



The impacts of maternal mortality

Under-five mortality and household finances

Global Health and
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AUTHORS

Jenny Kudymowa, Thomas R Vargas

MANAGER

Aisling Leow

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For all queries, please contact ghd@rethinkpriorities.org.

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RETHINK PRIORITIES

530 Divisadero St. PMB #796
San Francisco, California 94117
United States of America



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Editorial note

This report was commissioned by GiveWell and produced by Rethink Priorities between October and December 2024. We revised the report for publication. GiveWell does not necessarily endorse our conclusions, nor do the organizations represented by those who we interviewed.

Our report aims to explore the impacts of maternal mortality on under-five mortality and household finances, with a focus on low-income countries. We reviewed the scientific literature, consulted an expert for additional insights, and developed a rough model to estimate the magnitude of these impacts and their variation across contexts.

We have tried to flag major sources of uncertainty in the report, and are open to revising our views based on new information or further research.

Executive summary

Notes on the scope and process of this project

This report was commissioned by GiveWell to inform their perspective on maternal health.

Our analysis focuses on three key questions:

1. **What are the impacts of maternal mortality on health and economic outcomes** within the family and household? This includes examining outcomes such as increased under-five mortality, poorer health among family members, and changes in household income. We also estimate the **magnitude of these impacts**, such as the number of under-five deaths that may occur per maternal death.
2. **How do these impacts vary across different countries or regions**, with a focus on low-income countries?
3. **What is the quality and strength of the evidence** for these impacts?

Our primary focus is on the **effects of maternal mortality on under-five mortality and household finances**.

This report does not touch on cases of maternal mortality where there is no birth (i.e., during pregnancy before child viability).

The remainder of this report is organized as follows. [First](#), we provide details on our approach to identifying relevant literature. [Second](#), we provide an overview of the types of papers we [shortlisted](#), commenting on our ability to answer our research questions given the quality of the evidence. Third, we provide our findings on the effects of maternal mortality on 1) [under-five mortality](#) and 2) [household finances](#), including best guesses for the magnitudes of the effects.

Key takeaways

- We found a moderate amount of evidence on the effects of maternal mortality on child mortality and household finances in low-resource settings. Out of 104 articles initially identified, we [shortlisted](#) 24 for detailed review, comprising mainly observational studies, along with reviews, qualitative studies, and mixed-methods research. Only one study, focused on income effects in China, used a quasi-experimental design. [\[more\]](#)
- This evidence faces several major limitations, reducing its reliability and generalizability, and making it challenging to derive a best guess estimate for the magnitude of effects:
 - Due to a severe lack of causal evidence, the findings are likely subject to significant threats to internal validity, such as confounding factors (e.g., poverty, poor healthcare access, and joint illness) and reverse causality, which likely inflate the observed effects. [\[more\]](#)
 - Even though the highest share of studies we found is set in sub-Saharan Africa, none are conducted in the countries with the highest estimated maternal mortality ratios (e.g., Chad, Nigeria, South Sudan), limiting the applicability of findings to these contexts. [\[more\]](#)

- The majority of studies examining the effects of maternal mortality focus on child mortality as the primary outcome (~72%), with fewer studies focusing on household economic impacts (~28%). The most commonly used definition of maternal mortality is the WHO definition (~48%), which we use as our primary definition given data availability. [\[more\]](#)
- Results on the effects of maternal mortality on under-five mortality:
 - The evidence consistently shows that maternal mortality is strongly correlated with increased under-five mortality in low-resource settings, with the effect varying widely across studies and being most pronounced for postneonatal children. There are some indications that effects persist beyond infancy. [\[more\]](#)
 - Our best guess point estimates suggest that maternal mortality is associated with an 8–11x increase in mortality for newborns, 13–19x for postneonates, and 3–4x for postinfants, based on pooled relative risks from the [Nguyen et al. \(2019\)](#) meta-analysis. Note that these estimates reflect associations, not causal effects. To test the sensitivity of these estimates to an outlier study ([Moucheraud et al. 2015](#)), we derive separate estimates including and excluding this study. [\[more\]](#)
 - We explored four pragmatic, highly imperfect approaches to reduce the likely upward bias due to confounding factors and reverse causality. Based on these findings, we chose to use 50% as a rough estimate of the size of the bias, but we are highly uncertain about this figure. [\[more\]](#)
 - **Our model estimates up to ~0.5 additional under-five deaths per maternal death in high maternal mortality settings, with > 90% occurring during the first year.** This estimate is sensitive to key assumptions, including a default 50% reduction in effect size due to bias and the inclusion of an outlier study ([Moucheraud et al., 2015](#)); excluding this study lowers the estimate to a maximum of ~0.3 additional under-five deaths per maternal death. **We consider the evidence sufficiently strong to recommend GiveWell account for these effects in their cost-effectiveness analysis.** [\[more\]](#)
 - The variability in the association between maternal mortality and child mortality across studies likely reflects contextual factors, such as breastfeeding practices, access to obstetric care, caregiving roles, and support systems for maternal orphans. While it is unclear where the top maternal mortality countries fall within the reported range of effect sizes, their high maternal and child mortality rates suggest risks may align with the higher end, though lower breastfeeding rates might mitigate some risks. [\[more\]](#)
 - The literature focuses primarily on the effects of maternal mortality on index children (i.e., newborns or infants) due to their direct dependency on maternal care and the structure of available data, with very limited evidence on non-index children. One study ([Moucheraud et al., 2015](#)) found no significant effects on non-index children, possibly because older children face fewer critical developmental disruptions and may benefit from alternative caregiving by extended family or community members. [\[more\]](#)
 - The evidence on maternal mortality's effects on child morbidity in low-resource settings is very limited and mostly qualitative, highlighting risks like anxiety,

depression, malnutrition, infectious diseases, and delayed healthcare. However, much of this research focuses on orphanhood broadly rather than maternal mortality specifically, and the qualitative nature of the studies makes the magnitude of these effects unclear. [\[more\]](#)

- Results on the effects of maternal mortality on household finances:
 - The literature on the economic effects of maternal mortality is very limited, predominantly qualitative, with the only quantitative evidence derived from a single dataset from rural China. While the reported effects appear plausible to us, we have little confidence in the specific estimates provided by the existing literature. [\[more\]](#)
 - Maternal mortality imposes substantial short-term financial burdens on households, including high funeral costs (~15-150% of annual household income), significant healthcare expenses (~33-50% of annual household expenditure) and increased caregiving costs for infants (e.g., formula expenses doubling infant care costs). [\[more\]](#)
 - Maternal mortality disrupts household finances, reducing income (~32%) and increasing debt (3.2 times) within the first year, as shown in rural China. Remarriage is a common coping strategy but incurs high costs, exceeding 100% of annual income in rural China. While qualitative studies from other countries align with these findings, geographic variability and long-term effects remain unclear due to data limitations. [\[more\]](#)
 - **We deem the evidence insufficient for GiveWell to adjust their cost-effectiveness analysis to account for maternal mortality's effects on household finances.** While maternal deaths are associated with significant financial costs, our very rough model suggests that causal costs unique to maternal death could constitute very roughly 16% of annual household income and include newborn healthcare and formula expenses. Most costs likely occur in the first year, driven by infant formula, and phase out afterward.

Research process

Our approach relied on desk research, searching for and examining relevant peer-reviewed scholarship through a five-step process. We outline the process at a high level in this section, with more detail on the exact methods and queries deployed to identify papers in [Appendix A](#). We keep track of the studies we identified and reviewed and some of their key characteristics in this spreadsheet.

Step 1: Search strategy and literature identification

We conducted extensive Google Scholar and AI-augmented searches for papers related to our research topics (detailed in [Appendix A](#)), yielding 104 papers after eliminating duplicates.¹ We listed these studies [here](#).

While it remains possible that we missed important papers looking at the relationship between maternal death and the outcomes of interest, we are reasonably confident that we captured most of these articles. First, while our search was narrow and over a few hours, we seemed to

¹ The initial search yielded 130 papers.

have hit saturation very quickly—the same studies kept showing up no matter how we worded our queries. Second, the fact that we identified the same papers that GiveWell initially flagged as potential resources reinforced our confidence in the results of our search. Third, skimming the references in some of the key papers did not yield additional studies.

Step 2: Preliminary screening and short-listing of studies

We scanned all papers identified in step one for their independent and dependent variables. We flagged papers that measured the effects of maternal mortality (however defined) on household income and under-five mortality, shortlisting those with these outcomes for further reading regardless of method. This yielded 30 papers (see column K “Shortlisted” in [this sheet](#)).

Step 3: In-depth review and study prioritization

Prioritization for in-depth reading was based on methodological rigor, favoring quasi-experimental designs, and reviews, followed by mixed-method, observational, and qualitative studies. Upon closer examination, we discarded 6 papers (see [here](#)) as not fitting our search criteria,² and prioritized the remaining 24 studies (see [here](#)).

Step 4: Expert consultation

Finally, to ensure comprehensiveness, we attempted to consult with experts in maternal and newborn health and causal inference. We contacted several experts identified during our literature scan and were able to schedule one expert conversation. This discussion was used primarily to validate our understanding of the state of knowledge in this area and to check whether we had missed any key studies or findings. Following this conversation, we decided not to pursue further expert outreach, as we did not expect it to be very fruitful given the limited number of relevant and recent academic papers.

Step 5: Additional literature research

In cases where additional information was needed, we conducted targeted literature searches to address specific gaps. For example, we reviewed research on funeral costs in sub-Saharan Africa to better understand the financial burden associated with maternal mortality and examined whether these costs differ by gender. Additionally, we explored the literature on the effects of maternal mortality on child morbidity to provide a more comprehensive understanding of its broader health impacts. These targeted efforts allowed us to supplement our findings and address nuances not fully covered in the initial literature review.

Evidence review and quality assessment

Before discussing our [results](#), we provide a high-level overview of the 24 studies we [shortlisted](#).

The predominantly observational evidence faces threats to internal validity, including confounding and reverse causality, likely causing upward bias

The evidence base is largely composed of quantitative, observational studies, complemented by qualitative and mixed-methods approaches, systematic reviews, and a simulation study.

[Table 1](#) shows the distribution of studies by evidence type. More than half of all papers are quantitative, observational studies, using surveys alongside standard statistical methods to determine associations between a mother’s death and the outcome of interest. Most of these studies were either cohort designs (following individuals over a long period of time), or used administrative data to understand the short-run effects of maternal mortality on outcomes of

² These papers actually focused on different outcomes, including morbidity and education.

interest. About 8% of papers were qualitative in nature, deploying interviews and focus groups to understand how maternal death affects households. Reviews and mixed-methods papers comprised together another 25% of studies. Two papers conducted a systematic review and meta-analysis of observational papers (some of which were included in our own review)³, while an additional one conducted a narrative-based literature review. All three mixed-method papers combined household surveys with qualitative interviews, and in one case with focus groups. Some of these mixed-methods papers were purely descriptive on the quantitative end. We also found a study that uses a Monte Carlo simulation model to estimate the relationship between maternal and newborn mortality.

While two quasi-experimental studies in our review rely on a difference-in-difference (DID) approach to examine maternal mortality's effects, methodological limitations weaken our confidence in their findings. We identified two quasi-experimental studies by a related set of authors⁴ that leverage a DID design as a causal identification strategy⁵ to identify the effect of maternal death on child mortality and household economy outcomes. The first paper, [Zhou et al. \(2016\)](#), only presents descriptive statistics on the differences between comparison groups with regard to neonatal death on follow-up, but these differences are not modeled (i.e., do not take advantage of the DID).⁶ Thus, we weigh the evidence with respect to infant mortality effects in this paper in the same way as an observational study. The other study, [Wang et al. \(2013\)](#), employs a DID approach, but we have concerns about the validity of the key identifying assumption—the parallel trends assumption—which may not hold. We discuss these papers in the relevant sections on [under-five mortality](#) and [household finances](#) in more detail.

³ Specifically, most of the papers in these reviews that did not appear in our own review were published before 2010. There are two papers that would seem to meet our criteria but are not in our review: [Sartorius et al. \(2011\)](#) and [Sartorius et al. \(2010\)](#). These observational papers (which are about the same population and by the same authors) are focused on understanding the predictors of child mortality, rather than the specific effects of mother's death. Still they do report effects consistent with the other studies in our sample and would therefore not significantly alter our understanding of the relationship between mothers' death and under-five mortality.

⁴ Some of the authors are the same, but not all. The core group of these authors studying outcomes in China seems to be: Haijun Wang, Fang Ye, Yan Wang, and Dale Huntington.

⁵ The quasi-experiment looking at health outcomes does not actually use the DID design to assess mortality outcomes on children, providing only descriptives on this outcome. It goes on to assess causal effects on other continuous health outcomes.

⁶ See: "A total of 14 of 120 index children (11.6%) died in the affected group, 12 of whom died before the baseline survey and 2 of whom died during the follow-up, and none died in the control group" [Zhou et al. \(2016\)](#).

Table 1: Distribution of studies by empirical approach

Evidence type	Number	Share
Observational	13	54.17%
Review	3	12.50%
Mixed-method	3	12.50%
Quasi-experimental	2	8.33%
Qualitative	2	8.33%
Simulation	1	4.17%
Grand total	24	100.00%

Note. Calculated from our [shortlist](#) of studies.

The evidence is likely affected by confounding factors and reverse causality, plausibly leading to overestimated effects.⁷

As the studies examining the effects of maternal mortality on child mortality and household finances are almost exclusively correlational, we have major concerns about potential biases, particularly due to confounding factors and reverse causality.

- **Confounding factors:**
 - **Shared socioeconomic and environmental conditions:** Factors such as poverty and poor healthcare access can independently increase the likelihood of maternal mortality, child mortality, and reduced household income. For example, households with limited access to healthcare are more likely to experience both maternal deaths and poor child health outcomes, creating a spurious association between maternal mortality and these outcomes.
 - **Joint illness:** Shared illnesses or birth complications that affect both mother and child can further confound the association between maternal and child mortality. If a mother dies from a transmissible disease like HIV/AIDS, her child may also contract the illness and die, not because of the loss of maternal care but due to the same underlying cause. This biological link makes joint illness a potentially strong confounder that can inflate the observed association between maternal mortality and child mortality.
- **Reverse causality:** In some cases, the direction of causality may be reversed or bidirectional. For instance, a household's pre-existing economic struggles may weaken maternal health, increasing the likelihood of maternal mortality. Similarly, a severely ill child requiring intensive care and resources could place additional stress on the mother, exacerbating her health risks. These dynamics complicate the interpretation of

⁷ A related issue in this context is publication bias, though we are less concerned about it compared to internal validity threats. Our sample of 19 quantitative studies all show statistically significant relationships in the same direction, which is unusual given that at a 95% confidence level, ~1 study would typically show a null result if the effect were true. Maternal death is a rare event, even in high-mortality contexts, meaning only strong relationships are likely to reach statistical significance. This suggests that the effects may indeed be very large, but other factors (e.g., publication bias, incorrect covariate adjustments) could also be at play. While we generally trust that the reported associations are valid, we remain highly uncertain and would revise our views significantly with more robust, causal evidence.

observed associations, as maternal mortality might sometimes be a consequence, rather than the cause, of adverse child or household outcomes.

We discuss our attempts to quantify or eliminate the bias in the relevant sections on [under-five mortality](#) and [household finances](#) in more detail. In [Appendix G](#), we provide examples of possible research designs to identify the causal impacts of maternal mortality if a funder were interested to fund research in this area.

While most evidence is from low-resource settings, its applicability to the top maternal mortality countries remains unclear

We also have concerns about external validity. Even though the evidence in our review is predominantly focused on low-resource settings, none of the studies in our [shortlist](#) are set in the three countries with the highest estimated maternal mortality ratios (Chad, Nigeria, South Sudan)⁸. The highest share of studies we found is in sub-Saharan Africa (37.5%), but these studies are concentrated in a few locations (see [Appendix E](#) for a heatmap of the geographical distribution of studies in our shortlist).⁹ For example, studies conducted in Ethiopia, Kenya, and South Africa represent 27% of the sample (9% each.) While data from the WHO show that maternal mortality is concentrated in a few sub-Saharan countries, none of the top 10 feature among our studies.¹⁰

While sub-Saharan African countries share some characteristics, there is still substantial heterogeneity with respect to healthcare infrastructure, cultural practices, and socioeconomic conditions, which makes it difficult to say whether the evidence we have identified here would apply in those countries.

We discuss the issue of generalizability across geographies in more detail in the respective results sections on [under-five mortality](#) and [household finances](#).

The majority of studies use the WHO definition of maternal mortality, focusing on mortality outcomes over income effects

Definitions of maternal death vary substantially across studies, with the WHO definition being the most frequently applied, appearing in nearly half of the cases. We focus predominantly on this definition in our report, as it aligns with the majority of the available evidence. Across the 24 studies we examined, the operationalization of maternal death varied considerably, and some papers included multiple instances such that the total $n = 44$. See column 'Grand Total' in [Table 2](#). The most frequent choice (~48%) for the independent variable

⁸ Based on [WHO \(2023\)](#) data, the top three countries with regard to maternal mortality ratio are South Sudan, Chad, and Nigeria.

⁹ The other large region in terms of representation is Asia (~28%), though many studies come from China (~12.5%) and Bangladesh (~9%). The authors of the studies set in China are a single team using the same data and similar econometric strategies over the four papers. No other region stands out as having sufficient evidence to form a confident view on how the takes we express here would apply to those settings.

¹⁰ Based on [WHO \(2023\)](#) data, the top 10 countries with regard to maternal mortality rate are South Sudan, Chad, Nigeria, Central African Republic, Guinea-Bissau, Liberia, Somalia, Afghanistan, Lesotho, and Guinea (in this order).

aligned with the WHO's definition of maternal mortality.¹¹ The next most common independent variable entailed using timing of a mother's death across set intervals or larger time horizons (~30%). These "intervals" correspond to deaths occurring, for example, between months 1 and 3 of a child's birth, or within the first year of life, corresponding to the IHME definition of maternal mortality.¹² A smaller share of operationalizations entailed death occurring at any time during childhood (~14%) or did not specify the exact definition of maternal death (~9%).

Table 2: Contingency table of distribution of dependent and independent variables across shortlisted studies

Independent variable	Dependent variable		
	Household economy	Child mortality	Grand total
WHO maternal mortality	10	11	21
Intervals, various	--	13	13
Death at any time	--	6	6
Not specified	3	1	4
Grand total	13	31	44

Note. Calculated from our [shortlist](#). Blank cells indicate that our sample did not include any papers investigating this relationship.

Child mortality is the primary outcome examined, while household economic impacts are less frequently addressed. We examined the independent-dependent variable distribution to see what types of associations are being tested across our sample of papers. Each filled cell of [Table 2](#) represents one such association. A majority of the associations focused on child mortality as an outcome (~72%); fewer focused on the household economy as an outcome (~28%).¹³ With regard to the effect of maternal mortality on child mortality, most associations deployed the WHO definition of maternal mortality or other intervals.¹⁴ Similarly, with regard to the effect of maternal mortality on the household's economy, the vast majority of tests used the WHO definition—any remaining papers did not specify.

¹¹ The WHO defines maternal mortality as “the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from unintentional or incidental causes” ([WHO, 2019](#), p. 8).

¹² “GBD defines maternal deaths as any death of a woman while pregnant or within one year of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes” ([IHME, 2024](#)).

¹³ In terms of actual papers 17 papers reported effects on child mortality, while six reported effects on the household economy.

¹⁴ Of those papers using different intervals, the most common type of interval was death within the first year of the child's life.

Results: Effects of maternal mortality on under-five mortality

This section aims to estimate the impact of maternal mortality on under-five mortality in the top three countries with the highest estimated maternal mortality ratios (Nigeria, Chad, South Sudan), drawing from the scientific literature. We begin by reviewing some [high-level findings from the empirical literature](#) and outlining the resulting [point estimates](#) we use to capture the *association* between maternal and under-five mortality. Acknowledging that these associations likely overestimate the causal effect due to confounding factors and reverse causality (as explained [here](#)), we explore pragmatic approaches to quantify or [reduce this bias](#). All of these findings are then incorporated into a [model](#) to estimate the *causal effect* of one maternal death on additional child deaths. Finally, we examine contextual mediating factors that may account for [geographical variability](#) in the effects, the evidence on how maternal mortality affects [non-index children](#), and the evidence on [child morbidity](#) associated with maternal mortality.

Before presenting the results, we would like to provide some **terminological definitions** to clarify key terms used in this section:

- **Index children:** The reference birth used to measure the timing of maternal death in relation to the child's life.
- **Non-index children:** Older siblings of the index child or other children living in the household.
- **Neonates/newborns:** Children aged 0-28 days.
- **Postneonates:** Children aged 1-12 months, excluding neonates.
- **Infants:** Children aged 0-12 months, including neonates.
- **Postinfants:** Children older than 1 year but under 5 years.
- **Under-five:** All children under five years, including neonates, infants, and postinfants.

Unless stated otherwise, **this section focuses by default on maternal mortality as defined by the WHO (within 42 days postpartum)¹⁵ and is based on index-children** to estimate the effects on child mortality. We discuss the mortality effects on non-index children separately [here](#).

[Maternal mortality is associated with an increased child mortality risk, with effects peaking postneonatally and possibly persisting beyond infancy](#)

While the evidence consistently shows that maternal mortality is associated with an increase in child mortality, the magnitude of this effect varies widely across studies and contexts. Please keep in mind that the evidence is correlational only. [Table 3](#) and [Appendix C](#) summarize the evidence on the effects of maternal mortality as defined by the WHO on child mortality from several quantitative, observational studies for newborns and infants, respectively. While the studies in our sample report magnitudes in different units, all studies report relative risks or hazard ratios significantly larger than 1. Overall, maternal mortality is clearly associated with an increased risk of child mortality.

What also stands out to us is the large variation in effect sizes across studies, even though the studies are set in comparatively low-resource settings. For newborns, the estimated relative risks range from 6x to 46x (see [Table 3](#)). For infants, the variation in relative risks is even higher, with relative risks reaching up to 66x (see [Appendix C](#)). Note that these large ranges are largely driven by an outlier study from Ethiopia ([Moucheraud et al., 2015](#)). Excluding the

¹⁵ We revert to the IHME definition of maternal mortality (within 365 days postpartum) if no evidence is available for the WHO definition and indicate whenever this applies. However, this has little impact on our results, as the findings are similar across the WHO and IHME definitions (see, e.g., [Figure 1](#)).

findings by [Moucheraud et al. \(2015\)](#) yields much smaller ranges (e.g., 6-7x for newborns). However, after reviewing the study in detail, we found it comparable in quality to other studies and the higher effect sizes seemed plausible to us given contextual factors (e.g., high dependency on breastfeeding and very limited access to obstetric care). Thus, we decided not to dismiss its findings, but conducted a sensitivity analysis in our [model](#) in which we exclude the findings of [Moucheraud et al. \(2015\)](#) (see also [next section](#) for more detail).

More generally, while we expect that some of the variation in effect sizes might be due to differences in study design and data quality, we also think that there is plausibly a high genuine heterogeneity in effect sizes across contexts and geographies, which is driven by contextual mediating factors. We explore the mediating factors that likely drive some of this heterogeneity [here](#).

Table 3: Summary of quantitative evidence of the association between maternal mortality (within 42 days of birth) and neonatal mortality (within 28 days)

Title [ID]	Geography	Study design	Specific impact	Effect size
Saleem et al. (2014) [ID 98]	Argentina, Guatemala, India, Kenya, Pakistan, and Zambia.	<i>Observational.</i> Simple statistical modeling estimating relative risks for ~220,000 pregnant women	Perinatal mortality	RR: 4.30; 95% CI: 3.26–5.67
			7-day mortality	RR: 3.94; 95% CI: 2.74–5.65
			28-day mortality	RR: 7.36; 95% CI: 5.54–9.77
Finlay et al. (2015) [ID 11]	Rural Tanzania	<i>Observational.</i> Longitudinal study deploying survival analysis	0-1 month mortality	RR = 6.47; 95% CI: 3.25–12.87
Pande et al. (2015) [ID 13]	Kenya	<i>Mixed-method.</i> Matched quantitative data, but no statistical modeling	Newborn (within 1 month, maternal death) mortality	26.5% probability of death, compared to no deaths among children who did not lose their mother.
Moucheraud et al. (2015) [ID 9]	Ethiopia	<i>Observational.</i> Survival analysis to calculate cumulative survival probabilities	Newborn death (1 month)	0.375 probability of survival, or 46x increase in probability of dying over children with mothers who live
Nguyen et al. (2019) [ID 28]	LMICs studies from 1980-2017	<i>Review.</i> Meta-analysis, including 13 articles reporting 11 cohorts of 11 original studies, though not all report 28-day mortality	28-day mortality	RR: 11.3 (95%CI: 5.9–21.8)
Scott et al. (2017) [ID 14]	The Gambia	<i>Observational.</i> Survival analysis on surveillance data.	1-week mortality	HR: 3.05 (95%CI: 1.12 - 8.28)
			1-week to 1 month mortality	HR: 6.99 (95%CI: 2.98–16.36)

Note. Data from our review of the papers.

There appears to be an inverse-U relationship between maternal mortality and child mortality across different child age groups, with the association being strongest for postneonatal children, somewhat lower for newborns, and then declining after infancy. Considering relative mortality risks of children whose mothers died vs. children whose mothers survived, the evidence consistently shows an inverse-U relationship between maternal mortality and child mortality across different age groups. Relative risks are, by far, highest in the postneonatal stage, i.e., just after the neonatal period, and decline again after infancy. This pattern can be clearly seen in the pooled relative risk estimates from [Nyugen et al.'s \(2019\)](#) systematic review (see [Figure 1](#) below), but are also visible in individual studies (see Table 1 in [Nyugen et al., 2019](#)). Specifically, using the WHO definition of maternal mortality (42 days), [Nyugen et al.'s \(2019\)](#) pooled relative risk estimate is ~11 for the neonatal period (0-28 days), rising to ~35 at 1-6 months, and is lower thereafter (~3 for 6-12 months). A similar pattern can be found if we use the IHME definition of maternal mortality (0-12 months).

Figure 1: Pooled relative risk estimates for child mortality from [Nyugen et al.'s \(2019\)](#) systematic review

a.) Pooled risk of child mortality stratified by death of a mother when child aged 0–42 days, 0–12 months, 0–5 years and 0–10 years

Age of child at mother's death (exposure)	Age at risk of child death (outcome)									
	0–7 days	8–28 days	0–28 days	1–6 months	6–12 months	0–1 years	1–2 years	2–3 years	3–4 years	
0–42 days ^a	4.03 (2.92–5.57) ^a	11.73 (3.82–36.01)	11.31 (5.88–21.75) ^b	35.48 (9.65–130.47) ^c	2.81 (0.74–10.73)		6.86 (2.19–21.45)			
0–12 months ^m			11.06 (3.74–32.74) ^d	27.45 (17.61–42.81) ^e	12.20 (7.91–18.81) ^f	15.90 (2.1–16.10) ^g	9.79 (5.66–16.91)	1.66 (0.2–11.86)	3.79 (0.54–26.72)	

Note. Table 3 copied from [Nyugen et al. \(2019, p. 13\)](#), slightly adapted and cropped.

It is not surprising that the strength of the association decreases after infancy because, as children grow older, they become less dependent on direct maternal care, such as breastfeeding. Their nutritional needs and developmental requirements can be more easily met by alternative caregivers, and their immune systems tend to strengthen with age (e.g., [Nguyen et al., 2019](#)). What may, perhaps, seem surprising is that the effect is not highest for neonates, despite their extreme vulnerability and dependence. We have not seen any discussions on this in the literature, but we suspect this might be due to two factors:

1. Depending on the context, in the month after birth, families may still benefit from postpartum care and community support, which can temporarily buffer the impact of maternal loss.
2. The pattern may also be a statistical artifact due to the timing of how maternal mortality is measured. Since maternal mortality is tracked within 42 days postpartum, it is possible that most maternal deaths occur after the neonatal stage (the first 28 days) but still within the infant period (we do not know precisely the timing of maternal death within the 42 days). Consequently, the effects of maternal death may be disproportionately reflected in postneonatal and overall infant mortality rates.

Although the evidence becomes less robust as children age, there are some indications that effects may persist beyond infancy. Our impression is that the available evidence is strongest for the neonatal period and gets weaker as children get older.¹⁶ One reason is the volume of evidence. We found more studies focusing on the neonatal period than on later ages. Another

¹⁶ This is likely because child deaths become statistically rarer as children get older - newborn deaths (within 28 days) account for roughly half of all under-five deaths ([Li et al., 2021](#)), so larger sample sizes are required to have sufficient statistical power to be able to detect effects in older children.

reason is that these papers also cover a broader geography. We are more likely to believe associations that replicate along many different contexts. The quality of the evidence per se is not substantively different across studies.

Looking beyond infancy, the [Nguyen et al. \(2019\)](#) meta-analysis found that for 1-2 year old children, the relative risk of mortality is still substantial, at ~7 (see [Figure 1](#)). Unfortunately, we have not found any studies with our preferred definition of maternal mortality (within 42 days after birth) that reported effects on children aged over 2 years. However, [Nguyen et al. \(2019\)](#) offers evidence based on the IHME definition of maternal mortality (see [Figure 1](#)). If we consider maternal mortality within 0-12 months after birth, there is a pooled relative risk of ~2 for 2-3 year olds and of ~4 for 3-4 year olds.

Given the very limited evidence for older children, we do not necessarily trust the exact magnitude of estimated associations, but we find it plausible that the death of a mother can still have effects on child mortality beyond infancy. We have not seen clear evidence on why mortality remains elevated for older children, but [Nyugen et al. \(2019\)](#) hypothesized: “It is possible that lack of mother’s care in daily life, particularly when children are ill, might be associated with risk of childhood mortality at older ages. Child death up to 12 or 18 years of age, following a mother’s death, might be associated with other factors, including disease, malnutrition, poor hygiene, injuries, and psychological/mental problems.”

Our best guess is that maternal mortality is associated with an 8-11x increase in mortality for newborns, 13-19x for postneonates, and 3-4x for postinfants

Building on the findings from the literature we discussed in the previous section, **we now turn to deriving point estimates for relative risks that we use in our [model](#) below to estimate the number of additional child deaths associated with each maternal death. Please note that these point estimates are still *correlational*. We try to address a likely bias in the [next section](#).**

While the studies in our [shortlist](#) primarily focus on low-resource settings, none of them are set in the top three maternal mortality countries (Chad, Nigeria, South Sudan). As a result, it is not obvious which study results are most likely to generalize to these contexts without doing a deep contextual analysis of each region. As we discuss [below](#), factors such as healthcare infrastructure, caregiving norms, breastfeeding practices, and socioeconomic conditions can vary widely and significantly influence the applicability of findings across different geographies.

We decided to rely on point estimates from [Nguyen et al.’s \(2019\)](#) systematic review, which provides pooled relative risk estimates across diverse low-resource settings (see [Figure 1](#)). We believe these offer a robust starting point for deriving generalizable figures.

Moreover, since the pooled estimates in [Nguyen et al. \(2019\)](#) are heavily influenced by [Moucheraud et al. \(2015\)](#) as an outlier (as explained [here](#)), **we derive separate point estimates that either include or exclude [Moucheraud et al. \(2015\)](#), respectively.** Unfortunately, [Nguyen et al. \(2019\)](#) provide pooled relative risk estimates excluding [Moucheraud et al. \(2015\)](#) only for neonates, but not for other age groups. As we did not have sufficient time to replicate their meta-analysis excluding the outlier study for the two other age groups, we use a rough approximation: We assume that, if we exclude [Moucheraud et al. \(2015\)](#), the point estimate drops by the same proportion for postneonates and postinfants as it does for neonates (i.e., it corresponds to 67% [=7.6/11.3] of the point estimates including the outlier).

Our point estimates can be seen in [Table 4](#).

Table 4: Relative risk point estimates we use as inputs to our model

Age group	Relative risk estimate (correlational)		Explanation
	Incl. Moucheraud et al. (2015)	Excl. Moucheraud et al. (2015)	
Neonates (0-28 days)	11.3	7.6	Nguyen et al. (2019) report a pooled estimate of 11.3 including the outlier and 7.6 excluding it.
Postneonates (1-12 months)	19.1	12.8	<p><u>Including the outlier:</u> Nguyen et al. (2019) do not report pooled estimates for the entire postneonatal period, but provide separate estimates for 1-6 months (35.5) and 6-12 months (2.8). Since we have not found data on the relative proportions of these two age groups, we calculate a simple average of these estimates to derive a point estimate of 19.1.</p> <p><u>Excluding the outlier:</u> We use 67% of 19.1, which is 12.8.</p>
Postinfants (1-4 years)	4.1	2.7	<p><u>Including the outlier:</u> The evidence is more limited for children aged >1, but Nyugen et al. (2019) provides some estimates that we can use to derive a best guess:</p> <ul style="list-style-type: none"> • For 1-2 years, the relative risk is 6.9. • For 2-3 years, the relative risk is 1.7 (maternal mortality within 12 months). • For 3-4 years, the relative risk is 3.8 (maternal mortality within 12 months). <p>We assume that children are spread evenly across these age groups and calculate a simple average to estimate the relative risk for the 1-4 year age range. This yields a relative risk of 4.1.</p> <p><u>Excluding the outlier:</u> We use 67% of 4.1, which is 2.7.</p>

Based on four pragmatic approaches, we roughly estimate that 50% of the effect size is due to upward bias, though we are highly uncertain about this

As outlined [here](#), we think that the observed effect of maternal mortality on child mortality is likely overestimated due to various confounding factors and reverse causality. For example, socioeconomic constraints, such as poverty and limited healthcare access, can independently elevate child mortality risks and confound the association with maternal death. Additionally, shared health disadvantages, like preexisting conditions or a disease transmission from the mother to her child, may affect both mother and child outcomes.¹⁷ While the studies we reviewed include several control variables to address these potential confounders, we expect that residual confounding may still persist.

We explored several pragmatic, albeit imperfect, methods to better isolate causal effects. While these approaches are somewhat ad hoc, they offer potential insights into the underlying relationships. In [Appendix D](#), we describe four different approaches that leverage various control groups to reduce bias in the relative risk estimates. Here is a summary:

1. **Using maternal near-misses to address shared confounders:**
 - a. This approach involves comparing the association between maternal mortality and child mortality to the association between maternal near-miss events (severe birth-related complications where the mother survives) and child mortality. Since both share similar confounders (e.g., joint illness, socioeconomic factors), the difference isolates the unique effect of losing a mother. **We estimate that bias from shared confounders accounts for at least ~20% of the observed effect size.**
2. **Using paternal mortality to address shared confounders:**
 - a. This approach compares the association between maternal mortality and child mortality with the association between paternal mortality and child mortality. We expect that both maternal and paternal mortality are influenced by shared confounders, such as socioeconomic status, healthcare access, and environmental factors. The difference in associations isolates the unique effect of losing a mother, **with the bias from shared confounders estimated to account for at least ~50% of the observed effect size.**
3. **Using cause of death data to address joint illness as a confounder:**
 - a. The approach examines whether shared illnesses, like HIV/AIDS or TB, drive the association between maternal and child mortality. If maternal deaths from specific causes (e.g., HIV/AIDS) disproportionately increase child mortality, the effect may reflect illness transmission rather than the loss of maternal care. While we think this approach has some merit in theory, **we did not find data that we deem appropriate to use this approach.**
4. **Using maternal deaths beyond 42 days to address shared confounders (except joint illness):**
 - a. This approach compares the association between maternal deaths within 42 days and child mortality with the association between maternal deaths beyond 42 days and child mortality. This could eliminate various environmental confounders (e.g., socioeconomic status and healthcare access), but we expect that this approach is unlikely to eliminate joint illness and obstetric complications as

¹⁷ It is theoretically possible that confounding factors could lead to an underestimation of the effect of maternal mortality on child mortality. However, in this case, we could not identify any significant factors that would drive such an underestimation. All plausible confounders we could think of, such as socioeconomic constraints, healthcare access issues, and preexisting health conditions, are more likely to amplify the observed association, leading to potential overestimation instead.

confounders. We were unable to find data we deem sufficiently useful for this approach, so we did not pursue it further.

Of all the approaches explored, we expect approaches 1 and 2 to perform best, as they likely eliminate the most confounders. In practice, we have the most confidence in the results from approach 2 due to data availability, though only slightly more so than approach 1. **This leads us to lean towards assuming that 50% of the observed effect size is due to upward bias, though we acknowledge that it could plausibly be higher or lower.** We are highly uncertain about this assumption. We encourage readers to experiment with different assumptions with regards to the magnitude of the upward bias in the [model](#) (explained in the next section) to see how they influence the estimated effects of maternal mortality on under-five mortality.

Model results: We estimate that for 1 maternal death, there are up to ~0.5 additional under-five deaths, but this depends heavily on the assumed bias

Combining our [best guess point estimates](#) based on the empirical literature with additional inputs and assumptions, we built a [model](#) to estimate the number of additional child deaths per maternal death for different age groups and countries.

We outline the calculation steps here (see [Appendix B](#) for more detail):

1. We convert *overlapping* child mortality rate estimates from the World Bank for newborns (0-1 months), infants (0-12 months), and under-five children (0-4 years) to *non-overlapping* child mortality rate estimates for newborns (0-1 months), postneonates (1-12 months), and postinfants (1-4 years). This step ensures compatibility with the relative mortality risk estimates we obtained from the literature.
2. By combining child mortality rate estimates from step 1 and maternal mortality ratio estimates from the World Bank with the [relative mortality risk estimates](#) from the literature, we calculate separate mortality rates for children whose mothers died and for those whose mothers survived.
3. To account for a likely overestimation of the relative mortality risks from the literature due to confounding factors, we introduce an adjustment parameter.
4. Finally, we calculate excess child mortality attributable to maternal death for our *non-overlapping* age groups (newborns, postneonates, and postinfants) by subtracting the mortality rates of children with surviving mothers from the mortality rates of children with deceased mothers for each respective age group. The resulting figures represent the number of additional child deaths associated with one maternal death. Based on these, we can then calculate the respective excess mortality figures for *overlapping* age groups.

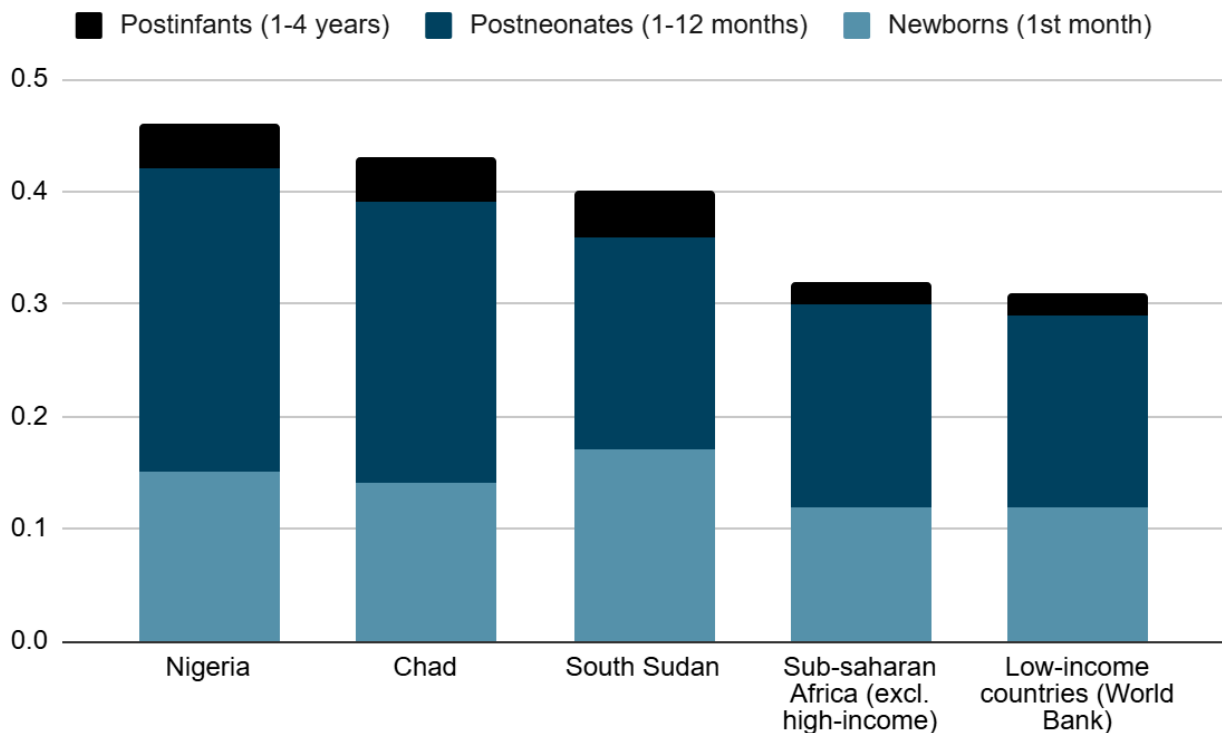
We used the model for the top maternal mortality countries (Chad, Nigeria, South Sudan), as well as sub-Saharan Africa (excluding high-income countries), and low-income countries as defined by the World Bank. Moreover, the model offers the option to include or exclude the relative mortality risk estimates from [Moucheraud et al. \(2015\)](#) as a sensitivity check (due to its outlier status, as we explain [here](#)). We include [Moucheraud et al. \(2015\)](#) as a default.

Here is a summary of the key findings (see [Figure 2](#) below):

- **We estimate that there are up to ~0.5 additional under-five deaths for 1 maternal death.** We find the largest effect in Nigeria and slightly smaller effects in Chad, South Sudan, and other low-income or sub-Saharan African countries. This assumes a bias of 50% and includes [Moucheraud et al. \(2015\)](#) as an outlier.

- **Almost all excess deaths occur during the first year of a child’s life** (e.g., 93% for Nigeria).
- **The effects are smaller if we exclude [Moucheraud et al. \(2015\)](#) as an outlier** (see [Appendix F](#)), **but still substantial**. For Nigeria, there are up to ~0.3 additional under-five deaths for 1 maternal death.
- **Our highest uncertainty related to these estimates is the size of the bias**. We think an assumed bias of 50% is reasonably conservative, but it may be larger or smaller.

Figure 2: Additional child deaths per maternal death (including [Moucheraud et al., 2015](#))



Note. The assumed bias is 50%. Calculations are [here](#).

Contextual factors, including cultural practices and healthcare systems, mediate the association between maternal and child mortality across studies

As mentioned [above](#), there is substantial heterogeneity in the reported associations between maternal mortality and child mortality across various studies and geographies. While quantitative analyses to determine the main drivers of this variability are lacking, qualitative evidence suggests that contextual factors likely play a significant role in mediating the effect.

The primary factors identified in the literature that may contribute to the observed heterogeneity in the association between maternal and child mortality include:

1. **Breastfeeding practices:** Losing a mother early in life can lead to the “interruption of breastfeeding, which is a major determinant of infant survival” ([Ronsmans et al., 2010](#)). This is especially risky for babies in settings where breastfeeding is near-universal, wet-nursing is uncommon, and formula is unavailable or unaffordable. For example, in Butajira, Ethiopia, 99.6% of infants are still breastfed at one year of age, which might explain the very large association (RR=46; see [Table 3](#)) between maternal and neonatal mortality in the same region ([Moucheraud et al., 2015](#)).

2. **Access to obstetric care and childbearing practices:** In the absence of professional medical care, a child is more dependent on the mother’s care, and thus more vulnerable to adverse effects if the mother dies. For example, a low share of deliveries attended by a skilled provider (~25%) may partially explain the very strong association between maternal and child mortality in Butajira, Ethiopia ([Moucheraud et al., 2015](#)).
3. **Caregiving by fathers:** Depending on the context, fathers may or may not take on childcare responsibilities after the death of their wife. For example, in Bangladesh and Ethiopia, there is a strong “gendered division of household duties [which] leaves fathers unprepared to assume caregiving responsibilities” ([Molla et al., 2015](#); [Ronsmans et al., 2010](#)). [Yamin et al. \(2013\)](#) found that in Tanzania, “the erosion of collective social support systems [...], has left fathers disinclined to assume individual responsibility for the care and support of their children, especially infants”.
4. **Family reconstruction:** Family “reconstruction” through remarriage, foster care, or kinship can reduce the risk of child death caused by maternal death”, but the extent and effects of this seem highly contextual ([Atrash, 2011](#)). For example, in some contexts (e.g., Bangladesh), widowed fathers tend to remarry quickly ([Ronsmans et al., 2010](#)), whereas in others (e.g., Tanzania) it is common that families are dissolved and orphaned children are separated and placed in different homes of relatives ([Yamin et al., 2013](#)). According to [Chikhungu et al. \(2017\)](#), “even though adoption and remarriage may protect children left motherless as a result of maternal mortality, the quality of care received by such children may be lower than the care they would have otherwise received from their biological mothers”.
5. **Support services and programs for maternal orphans:** While there is “a well-established social protection system in South Africa, with grants for children and older people that may enable families to support at-risk children” ([Houle et al., 2015](#)), there is a lack of structured support systems for orphan care in many other settings (e.g., Ethiopia, see [Moucheraud et al., 2015](#)).

We think that the relative risk of child mortality in the three countries with the highest estimated maternal mortality ratios could plausibly fall on either the higher or lower end of the spectrum, but determining this with confidence would require a deeper review of contextual factors. We have not seen any evidence to determine which of these mechanisms are quantitatively the most important, and we do not believe there is a straightforward way to assess whether the countries with the highest estimated maternal mortality ratios (Chad, Nigeria, South Sudan) are closer to the higher or lower end of the effect sizes reported in the literature. On the one hand, Chad, Nigeria, and South Sudan have exceptionally high maternal and child mortality rates, even compared to other sub-Saharan African countries, suggesting that they likely have underdeveloped healthcare and obstetric care systems. This would suggest that the relative risks are at the higher end. On the other hand, breastfeeding rates in these countries are comparatively low.¹⁸ This may mitigate some of the risk associated with maternal mortality, particularly in settings where alternative feeding options are accessible, and thus, would suggest a relative risk at the lower end.

¹⁸ According to a 2022 survey in Chad, only ~7% of 0-6 month old children are exclusively breastfed ([Mamgobaye, 2024](#)). In Nigeria, an estimated 34% of 0-6 month olds are exclusively breastfed ([ThisDay, 2024](#)). In South Sudan, 60% of children under six months were exclusively breastfed in 2023 ([UNICEF, 2024](#)). While this is a relatively high breastfeeding rate, it is still significantly lower compared to near-universal breastfeeding of infants in Ethiopia.

The only study we found that examined the effects on non-index children's mortality reported null results

Our impression is that there is very little focus on the effects on non-index children (i.e., older siblings or other children in the household) in the literature relative to index children. We expect that this is mainly for two reasons:

1. **Direct dependency:** The effects of maternal mortality on index children are presumed to be highest, as index children tend to be the most dependent on the mother for critical survival needs, such as breastfeeding and immediate caregiving.
2. **Data availability:** Many datasets and studies are structured around birth and delivery events, making it easier to track outcomes for index children than for siblings or other household members.

Based on our review of the [shortlisted](#) studies, we identified only one study that directly examined the effects of maternal mortality on non-index children: [Moucheraud et al. \(2015\)](#). The authors found no significant effects on non-index children. While they reported substantial effects on index children, with a 46-fold increase in neonatal mortality, the study reported that “non-index children of maternal deaths do not have a significantly different ($p=0.6$) probability of death than children whose mothers survived (7% and 9%, respectively)”¹⁹. Unfortunately, the authors do not discuss this finding in any more detail. Thus, we do not know how old the index-children were when their mothers died or whether these children were primarily cared for by non-maternal caregivers (e.g., extended family members or older siblings).

At first, we were surprised by this result as it seemed at odds with our previous finding that the effects of maternal mortality may persist beyond infancy (as we discussed [here](#)), but we think there might be a plausible explanation for this. One possible—though speculative—explanation for this seeming discrepancy is that index children whose mothers die during infancy may experience long-term complications, such as nutritional deficiencies or poor health early in life, which make them more vulnerable even years later. In contrast, non-index children, who are typically older at the time of their mother's death, may not face the same critical developmental disruptions and may be therefore less affected in the long term. Moreover, in some cultural contexts, extended family networks or community support systems may step in to care for non-index children, mitigating the potential impacts of maternal loss. For example, in The Gambia, mothers tend to leave their babies in the care of relatives from around six months of age so that they can resume their farming work ([Sear et al., 2002](#)).

Qualitative evidence links maternal mortality to child morbidity, including mental health issues, malnutrition, infection, and delayed healthcare-seeking

The evidence on the effects of maternal mortality on child morbidity in low-resource settings is very limited and predominantly qualitative. Reports highlight adverse effects on mental health, increased risks of malnutrition and infectious diseases, as well as delays or reductions in healthcare-seeking behavior. However, not all the evidence we found was specifically related to maternal deaths, with some findings applying more broadly to parental mortality or orphanhood.

¹⁹ Moreover, “the survival function for non-index children of maternal deaths [...] is not significantly different from that of their counterparts with surviving mothers ($p=0.38$)” ([Moucheraud et al., 2015](#)).

While we spent ~1.5 hours reviewing the literature specifically on the effects of maternal mortality on child morbidity, we are fairly confident that an additional 10 hours of research would be unlikely to substantially update our views, though we recommend confirming this with an expert to be certain.²⁰ Our impression is that the literature does not typically focus directly on child morbidity as an outcome of maternal mortality. Instead, much of the existing research centers on the child mortality effects of maternal death, with child morbidity often mentioned only in passing. The most thorough evidence relates to anxiety and depression among children, but this body of work tends to address orphanhood in general rather than the specific impacts of maternal mortality.

Anxiety and depression:

- A study from Uganda reported that “children living with widowed fathers and those living on their own were significantly more depressed” ([Sengendo & Nambi, 1997](#)).
- Another study in Uganda found that “children aged 11-15 years whose parents (one or both) were reported to have died from AIDS [...] had greater risk (vs. non-orphans) for higher levels of anxiety (odds ratios (OR)=6.4), depression (OR=6.6), and anger (OR=5.1)” ([Atwine et al., 2005](#)).
- In Zimbabwe, “orphans had more psychosocial distress than did non-orphans. For both genders, paternal, maternal and double orphans exhibited more severe distress than did nonorphaned, nonvulnerable children” ([Nyamukapa et al., 2011](#)).

Nutritional deficiencies, stunted development, and infections:

- A study in rural Malawi found that maternal mortality leaves infants vulnerable to malnutrition due to the absence of breastfeeding, while older maternal orphans face health risks from inadequate caloric and protein intake, leading to stunted development and susceptibility to infections. Study participants noted that maternal orphans are particularly vulnerable during disease outbreaks due to low immunity caused by poor nutrition ([Bazile et al., 2015](#)).
- A study in Tanzania found that maternal orphans face significant nutritional challenges, with only 15% of maternal orphans ever breastfed and fewer than 5% breastfed for longer than one month. Due to the high cost of formula, many families substitute cow’s milk, which can cause gastric distress, exacerbating the risks of undernutrition, stunting, and mortality. Limited food quality and quantity within households further heighten the vulnerability of maternal orphans, particularly during infancy ([Yamin et al., 2013](#)).

Reduced and less timely healthcare-seeking behavior:

- A study in Ethiopia highlighted that maternal orphans often face delays in healthcare and immunization, as caregivers, including stepmothers and fathers, may not prioritize their health as highly as biological mothers would. Male caregivers often postpone seeking medical care, hoping children will recover on their own to avoid incurring medical expenses ([Molla et al., 2015](#)).

A quantitative study on children’s causes of death in Bangladesh mirrors some findings of the qualitative studies. [Ronsmans et al. \(2010\)](#) conducted a quantitative, observational analysis in Bangladesh to compare the causes of death among children whose mothers died with those whose mothers survived (see [Appendix H](#)). They find that “infants whose mothers died were more likely to die from diarrhoeal diseases and nutritional deficiency than were those whose mothers survived ($p<0.0001$). Malnutrition was much more common in children aged 12–119

²⁰ For example, we think that Alicia Yamin ([Harvard Medical School, 2018](#)) from the Harvard Medical School could be a valuable expert to consult.

months whose mothers had died than in those whose mothers were alive ($p < 0.0001$).” These findings highlight shared themes such as the heightened risk of malnutrition and infectious diseases.

Based on these findings, we have two main takeaways related to child morbidity effects:

- In our view, the most robust evidence on child morbidity effects relates to anxiety and depression. However, we have not reviewed the studies sufficiently to determine whether the effects differ between maternal and paternal deaths, as most focus on orphanhood more generally rather than maternal mortality specifically.
- Despite the limited evidence, we find it intuitively plausible that maternal mortality has physical health impacts on children. For instance, while malnutrition resulting from maternal death may not always lead to child mortality, it could cause long-term health consequences such as stunting or wasting. Unfortunately, the magnitude of this effect remains unclear, as the available qualitative evidence does not provide sufficient quantification.

Results: Effects of maternal mortality on household finances

This section explores the empirical literature on the economic effects of maternal mortality. As illustrated [previously](#), much less has been written about its effects on household finances compared to its impacts on child mortality. This literature is predominantly qualitative. While three quantitative studies have been published ([Wang et al., 2013](#); [Ye et al., 2012](#); [Ye et al., 2015](#)), all are based on the same data set collected in rural China, limiting the breadth of quantitative insights available.

We identified six papers that are most relevant to this topic and provide an overview of their key findings in [Table 5](#). These studies examine a range of financial outcomes, including changes in household income, expenditure patterns, debt levels, and the redistribution of labor and caregiving responsibilities. **The main finding across all these studies is that maternal mortality significantly disrupts household finances, leading to reduced income, increased economic strain, and reallocation of labor to compensate for lost caregiving roles.**

In the following discussion, we structure the literature into [short-term effects](#), such as funeral costs, healthcare costs, and increased care expenses for infants, and [medium-term effects](#), including income changes and the financial implications of remarriage. While we think this distinction provides a useful framework, it is not entirely clear-cut as many effects can overlap or evolve over time. A [model](#) considers how much of the costs we expect to be unique to maternal deaths, as opposed to costs that would also occur following the death of a father or other caretaker.

Although beyond the scope of this report, we would like to highlight evidence suggesting long-term economic strain, such as educational setbacks for children, early marriage, and early childbearing, which can perpetuate intergenerational cycles of poverty.²¹ An interested reader may find [Bazile et al. \(2015\)](#) a useful starting point for exploring longer-term effects. Additionally, our [longlist](#) of papers includes studies that examine the educational impacts of maternal mortality.

²¹ There is more evidence on the intergenerational effects of parental mortality from high-income countries, such as [Kane et al. \(2009\)](#), [De Giorgia et al. \(2023\)](#), and [Debiasi et al. \(2021\)](#).

Table 5: Summary of evidence on the effects of maternal mortality on household finances

Title [ID]	Geography	Study design	Specific impact	Effect size
Wang et al. (2013) [ID 1]	China	<i>Quasi-Experimental</i> . Matched groups compared via DID.	Household annual income	32% decrease
			Household annual expenditure (consumption)	25% decrease
			Household debt	3.2x increase
Ye et al. (2012) [ID 6]	China	<i>Observational</i> . Matched groups compared via standard statistical techniques (t-tests).	Household costs	11x increase over households with no maternal death, most of them funeral costs. If funeral costs are removed, 6x.
			Wealth/debt	~56% of affected households borrowed money or took loans to deal with costs.
Ye et al. (2015) [ID 36]	China	<i>Observational</i> . Matched groups compared via standard statistical techniques (structural equation modeling.)	Household income	-0.43 SD, p = 0.041
			Household expenditures (consumption)	-0.51 SD, p<0.001
Kes et al. (2015) [ID 3]	Kenya	<i>Mixed-method</i> . Quantitative survey of all births in a particular region, no statistical modeling only t-tests, alongside interviews and focus groups.	Household debt	44% of households had to seek outside financing to help with funeral costs.
			Household wealth	27 % of households had to sell assets to deal with funeral costs.
			Household income	Partners took the equivalent of 2 months off work to deal with a pregnant woman's illness and funeral.
Lawrence et al. (2022) [ID 4]	Ghana	<i>Mixed-method</i> . Quantitative survey of households with deceased mother, simple	Household income	62% of households report a decrease in income; some households lost other jobs because of time away dealing with

		descriptives, no statistical modeling, alongside semi structured qualitative interviews.		mothers' illness and death.
			Household wealth/debt	A majority of respondents reported significant financial pressure, due to hospital bills and burial costs (though these are not quantified.)
Molla et al. (2015) [ID 2]	Ethiopia	<i>Qualitative.</i> Qualitative study including interviews and focus groups	Household wealth	Respondents report depleting savings and selling valuable assets to deal with funeral costs.

Immediate financial impact

This section examines the immediate financial consequences of maternal mortality, focusing on costs incurred shortly after the death. The literature highlights three categories as the largest and most prominent expenses: [funeral costs](#), [healthcare costs](#) related to the mother's death, and [increased caregiving expenses](#) for surviving infants, such as formula to replace breastmilk.

Funeral costs following maternal deaths impose significant financial burdens on households, often ranging from 15% to 150% of annual household income

Funeral costs following maternal death are consistently reported as a significant financial burden, often depleting savings and forcing households to rely on loans, asset sales, or family support. Across the studies we reviewed, a recurring theme relates to funeral costs. Studies from various countries in sub-Saharan Africa report that funeral costs are large, rapidly deplete family savings, and place significant financial pressure on households (e.g., [Molla et al., 2015](#); [Lawrence et al., 2022](#)). In Kenya, families are expected to provide “food for close relatives, in-laws and guests who attend the funeral” and frequently have to rely on financial support from e.g., relatives (87%), sold assets (27%), or loans (15%) ([Kes et al., 2015](#)).

Studies from Kenya, South Africa, Tanzania, Thailand, and China show that direct funeral costs²² following maternal or adult deaths can range from ~15-150% of annual household income:

- A study in Kenya found that average funeral costs following a maternal death constituted 100-150% of the annual per capita household expenditures ([Kes et al., 2015](#)).
- A study in South Africa found that “on average, households spend the equivalent of a year's income for an adult's funeral” ([Case et al., 2013](#)).
- [Russell \(2004\)](#) found in a review on the costs of adult mortality from HIV/AIDS that funeral costs amount to ~25-50% of annual household income in Tanzania, and of ~60% in Thailand.²³

²² Our understanding is that these studies only include direct costs, such as burial expenses or ceremonies and associated fees. They do not include indirect costs such as foregone income due to bereavement leave or lost productivity.

²³ These estimates are our own calculations based on Table 4 in [Russell \(2004\)](#).

- A study in China found that the median (non-reimbursed) costs of a maternal death correspond to >15% of a household's annual income ([Ye et al., 2012](#)).²⁴

We have not found any indication that the costs of maternal funerals differ from those of other household members, but a study in South Africa found that funeral expenses for women are 14% lower than for men. We spent ~1.5 hours reviewing the literature on funeral expenses for mothers and other household members in sub-Saharan Africa. While our prior was that maternal funerals might be more elaborate and expensive given the central role of mothers in families, we found no evidence supporting this. Instead, a study in South Africa ([Case et al., 2013](#)) indicates that funeral expenses for women are 14% lower than for men, and borrowing for women's funerals is ~3 percentage points less likely, likely as a result of a lower social status of women.²⁵ We have not found comparable figures from other countries.

The funeral costs families face when a mother dies are mediated by a variety of factors which differ across geographies, such as:

- **Cultural practices around funerals:** In many communities, funerals are culturally significant events, but the scale and expense of ceremonies can vary based on local customs. [Jindra and Noret \(2022\)](#) argue that “in many African societies today, funerals and commemorations of deaths are the largest and most expensive cultural events, with families harnessing vast amounts of resources to host lavish events for multitudes”, but there are also differences across settings, e.g., rural/urban ([Jindra & Noret, 2011](#)).
- **Community support and contributions:** In many settings, community or extended family members contribute financially to funeral expenses, alleviating some costs for the immediate household. For example, in Ghana >80% of study participants reported receiving support from their family, the community, or a religious institution ([Lawrence et al., 2022](#)). [Kes et al. \(2015\)](#) report similar figures for Kenya. However, our overall impression is that the vast majority of funeral expenses are typically incurred by household members living with the deceased person (e.g., 90% in South Africa according to [Case et al., 2013](#)).
- **Access to social protection systems and funeral insurance schemes:** Households with access to funeral insurance or social protection systems may face reduced out-of-pocket expenses. A study in South Africa found that less than a third of the deceased had funeral insurance or a membership in a burial society ([Case et al., 2013](#)). Our impression is that such schemes aren't very common in many other sub-Saharan African countries.

Healthcare costs related to maternal death are substantial, with studies showing that they account for 33-50% of annual household expenditure, ~3-10 times higher than for controls

We found little information on healthcare expenditures associated with maternal death, but two studies suggest that healthcare expenses for the deceased mother and her baby is another large category of out-of-pocket expenditures:

- In rural China, the hospitalization and emergency costs were more than seven times higher when a maternal death occurred vs. no maternal death (USD 2,248 vs. USD 305)

²⁴ We calculated this figure based on two findings of [Ye et al. \(2012\)](#): (1) “More than 40% of the direct costs were attributed to funeral expenses” and “The median economic burden of the direct (and nonreimbursed) costs of a maternal death was quite high - 37.0% of the household's annual income.”
~15%=40%*37%.

²⁵ [Case et al. \(2013\)](#): “Women have lower status in the DSA than do men, so we would expect both that less would be spent on women's funerals, and that the probability of borrowing for a woman's funeral would be lower. We find that this is the case: with or without controls for household demographics and SES, approximately 600 Rand less is spent on a woman's funeral, and borrowing for a woman's funeral is 2.5 to 3.5 percentage points less likely on average.”

(Ye et al., 2012).²⁶ As [Figure 3](#) below shows, the costs were primarily for intensive care for the mother and newborn, and referral expenses. Healthcare costs for deceased mothers constituted **~50% of household annual expenditure**.²⁷

- Similarly, in Kenya, the healthcare costs associated with maternal deaths were significantly higher, due to more frequent service utilization and more involved treatments and interventions ([Kes et al., 2015](#)). The **total healthcare-related costs constituted 32-34% of household consumption expenditure for cases** vs. 5-12% for controls, that is, more than four times more (see Table 8 in [Kes et al., 2015](#)).

We did not have time to review the literature on healthcare expenditures associated with paternal or other adult deaths, and we expect such expenses to be highly age- and context-dependent. It is not obvious to us that healthcare expenses related to the deceased mother herself are necessarily higher or lower than those associated with the death of another adult. However, maternal deaths are distinct in that they are often accompanied by substantial healthcare expenditures related to a newborn, which would not typically arise following the death of another adult. Using [Figure 3](#) from [Ye et al. \(2012\)](#), we find that **healthcare expenses related to newborn care constituted approximately half of the total healthcare expenses incurred for deceased mothers and their newborns**.

We expect these healthcare costs to **vary significantly across geographies due to factors such as the availability and cost of medical services, the accessibility of emergency care, health insurance coverage, and cultural practices surrounding maternal health**, but we have not investigated this further.

²⁶ The comparison is between households matched on several criteria: living in the same village, similar economic status, and same household type, i.e., nuclear or extended.

²⁷ We calculated this based on the total annual household expenditure in Table 1 of [Ye et al. \(2012\)](#), i.e., USD ~4,500.

Figure 3: Non-funeral direct costs for households with maternal death

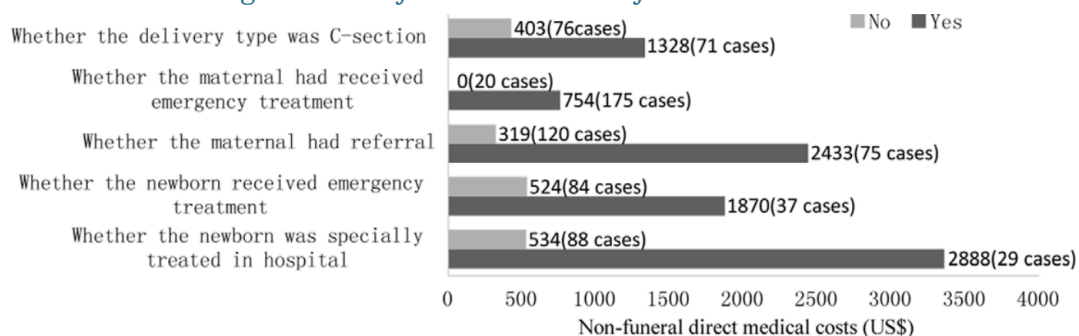


Figure 1. Non-funeral direct costs for households with maternal death. Note: costs presented here are sub-group analysis based on the affected group (n = 195); 48 cases were missing in category of delivery type (48 women in affected group died before childbirth and no delivery type was concerned); 74 cases were missing in category of whether the newborn received emergency treatment (48 women in affected group died before childbirth, 24 cases were stillbirths, and 2 cases were unknown); 78 cases were missing in category of whether the newborn was specially treated in hospital (48 women in affected group died before childbirth, 24 cases were stillbirths, and 6 cases were unknown). doi:10.1371/journal.pone.0038467.g001

Note. Copied from [Ye et al. \(2012\)](#).

Note that the impact of maternal mortality on healthcare costs depends heavily on the choice of comparison group or counterfactual. If the counterfactual assumes that a saved mother would suffer from illness or long-term health consequences, the avoided healthcare costs would be relatively low due to the ongoing need for medical care. Conversely, if the counterfactual assumes a healthy mother, the avoided healthcare costs would be much higher, as there would be minimal healthcare expenses in the absence of mortality. We are unsure which counterfactual assumption about maternal health is more appropriate for GiveWell, and our impression is that [Ye et al. \(2012\)](#) does not provide sufficient information to determine whether the comparison group of mothers who survived were healthy or not.

Increased spending on infant care after maternal death can more than double costs, mainly due to formula expenses

When a mother passes away and breastfeeding stops abruptly, families often face increased expenses for alternative food sources, such as infant formula. Several qualitative studies have reported formula as a significant and often unaffordable expense for households (e.g., [Molla et al., 2015](#); [Lawrence et al., 2022](#); [Yamin et al., 2013](#)), yet we have only seen one study that attempted to quantify the expense. In rural China, the expenses related to infant care were more than double for families with deceased mothers vs. families with surviving mothers (USD 1007 vs USD 484) ([Ye et al., 2015](#)). This expense represented ~22% of annual household expenditure for households that had experienced a maternal death vs. ~11% for households without a maternal death.²⁸ As we expect that the cost is mainly for formula, we expect that the increased spending on infant care is unique to maternal deaths.

We would expect these costs to vary significantly across geographies due to differences in formula availability, local pricing, and cultural practices surrounding infant feeding. In areas with limited access to formula, costs might represent an even greater share of household income, making formula largely unaffordable. Additionally, the prevalence of alternative feeding methods, such as animal milk or traditional weaning foods, may also affect the financial burden of replacing breastfeeding.

²⁸ This is based on the total annual household expenditure in Table 1 of [Ye et al. \(2012\)](#), i.e., USD ~4,500.

Medium-term financial consequences

A study in rural China found that maternal mortality reduces household income by 32% within the first year, though longer-term effects remain unclear

The strongest evidence we found on the effects of maternal mortality on household finances comes from a quasi-experimental design by [Wang et al. \(2013\)](#) in rural China. The study leverages a difference-in-differences (DID) design combined with matching to investigate the impact of maternal mortality on household income, expenditure and debt. Researchers analyzed data from 183 households experiencing maternal death and 346 households with childbirth but no maternal death.²⁹ Households were matched on a small set of criteria, such as living in the same village, similar economic status, and same household type (i.e., nuclear or extended).³⁰

In this study, experiencing a maternal death lowers annual household income by almost a third (~32%), decreases annual household expenditures (consumption) by a quarter (~25%), and increases the accumulated household debt by 3.2 times one year after the maternal death in comparison to households that did not lose a mother. This paper also discusses important changes in the composition of spending that might have effects on morbidity, including lower consumption on food which is being substituted by higher consumption on cigarettes and alcohol.

Overall, we trust the broad findings of this study and believe it effectively addresses or alleviates many of the concerns we initially had, though we remain cautious about trusting the exact magnitude of the estimated effects.³¹ Our main remaining concern is the inability to assess the plausibility of the identifying assumption—that the economic outcomes of the treatment and control groups would have followed similar trends in the absence of treatment. The study does not provide data on pre-treatment trends in outcomes. Moreover, the study does not compare pre-treatment characteristics across groups beyond the limited set of characteristics used for matching, which gives us a limited view on how successful the matching was. **In the absence of this information, we think it is possible that potentially different parallel trends may lead to somewhat overestimated effects.**³²

Moreover, the external validity of the study is limited, as it focuses on rural China. Our very low confidence guess is that the effects might be higher in South Sudan, Chad, and Nigeria compared to rural China, given we suspect these countries have higher poverty rates, more

²⁹ The households were located in rural regions of Hebei, Henan, and Yunnan provinces, selected to represent areas with low, moderate, and high Maternal Mortality Ratios (MMRs) within rural China.

³⁰ “Having childbirth within 3 months of the baseline interview, living in the same administrative village, with similar economic status evaluated by the administrative village cadres (i.e., rich, moderate, poor), and the household type is the same as that of the affected family before maternal death (i.e., nuclear or extended; with or without older children)” ([Wang et al., 2013](#)).

³¹ For example, we were initially concerned that household income and expenditures were self-reported. However, the authors found no significant difference between self-reported figures and official, administrative figures, which increased our confidence in the validity of their findings. Moreover, we were at first concerned about the fact that both the baseline and the follow-up surveys were conducted after the treatment (i.e., the maternal death), which could lead to underestimating the effects of maternal death. However, we realized that the baseline survey collected economic information from the year before maternal death or childbirth to counter potential underestimation effects.

³² For example, if households that experienced maternal mortality were already on a downward income trend before the mother’s death (e.g., due to prolonged illness), this pre-existing difference may inflate the estimated effects. Moreover, it is possible that the control group (families without maternal mortality) is better off in unobserved ways (e.g., better health, access to resources), in which case the effects of maternal mortality may also appear larger than they truly are.

fragile healthcare systems and weaker social safety nets though we have not explored this in detail.

We have not found similar studies for a direct comparison of findings.³³ However, the results of several qualitative or mixed-methods studies align with those found by [Wang et al. \(2013\)](#) and provide some insights into the mechanisms driving income changes. For example, [Lawrence et al. \(2022\)](#), studying Ghana, report that 62% of households with maternal loss report a drop in income without specifying the exact decrease. Similarly, in Ethiopia, households reported income losses due to the deceased mother's lost contributions from selling agricultural products ([Molla et al., 2015](#)). In Kenya, [Kes et al. \(2015\)](#) identified the following mechanisms that drive changes in income:

- **Loss of maternal income:** Income from the deceased mother's farming or other productive activities was no longer available.
- **Relatives giving up work:** Mothers-in-law often left wage labor to take care of children left behind by the deceased woman.
- **Reduced work by fathers:** Husbands took on additional caregiving responsibilities, which limited their time for productive work.
- **Limited increases in productivity:** Only in a small number of cases—such as among surviving spouses—was there an increase in productive activity to compensate for the loss.

Unfortunately, we have not found any longer-term investigations of income or expenditure effects of maternal deaths beyond the first year. We expect that, as more time passes, income losses may diminish due to factors such as remarriage, adaptation of household roles, and gradual recovery of economic activities, although we lack data to verify this hypothesis.

Cost of remarrying

Our impression is that, in many contexts, remarriage of fathers is a common coping strategy after maternal death to compensate for the loss of caregiving and household support. This practice can potentially mitigate some of the long-term economic impacts, such as income losses and caregiving deficits, but often introduces short-term costs. References to this practice have been noted across various countries, including Ethiopia ([Molla et al., 2015](#)), Tanzania ([Yamin et al., 2013](#)), Bangladesh ([Ronsmans et al., 2010](#)), and China ([Ye et al., 2015](#)).

Unfortunately, [Ye et al. \(2015\)](#) provides the only estimate of the costs of remarrying following maternal death that we have encountered in a short search. In rural China, ~14% of fathers remarried within the first year following the death of their wives with **an average remarriage expenditure of USD 4667, which constitutes more than 100% of annual household expenses.** According to [Ye et al. \(2015\)](#) “in rural China, marriage/remarriage costs an enormous amount of money for the wedding ceremony, and a large amount of money is given to the bride's family as cash gifts. In addition, the groom's family also receives a large amount of money from relatives and friends in the wedding ceremony.”

We did not have sufficient time to review the literature on whether remarriage expenses differ for mothers vs. fathers, however, **our (highly uncertain) guess is that remarriage expenses might be higher for men, on average, as these often incur significant costs for bride prices** ([BBC, 2015](#)).

³³ At first glance, we thought that [Ye et al. \(2015\)](#) reported similar findings to [Wang et al. \(2013\)](#). However, we realized that both studies are actually based on the same data.

Geographic variability likely plays a significant role in the costs and prevalence of remarriage due to differences in cultural norms, remarriage rates, and associated marriage expenses. For example, in some contexts, lower remarriage rates or less costly marriage traditions may reduce the economic burden, while in others, high dowry demands or elaborate ceremonies could exacerbate costs. We did not have time to investigate this further, but we expect that an additional ~2 hours of targeted literature research might yield more data points on the costs associated with remarriage across different cultures.

Model results: We estimate that causal costs unique to maternal death constitute ~16% of annual household income and are likely short-term

We are generally unconvinced by the strength of the evidence, and would suggest that it is not sufficient for GiveWell to need to adjust their cost-effectiveness analysis to account for the effects of maternal mortality on household finances. However, to clearly demonstrate our thinking about which financial outcomes are affected in ways that are unique to mothers (as opposed to all caregivers), and give a ballpark estimate of how big an adjustment might be, we created a very rough [model](#). This is significantly less thorough and evidence-based than the calculations for child mortality, and our inputs are highly uncertain (particularly with regards to the uniqueness of each element to mothers).

While the previous sections demonstrate that the costs and income losses following maternal death can be extremely high—sometimes exceeding total annual household income or expenses—we believe that only a small portion of these are unique to mothers and a causal effect of maternal death. **Our estimate suggests that causal costs unique to maternal death could account for roughly 16% of annual household income. Specifically, we consider only healthcare costs related to newborns and infant formula expenses to be unique to mothers.** In contrast, we expect that other costs, such as funeral expenses, remarriage costs, and income losses, equally affect fathers and other caretakers, in some cases likely more so than mothers.

We are highly uncertain about this estimate, particularly regarding two key assumptions: (1) the share of effects unique to mothers, given significant data limitations, and (2) the potential magnitude of bias due to confounding factors (see [model](#) for more detail). Moreover, we have not consistently found all costs expressed as a percentage of household income, with some reported only as a share of household expenses. We assume these are equivalent, though this is unlikely to be accurate.

Although longer-term data on costs is lacking, **we expect the majority of these costs to occur in the first year, primarily due to infant formula dependence, and to diminish significantly in subsequent years.**



Contributions and acknowledgments

Jenny Kudymowa and Tom Vargas jointly researched and wrote this report, with Aisling Leow providing supervision. Special thanks to John Firth, Aisling Leow, Meika Ball (GiveWell), and Hannah Bell (GiveWell) for their valuable feedback on drafts. Thanks also to Thais Jacomassi and Shaan Shaikh for their copyediting support, and to Ula Zarosa for assisting with the online publication of the report. Further thanks to an external academic expert for taking the time to speak with us. GiveWell provided funding for this report, but it does not necessarily endorse our conclusions.

Appendices

Appendix A. Search strategy

To identify relevant papers we relied on a combination of simple web searches and AI-augmented searches via Elicit and Consensus. Specifically, this entailed the following activities:

1. On Oct 17, we conducted an initial Google Scholar search to help understand the possible volume of studies and help build the draft spreadsheet that we subsequently shared with GiveWell on Oct 18. We searched for “effect of maternal mortality on household income” filtering for papers since 2010³⁴; we scraped all papers on the first page, save for those clearly not relevant to the topic.³⁵ On Oct 18, we conducted more targeted Google Scholar searches. Our aim was to capture as many variations of the following prompts as possible within 2 hours of searching, filtering for papers since 2010, and scrapping results from the first 10 pages:³⁶
 - a. causal effect of maternal mortality on household income
 - b. causal effect of maternal death on newborn/under-five death
2. On Oct 18, we initiated two Elicit searches using the prompts below. We downloaded the entire dataset of papers that appeared after having used 100 tokens each search.³⁷
 - a. What is the causal effect of maternal death on newborn/under-five death?
 - b. What are the causal effects of maternal death on household income?
3. On Oct 18, we also conducted two Consensus searches using the prompts below. In general, these searches were not as useful as the above approaches and yielded only a single additional paper that we had not otherwise encountered.
 - a. What are the causal effects of a mothers' death on the household?
 - b. What are the causal effects of a mothers' death on children's mortality?
4. On Oct 18, we reviewed the papers that Meika Ball had incorporated into the project brief. These papers had already been uncovered in our research or were otherwise deprioritized because they did not meet our inclusion criteria.³⁸

Appendix B. Model to calculate the number of child deaths per maternal death

Step 1. Converting overlapping child mortality risk estimates to non-overlapping age group estimates:

From [World Bank Open Data](#), we have overall child mortality rate estimates (per 1000 live births) for the following *overlapping* age groups of children:

- Newborns (0-1 months): CMR_{neo}
- Infants (0-12 months): CMR_{inf}
- Under-five children (0-4 years): CMR_{u5}

³⁴ We selected 2010 quasi-randomly because we think it ensures 1) that we capture relatively recent data, and 2) that cut-off makes it more likely that we capture papers that are more likely to be structured around an identification strategy (i.e., are causal).

³⁵ For example, this search returned papers including: “Risk of maternal mortality in women with severe anemia during pregnancy and postpartum: a multilevel analysis” which is evidently not within our scope of work because it is about the causes of maternal mortality rather than its effects.

³⁶ In some searches, we forgot to put the filter so we captured some papers before 2010, but these were deprioritized in the shortlisting of papers to read.

³⁷ We think the counter that appears at the top of the table generating results and to the left of the download CSV button as “tokens,” though we remain unsure.

³⁸ Specifically, the piece by [Hough et al. \(2020\)](#) is outside of the scope of this review because it does not deal with maternal mortality but postpartum hemorrhage.

To ensure compatibility with our [relative mortality risk estimates](#) from the literature, we need to calculate estimates for the following *non-overlapping* age groups of children as follows:

- Newborns (0-1 months): CMR_{neo}
- Postneonatal children (1-12 months): $CMR_{postneo} = CMR_{inf} - CMR_{neo}$ (Equ. 1)
- Postinfancy children (1-5 years): $CMR_{postinf} = CMR_{u5} - CMR_{inf}$ (Equ. 2)

Step 2. Calculating the child mortality rates separately for children whose mothers died and children whose mothers survived:

We have given:

- **Relative risk (RR_i):** The relative risk of child mortality for children with a deceased mother compared to those with a surviving mother.
- **Maternal mortality ratio (MMR):** The number of maternal deaths per 100,000 live births.
- **Overall child mortality rate (CMR_i):** The overall child mortality rate (per 1000 live births).

Subscript i denotes the child age group (i.e., neonatal: 0-1 months, postneonatal: 1-12 months, and postinfancy: 0-4 years), thus: $i \in \{neo, postneo, postinf\}$.

Let $p_D = \frac{MMR}{100,000}$ represent the proportion of births where the mother died and $p_S = (1 - p_D)$ the proportion of births where the mother survived.

The overall child mortality rate CMR_i is a weighted average of the two groups of children (with subscripts D and S representing a mother who died and a mother who survived):

$$CMR_i = p_D \times CMR_{D,i} + p_S \times CMR_{S,i} \quad (\text{Equ. 3})$$

The relative risk RR_i of child mortality for children with a deceased mother compared to those with a surviving mother is defined as:

$$RR_i = \frac{CMR_{D,i}}{CMR_{S,i}} \quad (\text{Equ. 4})$$

We rearrange this as $CMR_{D,i} = RR_i \times CMR_{S,i}$. We substitute this into Equation 3.

$$CMR_i = p_D \times (RR_i \times CMR_{S,i}) + p_S \times CMR_{S,i} \quad (\text{Equ. 5})$$

We solve this for $CMR_{S,i}$:

$$CMR_{S,i} = \frac{CMR_i}{p_D \times RR_i + p_S} \quad (\text{Equ. 6})$$

And using Equation 4, we can also obtain $CMR_{D,i}$:

$$CMR_{D,i} = RR_i \times \frac{CMR_i}{p_D \times RR_i + p_S} = RR_i \times CMR_{S,i} \quad (\text{Equ. 7})$$

Step 3. Introducing an adjustment parameter to reduce the relative mortality risk we expect to be overestimated (i.e., subject to upward bias) due to confounding factors:

As explained [here](#), we expect that relative risk estimates from the literature are overestimated due to confounding factors. To account for this, we modify the relative risk as follows:

$$RR_{\alpha,i} = RR_i \times (1 - \alpha) \quad (\text{Equ. 8})$$

The bias factor (α) represents the fraction by which RR is reduced. We replace RR_i in Equations 6 and 7 by $RR_{\alpha,i}$.

Step 4. Calculating excess child mortality attributable to maternal death for each age group

We calculate excess mortality for children as a result of maternal death for newborns, postneonates, and postinfants as follows, i.e., for each $i \in \{neo, postneo, postinf\}$:

$$\Delta CMR_i = CMR_{D,i} - CMR_{S,i} \quad (\text{Equ. 9})$$

The resulting figures represent the number of additional child deaths for 1 maternal death for *non-overlapping* age groups.

Finally, we calculate the respective excess mortality figures for *overlapping* age groups as follows:

$$\Delta CMR_{neo} \quad (\text{from Equ. 9})$$

$$\Delta CMR_{inf} = \Delta CMR_{neo} + \Delta CMR_{postneo} \quad (\text{Equ. 10})$$

$$\Delta CMR_{u5} = \Delta CMR_{inf} + \Delta CMR_{postinf} \quad (\text{Equ. 11})$$

Appendix C. Association between maternal mortality and infant mortality

Table C.1: Summary of quantitative evidence on the association between maternal mortality (within 42 days of birth) on infant mortality (roughly 1-12 months)

Title [ID]	Geography	Study design	Specific impact	Effect size
Zhou et al. (2016) [ID 12]	Rural China	<i>Quasi-experimental.</i> Cohort study matching 188 households that experienced a maternal death matched to 346 that did not, though did not use DID strategy to assess causal effect on this outcome. So we weigh this evidence as we would an observational study with respect to infant mortality.	Infant mortality (within 15 months)	11.6% increase in probability of death.
Finlay et al. (2015) [ID 11]	Rural Tanzania	<i>Observational.</i> Longitudinal study deploying survival analysis	1-6 months	RR=20.68 (95% CI: 12.71-33.64)
			6-12 months	RR: 2.81 (95% CI: 2.19-21,45)
Pande et al. (2015) [ID 13]	Kenya	<i>Mixed-method.</i> Matched quantitative data, but no statistical modeling	Infant (within 12 months, maternal death)	Increase in mortality of ~8.7x
Moucheraud	Ethiopia	<i>Observational.</i> Survival	Infant	0.1875 probability of

et al. (2015) [ID 9]		analysis to calculate cumulative survival probabilities	death (6 months)	survival, or 65.96x increase in probability of dying over children with mothers who live
			Infant death (12 months)	0.1875 probability of survival (no additional children died in the maternal death group)

Note. Data from our review of the papers.

Appendix D. Attempting pragmatic approaches to quantifying causal effects

The following section provides an overview of the four approaches we employed to mitigate bias in the relative risk estimates reported in the literature. While these approaches are somewhat ad hoc, they offer potential insights into the underlying relationships. Moreover, each approach has major limitations and is insufficient to eliminate the bias in its entirety. We believe approaches 1 and 2 are theoretically the most promising, as they address the largest number of confounding factors. In practice, we have slightly greater confidence in the findings from approach 2. We expect its within-study comparison design to be more effective at mitigating bias than the cross-study comparison used in approach 1. We ultimately assumed a 50% bias based on the results from approach 2, although considerable uncertainty remains. While we acknowledge the bias could plausibly be higher, it may also be lower.

(1) Comparing effect sizes between maternal mortality and maternal near-miss cases:

What is the idea?

We can decompose the association between maternal mortality and child mortality into two components, i.e., (1) component that is due to actual maternal death, and (2) component that is due to other, confounding factors. The idea of the maternal near-miss (i.e., mothers that nearly died during childbirth) approach is to compare relative mortality risks from studies that estimate the association between maternal mortality and child mortality to studies that estimate the association between maternal near-miss and child mortality. The basic premise is that both types of studies are prone to very similar confounding factors and the main difference is that in one type of study the mother died, and in the other, the mother was at the brink of death, but was lucky to survive. That is, we assume that the main difference between the mothers who died and those who nearly died is chance (though we think this is a heroic assumption). If we then compare the estimated relative risks from one type of study to the other, this would essentially cancel out the proportion of the effect due to confounding factors and leave only the effect which is due to the mother dying.

What did we find?

We found only one study that estimated the effect of maternal near-miss on child mortality in a way we could use for this analysis ([Adem Aliyi et al., 2021](#)). The authors found a relative mortality risk of 8.4 in Ethiopia for newborns of mothers who nearly died and mothers with no maternal near miss. The equivalent relevant figures from a study on maternal mortality in Ethiopia yields a relative risk of 46 ([Moucheraud et al., 2015](#)), as shown in [Table 3](#). **Taking these figures at face value would imply that the bias corresponds to ~20% ($\approx 8.4/46$) of the reported effect size.**

How much do we trust this finding?

The biggest issue we see with this approach is that maternal near-miss studies and maternal mortality studies tend to be set in very different healthcare-related contexts. The [Adem Aliyi et al. \(2021\)](#) near-miss study is set in a hospital, whereas the [Moucheraud et al. \(2015\)](#) mortality study is set in a community where ~90% of women give birth at home and have limited access to skilled healthcare providers. This could mean that near-miss survivors have better access to life-saving medical care and it might be this access (rather than the fact that the mother survived) which ensures the children also survive (in which case the bias is likely underestimated), but it could also mean that near-miss mothers had generally worse health and were thus more likely to be hospitalized compared to mothers who died in communities (in which case the bias is likely overestimated). We didn't have time to investigate this any further, but our intuitive guess is that the former effect prevails. **In this case, ~20% could be considered a rough lower bound of the bias, but we are highly uncertain about this.**

(2) Comparing effect sizes between maternal mortality and paternal mortality:

What is the idea?

Both maternal and paternal mortality are likely influenced by shared socioeconomic, environmental, or household factors that can be confounding factors (e.g., limited healthcare access). Comparing the two can help isolate biases due to these shared factors. For example, if paternal mortality does not increase child mortality to the same extent as maternal mortality, it provides indirect evidence that the maternal mortality effect includes unique pathways (e.g., loss of breastfeeding or maternal caregiving). In this context, we make the assumption that the paternal mortality-child mortality association represents only the bias due to shared confounders and excludes maternal-specific pathways (e.g., breastfeeding interruption, maternal caregiving). The difference between maternal and paternal mortality associations would then reflect the maternal-specific causal effect.

What did we find?

We found three studies in LMICs that investigated the effect of paternal mortality on child mortality. Two of these studies found no effects on child mortality: (1) [Ronsmans et al. \(2010\)](#) investigated both the effects of maternal and paternal mortality on child mortality in Bangladesh. While they found large effects related to maternal mortality, they found basically no effect related to paternal mortality and considered it “negligible”.³⁹ However, we put less weight on this study as it defines parental mortality as deaths within 10 years postpartum, which is a far longer timeframe than our preferred definition of 42 days postpartum. (2) Similarly, in a study from the Gambia, paternal death also had no effect on child survival ([Sear et al., 2002](#)). We also put less weight on this study as the timing of the parental death was not clear to us when reviewing the study. For both of these studies, we also have a suspicion that they may have been underpowered to detect and statistically significant effects for fathers. The only other study relevant study we found is from South Africa ([Sartorius et al., 2011](#)) and our understanding is that maternal and paternal mortality was defined as the death of a mother or father happening when the child was 1-4 years old, which also doesn't correspond to our preferred definition of maternal mortality. The study reported that paternal mortality increased the risk of child mortality with a relative risk of ~2.4. The corresponding figure for

³⁹ [Ronsmans et al. \(2010\)](#): “The cumulative probability of survival to age 10 years was 24% in children whose mothers died (n=1385) before their tenth birthday, compared with 89% in those whose mothers remained alive (n=143 473). The greatest effect was noted in children aged 2–5 months whose mothers had died (rate ratio 25.05, 95% CI 18.57–33.81). The effect of the father's death (n=2691) on cumulative probability of survival of the child up to 10 years of age was negligible. Age-specific death rates did not differ in children whose fathers died compared with children whose fathers were alive.”

mothers was ~5.2. Thus, taking these figures at face value, the bias would correspond to ~50% ($\approx 2.4/5.2$).

How much do we trust this finding?

Besides limitations of the individual studies we already mentioned (i.e., related to the definitions of maternal and paternal mortality), we see two other main issues with this approach. On the one hand, this approach relies on the assumption that paternal mortality captures only shared confounding factors and no paternal-specific effects on child mortality. If paternal mortality has direct effects on child mortality (e.g., loss of economic support or loss of caretaking), this would lead to an overestimate of the bias in the maternal mortality association. However, our overall impression of reading the literature is that fathers likely have more indirect effects on the survival of their children than mothers as they tend to have little involvement in caretaking relative to mothers and are often not the sole earners, though this is likely highly context-dependent. On the other hand, the bias might be underestimated if paternal mortality does not fully reflect shared socioeconomic or environmental confounders. For example, maternal mortality may still be influenced by maternal-specific confounders (e.g., complications during pregnancy or childbirth or lack of obstetric care) which paternal mortality cannot account for. We did not have time to investigate this in more depth, but our intuitive guess is that the latter effect is stronger than the former. Another complicating factor is that we aren't quite sure what to make of the zero effects for paternal mortality reported by two of the studies, though, as mentioned, we put little weight on those. **All in all, our rough guess is that ~50% could potentially be considered a lower bound of the bias, though we are highly uncertain about this.**

(3) Using cause of death information to eliminate joint illness as a confounding factor:

What is the idea?

One potential confounding factor is mothers and their children dying of the same illness. If a mother dies because of a particular illness, it may pass on to the child affecting their probability of survival. The question is how to partial out the unique effect of losing a mother, rather than the effect of that third factor or illness. If children are dying from largely the same causes as their mothers, then we can reasonably say that some third factor is likely to be driving some of the association between maternal and child death. If, by contrast, neonates are dying mostly from causes plausibly unrelated to the mother's disease then we could attribute some of (or place some bound on) the effect to the absence of a mother.

What did we find?

Unfortunately, the types of detailed maternal and child cause of death data necessary to use this approach do not exist in our sample, but evidence from [Houle et al. \(2015\)](#) comes reasonably close to this. Using demographic surveillance data in rural South Africa, they show that maternal death increases the probability of death among children.⁴⁰ What is unique about their approach is that they have data on maternal cause of death. Interacting these two variables (maternal death x cause) returns relative risks for neonatal death by maternal cause of death. The results in [Table D.1](#) below show that having either HIV/AIDS or TB increases the child's risk of death above and beyond a mother's death by other causes. Whereas a mother dying of HIV/AIDS or TB increases the relative risk of child death by ~29x (see 'HIV/AIDS or TB early maternal death' in Table D.1), a mother dying of alternative causes increases the risk of child death by 'only' ~9x (see 'Non-HIV/AIDS or TB early maternal death' in Table D.1). **If we make the heroic assumption that the 9x corresponds to the effect for those not exposed to**

⁴⁰ Their definition of early maternal death is identical to the WHO definition of maternal death.

joint illness, and the 29x is the effect for those exposed to joint illness, the bias due to joint illness corresponds to 70% ($\cong 1-9/29$).

How much do we trust this finding?

As both HIV/AIDS and TB can be transmitted to children, it is possible mothers who die of those illnesses have children who are also at increased risk of dying of the same illnesses. Moreover, we suspect that HIV/AIDS and TB can also lead to birth complications, making child death more likely (though we haven't checked the extent to which this is the case). The evidence is consistent with the association between maternal and child mortality being partially driven by joint illnesses rather than by the unique effect of losing a mother. However, there are two major issues here: (1) We do not know the child's cause of death, thus cannot be sure whether mothers and children actually died from the same illness. Thus, we can not be certain of what factors drive the effect. (2) It is also possible that mothers and children who do not die of HIV/AIDS or TB die of other joint illnesses (or possibly birth complications that affected both the mother and her baby). Alternative causes of death are unfortunately not reported in this study. Besides these issues, shared illness is only one out of likely many other confounding factors. Thus, eliminating it would likely not remove the bias in its entirety. Another complicating factor is that we expect that HIV and TB disproportionately affect mothers with low socioeconomic status due to increased exposure to risk factors (though we haven't checked this). In this case, the mortality of children with mothers who died of HIV/AIDS or TB may actually be driven by a lower socioeconomic status rather than the disease itself. **All in all, we think the approach and the data we found to use it are too flawed for us to trust its findings, so we decided to dismiss this approach.**

Figure D.1: Mortality rates and predictors for child death in South Africa

Mother's survival status × mother's cause of death					
Survives			1.000	[1.000, 1.000]	.
HIV/AIDS or TB early maternal death			29.220	[11.688, 73.049]	<0.001
HIV/AIDS or TB late maternal death			14.332	[6.924, 29.665]	<0.001
HIV/AIDS or TB other death			7.477	[3.931, 14.222]	<0.001
Non-HIV/AIDS or TB early maternal death			9.197	[3.908, 21.647]	<0.001
Non-HIV/AIDS or TB late maternal death			12.453	[4.743, 32.697]	<0.001
Non-HIV/AIDS or TB other death			10.358	[4.772, 22.483]	<0.001

Note. This is the bottom panel of Table 2 from [Houle et al. \(2015\)](#).

(4) Leveraging maternal deaths beyond 42 days:

What is the idea?

Another strategy we thought about to place bounds on the bias was to leverage maternal deaths occurring beyond the typical 42 days. The idea is to compare the associations between maternal and child mortality for mothers dying within 42 days postpartum and mothers dying later than 42 days postpartum. This could eliminate some confounders that jointly impact maternal and child health, such as poverty, healthcare access, and environmental risks. However, we expect that this approach is unlikely to eliminate joint illness and obstetric complications as confounders, as we suspect these issues may be more present among mothers who died shortly after birth.

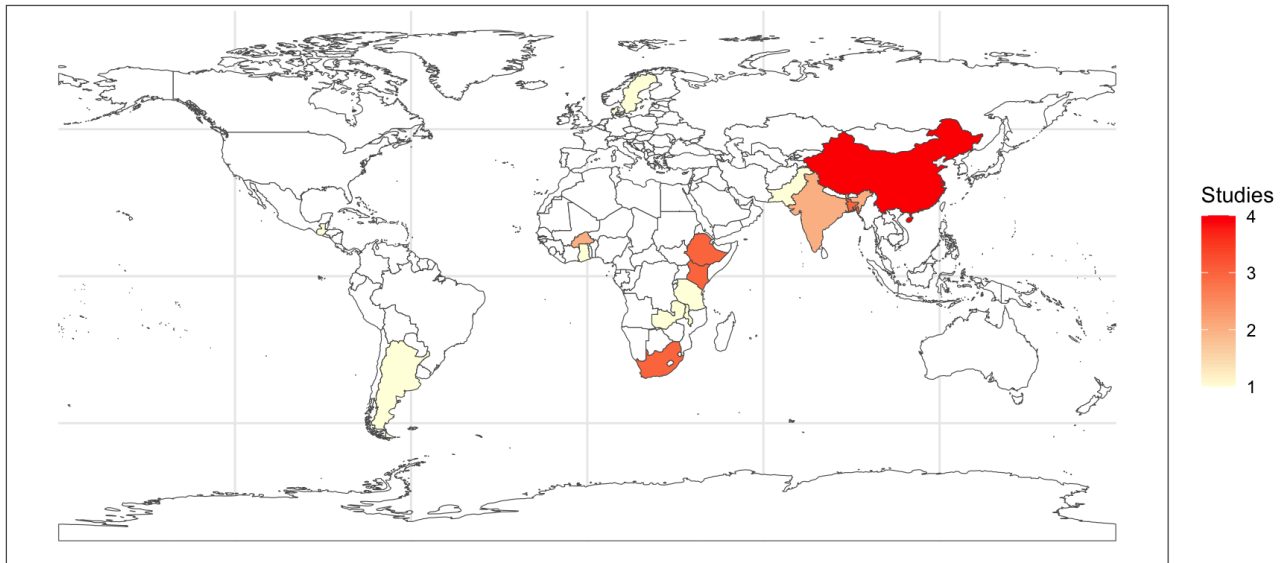
What did we find?

We reviewed several studies in our longlist but ultimately failed to find a study that we deemed sufficiently appropriate for this analysis, as studies either do not compare the effects of the timing of maternal death or, if they do use different maternal death timings, they then do not use a uniform timing of child death. We also do not think comparing across studies is very useful here as we wouldn't be able to distinguish how much of the difference in effects is due to the timing of death vs. due to contextual factors or factors such as study design and quality. **Thus, due to severe data limitations, we decided to not pursue this approach further.**

Appendix E. Heatmap of the number of studies in our shortlist across countries

Figure E.1: Heatmap of the number of studies in our shortlist by count

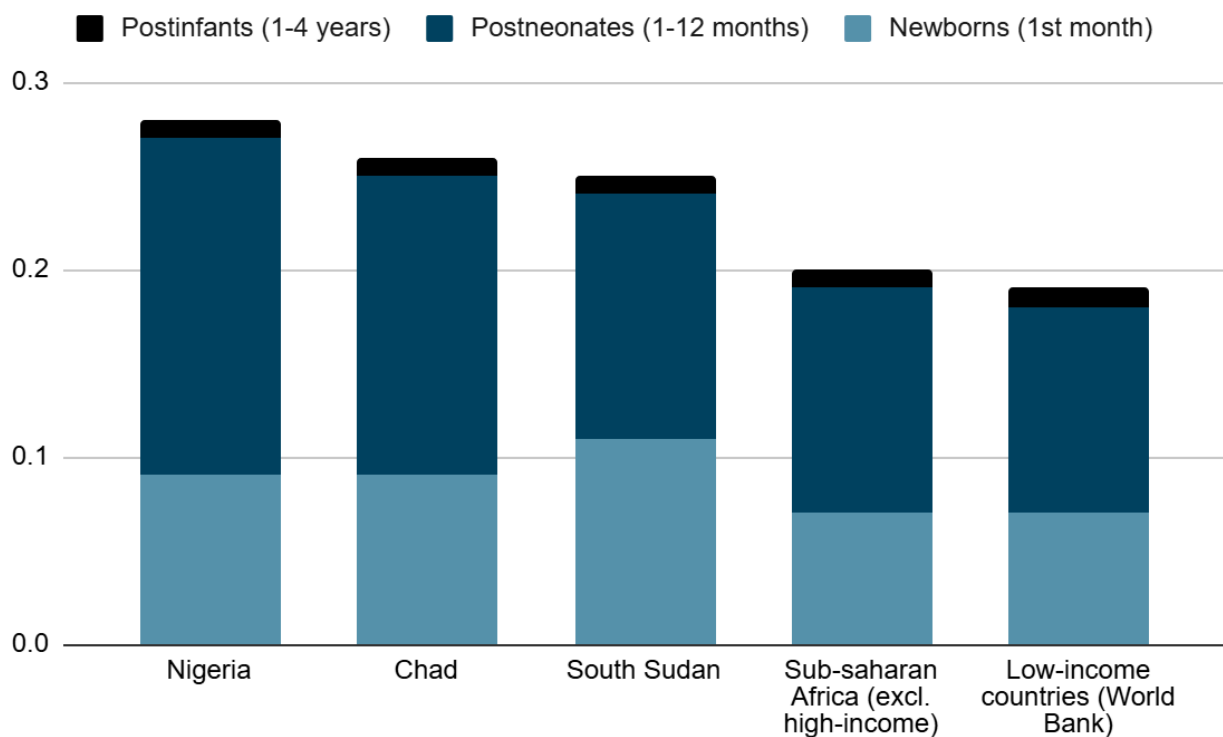
Geographic Distribution of Studies



Note. Data from our [shortlist](#). Countries shaded in white are not represented in our shortlist.

Appendix F. Additional child deaths per maternal deaths (excl. Moucheraud et al., 2015)

Figure F.1: Additional child deaths per maternal deaths (excl. Moucheraud et al., 2015)



Note. The assumed bias is 50%. Calculations are [here](#).

Appendix G. Research designs to identify causal impacts of maternal mortality

To investigate the impact of maternal mortality on child mortality and household finances, the ideal evidence would come from studies employing strong causal inference methods. While randomized controlled trials (RCTs) would provide the most robust evidence, they are clearly infeasible and unethical in this context. Consequently, the most reliable insights are likely to come from quasi-experimental techniques. These methods focus on identifying a policy intervention or sudden shift that directly affects maternal mortality without directly influencing child mortality or household finances. However, without further research, we cannot currently think of any concrete, real-world policy or event that meets these criteria, which underscores the challenges in applying such methods in practice. Below, we summarize three illustrative approaches.

Difference-in-differences (DID):

This method compares changes in outcomes over time between households experiencing maternal mortality (treatment group) and similar households that do not (control group). For example, if a region introduces a maternal health intervention that reduces maternal mortality in one area while another region is unaffected, DID can estimate the impact by analyzing pre- and post-intervention trends. However, this approach relies on the assumption that, in the absence of maternal mortality, outcomes in the treatment and control groups would have followed parallel trends—a condition that can be difficult to verify.

Instrumental variables (IV):

This method relies on finding an external variable (instrument) that is correlated with maternal mortality but not directly with child or household outcomes. Examples include distance to a healthcare facility or access to maternal health interventions (e.g., subsidized care). However, given that maternal and child health interventions are often combined, it may be challenging to find instruments that influence maternal deaths without also affecting child deaths.

Regression discontinuity design (RDD):

RDD exploits thresholds, such as eligibility criteria for maternal health programs (e.g., age or income cutoffs), to compare outcomes just above and below the threshold. This approach creates a quasi-random comparison between otherwise similar groups. For example, if a maternal care voucher is available only to mothers below a certain income level, the outcomes of households just below and above the cutoff could be compared to estimate the impact of maternal survival on household finances and child health.

Appendix H. Child causes of death by age group and maternal survival status

Figure H.1: Causes of death in children according to age group and maternal survival status

	Age group								
	0-11 months			12-119 months			0-119 months		
	Mother died (n=73)	Mother survived (n=7357)	p value	Mother died (n=31)	Mother survived (n=2240)	p value	Mother died (n=104)	Mother survived (n=9597)	p value
Disorders arising in perinatal period*	12 (16%)	2972 (40%)	<0-0001	0	9 (<1%)	1-000	12 (12%)	2981 (31%)	<0-0001
Diarrhoeal diseases	19 (26%)	480 (7%)	<0-0001	2 (6%)	215 (10%)	0-763	21 (20%)	695 (7%)	<0-0001
Respiratory infections	18 (25%)	1611 (22%)	0-570	3 (10%)	247 (11%)	1-000	21 (20%)	1858 (19%)	0-804
Other infectious diseases	2 (3%)	430 (6%)	0-444	2 (6%)	168 (8%)	1-000	4 (4%)	598 (6%)	0-414
Nutritional deficiencies	12 (16%)	525 (7%)	0-006	14 (45%)	436 (19%)	1-000	26 (25%)	961 (10%)	<0-0001
Injuries	0	97 (1%)	1-000	4 (13%)	819 (37%)	0-001	4 (4%)	916 (10%)	0-044
Other causes	0	116 (2%)	0-631	1 (3%)	154 (7%)	0-719	1 (1%)	270 (3%)	0-373
Unknown	10 (14%)	1126 (15%)	0-870	5 (16%)	192 (9%)	0-184	15 (14%)	1318 (14%)	0-776

Data are number (%). *Includes premature, small for date, birth trauma, and birth asphyxia.

Table 6: Causes of death in children according to age group and survival status of the mother during 1987-2005

Note. Copied from [Ronsmans et al. \(2010\)](#).