multiplied by -1 and presented as negative values in the figure. For additional details and alternative assumptions, see Appendix Table A.7 and Section Appendix D.1. The drug treatment costs include the drug cost of providing mass school-based deworming from the NGO Deworm the World [14]. We calculate intergenerational mortality benefits as a monetary value of saved under-5 children's lives per deworming recipient, taking into account U5MR treatment effects, fertility rates, value of saved children's lives, and monetary value of child health gains. We use the U5MR treatment effects of children born from deworming recipients measured from 1998 to 2016 (from 0 to 18 years after the start of deworming) and pooled across rounds (from Table 1, Panel A, Column 1, Child (Under-5) Mortality: Full sample). We use the fertility rate for each year measured from 0 to 22 years after the start of deworming and pooled across rounds (See Appendix, Figure A.2). We assume a fertility remains constant at the 22-year level from years 22 to 25 post-treatment, and then to be conservative, we assume zero mortality benefits starting at 25 years post-treatment. Given the focus on U5MR, we assign health benefits at five years after a child's birth. For the monetary value of child health benefits, we estimate the costs per DALY based on two approaches: stated preference and revealed preference. For stated preference, we surveyed 753 respondents' willingness to pay for their child's health in Busia, Kenya. We estimate the willingness to pay per DALY averted at USD PPP 3611.20 (See Appendix Table A.7 and Appendix D.2). For revealed preference, we estimate the willingness to pay per DALY at USD PPP 66.82 [18]. The average estimated intergenerational mortality benefits are USD PPP 394 per year for stated preference, and USD PPP 7 per year for revealed preference. A return of 5% represents the real interest rate from 1998 to 2018 (based on Kenyan government bond rates and inflation rates). Assuming a discount rate of 5%, the NPV from intergenerational mortality benefits of stated preference is USD PPP 4657.91. The NPV from revealed preference is USD PPP 84.77. The annualized social IRR for intergenerational mortality benefits of stated preference is 124.6%, while the annualized social IRR for intergenerational mortality benefits of revealed preference is 41.5%. This figure only includes intergenerational mortality benefits and deworming drug treatment costs and does not incorporate positive consumption gains, earnings gains, or teacher costs considered in [14].

Table 1: Intergenerational Deworming Impacts on Child and Infant Mortality

	(1) Child (Under-5) Mortality	(2) Infant (Under-1) Mortality
Panel A: Full Sample		
Treatment (λ_1)	-.018**	-.006
	(.008)	(.005)
Control Mean	.076	.040
Treatment Effect (%)	-24.11	-14.85
Number Observations	10030	13549
Panel B: Female Parents		
Treatment (λ_1)	-.020**	-.007
	(.009)	(.007)
Control Mean	.075	.041
Treatment Effect (%)	-26.71	-16.30
Number Observations	5808	7458
Panel C: Male Parents		
Treatment (λ_1)	-.015	-.005
	(.017)	(.008)
Control Mean	.077	.039
Treatment Effect (%)	-19.82	-12.13
Number of Observations	4222	6091

Notes: Column (1) shows the PSDP treatment effect on child mortality, and column (2) shows the PSDP treatment effect on infant mortality. The *Child Mortality* outcome is an indicator which is 1 if the child died before the age of 5. The data is trimmed to include only children that we observe for at least five years since birth. Similarly, the *Infant Mortality* outcome is an indicator which takes a value of 1 if the child is died before the age of 1 or over. The data is trimmed to include only children we observe for at least one year since birth. Panel A shows results using the full sample of children, whereas Panel B (Panel C) shows the results from children of female parents (male parents). The sample excludes individuals who were treated in a separate vocational training intervention which occurred prior to KLPS-3 and those treated in a separate small grant intervention which occurred during KLPS-3. The sample weights are adjusted for intensive tracking and inclusion in the vocational training and/or cash grant control group. The weights used in the regressions are the average of these round-specific adjusted sample weights. Standard errors are clustered at the 1998 school level. * denotes statistical significance at 10 pct., ** at 5 pct., and *** at 1 pct level.

Table 2: Deworming Impacts on Potential Mechanisms for Intergenerational Effects

	Living Standards and Residential Choice			**Education Outcomes**		**Fertility Patterns**		**Access to Healthcare**	
	(1) Annual Per-Cap. Consumption	(2) Annual Ind. Earnings	(3) Lives in Urban Area	(4) Attended Sec. Ed.	(5) School Attainment	(6) Age at First Birth	(7) (-1)*Num. of Children	(8) Received ANC	(9) Inst. Delivery
Correlation with Under-5 Mortality (ρ)	-0.021	-0.033	-0.056	-0.079	-0.082	-0.073	-0.162	-0.014	-0.059
Panel A: Full Sample									
Treatment	305.1*	79.5	.042**	.023	.25	.42*	.11	.013**	.025
	(158.6)	(75.7)	(.019)	(.029)	(.18)	(.22)	(.11)	(.005)	(.019)
Control Mean	2156.5	1218.2	.455	.478	9.33	22.66	2.6	.955	.732
Treatment Effect (%)	14.15	6.53	9.33	4.83	2.67	1.86	4.13	1.32	3.45
Number Observations	4794	13624	13793	5506	5506	4597	5436	11789	11730
Panel B: Female Parents									
Treatment	89.4	40.6	.023	.076*	.43*	.33	.09	.017**	.050**
	(133.6)	(62.0)	(.020)	(.038)	(.24)	(.28)	(.12)	(.007)	(.022)
Control Mean	1715.2	673.6	.431	.378	8.74	21.13	2.8	.947	.668
Treatment Effect (%)	5.21	6.02	5.23	20.00	4.97	1.56	3.25	1.80	7.48
Number Observations	2473	6826	6853	2779	2779	2434	2747	6640	6603
Panel C: Male Parents									
Treatment	512.6*	118.2	.062**	-.029	.06	.52*	.12	.007*	-.007
	(303.9)	(132.7)	(.028)	(.033)	(.21)	(.26)	(.12)	(.004)	(.028)
Control Mean	2593.7	1727.8	.476	.569	9.87	24.25	2.4	.965	.81
Treatment Effect (%)	19.76	6.84	12.97	-5.14	.66	2.14	4.96	.71	-.86
Number Observations	2321	6798	6940	2727	2727	2163	2689	5149	5127

Notes: The table presents regression results of four main groups of outcomes on the PSDP treatment variable and their correlation with under-5 mortality. See Appendix C for details on the variable construction. Columns (1) to (3) are outcomes on living standards and residential choice. Columns (4) and (5) are outcomes on education outcomes and include respondents from the last survey they were observed across KLPS-2, KLPS-3, and KLPS-4. Columns (6) and (7) are outcomes on fertility patterns and includes respondents from the last round they were observed across KLPS-2, KLPS-3, and KLPS-4. In Column (7) the number of children outcome variable is multiplied by -1 to interpret positive coefficients as reductions in fertility and vice-versa. Columns (8) and (9) are outcomes on healthcare access for all live births in the KLPS sample from the last round the parents were observed. Correlations with under-5 mortality are calculated as the average of each outcome at the PSDP respondent level. Panel A shows the full sample of the respective outcomes, Panel B (Panel C) includes female (male) respondents. All regression specifications are weighted according to their inclusion in the KLPS sample, and re-weighted for intensive tracking The sample includes individuals in the PSDP sample and excludes individuals who were treated in a separate vocational training intervention which occurred prior to KLPS-3 and those treated in a separate small grant intervention which occurred during KLPS-3. Sample weights are adjusted for intensive tracking and inclusion in the vocational training and/or cash grant control group. Standard errors are clustered at the 1998 school level. * denotes statistical significance at 10 pct., ** at 5 pct., and *** at 1 pct level.