



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Original article

Projecting the Impact of the COVID-19 Pandemic on Child Marriage



Joshua Yukich, Ph.D.^a, Matt Worges, Ph.D.^c, Anastasia J. Gage, Ph.D.^c, David R. Hotchkiss, Ph.D.^c, Annie Preaux, M.P.H.^d, Colleen Murray, M.P.H.^b, and Claudia Cappa, Ph.D.^{b,*}

^a Department of Tropical Medicine, Tulane University School of Public Health and Tropical Medicine, New Orleans, Louisiana

^b Data and Analytics Section, United Nations Children's Fund, New York, New York

^c Department of International Health and Sustainable Development, Tulane University School of Public Health and Tropical Medicine, New Orleans, Louisiana

^d Department of Social, Behavioral and Population Sciences, Tulane University School of Public Health and Tropical Medicine, New Orleans, Louisiana

Article history: Received March 10, 2021; Accepted July 27, 2021

Keywords: Child marriage; Early marriage; Adolescent girls; Child rights; Pandemic

A B S T R A C T

Purpose: The study projects the potential impact of COVID-19 on child marriage in the five countries in which the burden of child marriage is the largest: Bangladesh, Brazil, Ethiopia, India, and Nigeria.

Methods: The projected impact of the pandemic on child marriage is based on a Markov model. A review of empirical and theoretical literature informed construction and parameter estimates of five pathways through which we expect an elevated marriage hazard: death of a parent, interruption of education, pregnancy risk, household income shocks, and reduced access to programs and services. Models are produced for an unmitigated scenario and a mitigated scenario in which effective interventions are applied to reduce the impact.

Results: The total number of excess child marriages in these five countries could range from 3.5 million to 4.9 million in the unmitigated scenario and from 1.8 million to 2.7 million in the mitigated scenario. The elevated risk compared with the baseline projection would continue until 2035.

Conclusions: These projections represent the impact in five countries that account for 50% of child marriages globally, implying that if similar patterns hold, we might expect the number of excess child marriages due to the pandemic to reach 7 million to 10 million globally. These estimates are necessarily subject to high levels of uncertainty because of limited evidence on the impacts in relation to child marriage and for parameter estimates. It will likely take years to understand the full impact of the pandemic. Despite these limitations, the potential for harm is unquestionably large.

© 2021 Society for Adolescent Health and Medicine. Published by Elsevier Inc. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

IMPLICATIONS AND CONTRIBUTION

Global progress against child marriage is at risk because of the COVID-19 pandemic. This study estimates the pandemic's impact on child marriage in the five countries with the largest burden. Estimates range from 3.5 million to five million additional child brides in these countries over the next decade without effective mitigation.

The pandemic caused by SARS-CoV-2 (COVID-19) has spread quickly around the globe. As of June 8, 2021, there were 173 million confirmed COVID-19 cases and 3.7 million people had

died from the virus worldwide [1]. A number of disturbing reports as well as empirical literature and theory make the compelling case that the COVID-19 pandemic may dramatically impact the global incidence and prevalence of child marriage through several proven mechanisms, including economic shocks, school closures/loss of learning, and adolescent pregnancies, among others [2,3].

Such impacts could stall, or even reverse, the substantial progress achieved in recent years to reduce the harmful practice of child marriage. While the scope of this practice is large, with an estimated 650 million girls and women worldwide who were

Conflicts of interest: The authors declare no potential conflicts, real or perceived.

Disclaimer: Publication of this article was funded by the Bill & Melinda Gates Foundation. The opinions or views expressed in this article are those of the authors and do not necessarily represent the official position of the funder.

* Address correspondence to: Claudia Cappa Ph.D., Data and Analytics Section, United Nations Children's Fund, 3 UN Plaza, New York, NY.

E-mail address: ccappa@unicef.org (C. Cappa).

first married or in union before age 18, the past decade has seen impressive advances, with the proportion of young women married as children declining by 15 per cent globally, from nearly one in four to one in five [4]. According to the United Nations Children's Fund, this progress has averted an estimated 25 million child marriages [5].

The purpose of this study is to propose and carry out an approach to project the potential impact of COVID-19 on child marriage. Although some efforts have been made to date to do so [2,3], primarily by extrapolating effects of the economic downturn and interruptions to programming, our study takes a more comprehensive approach to the types of risks the pandemic could introduce or exacerbate. Because no data on the effects of global pandemics on child marriage rates exist, we propose a framework for leveraging existing information on the rates and demographics of child marriage, as well as currently available research evidence on the effects of educational disruption, economic shocks, and program suspension on child marriage during previous crises, to predict the potential impact of the COVID-19 pandemic across the five countries where the largest numbers of child marriages globally occur.

Methods

To project the impact of the COVID-19 pandemic on child marriage, the five countries that have the highest number of child marriages were selected: Bangladesh, Brazil, Ethiopia, India, and Nigeria. These countries account for nearly half the global burden of child marriage. The impact is quantified as the prevalence of child marriage—that is, the percentage of women aged 20–24 years who were first married or in union before age 18. The incidence, or number of child marriages occurring each year, is also estimated.

Based on a literature review carried out for this study of how previous outbreaks, natural disasters, and extreme weather events, conflicts, and famines have affected child marriage, we developed a conceptual framework for the impact of the COVID-19 pandemic [4]. The framework includes five main pathways through which the pandemic may be expected to influence the likelihood of child marriage: (1) death of a parent, (2) interruption of education, (3) pregnancy risk, (4) household income shocks and poverty, and (5) reduced access to programs and services.

The study relied on a Markov model, a cohort-component approach that models a process of change for a population that moves from one or more states to other states in accordance with probabilities in a transition matrix [6]. This type of projection method was chosen over other possible approaches, including trend extrapolation and structural models, because of the unique parameters of the available data on COVID-19 and child marriage. Trend extrapolation is not appropriate for this study because the pandemic is recent, and data on the effects of previous crises on child marriage rates are unavailable. Structural models rely on modeling the relationships between an outcome and potential determinants of that outcome. These are not an option for this study because of the absence of empirical evidence on the precise effect sizes of various determinants depicted in the conceptual model (e.g., school closures and travel restrictions).

Analytical framework

A Markov model was used to project cohorts of girls exposed to the dual risks of marriage and mortality from age 10 through 24 [7]. These cohorts were balanced to match contemporary

demographic profiles, and the proportion of women aged 20 to 24 who experienced marriage before age 18 was calculated. By representing marriage and health status as states and changes in these states over time as transition probabilities between states, this process can be modeled using Markov chain models. Transition probabilities between states can be described by a square two-dimensional transition matrix T , where the element i, j is the transition probability between states i and j . The probability of being in a given state at time t is given by $X \times T^t$, where X is a vector giving the probability of being in a given state at the start of the model, and T^t is the product of multiplying t matrices T . Where the T matrices vary at each time step, the expression would be rewritten as $X \times T_1 \times T_2 \times T_3 \dots \times T_t$. In the case of child marriage, the T matrices represent the marriage hazard at any given age or point in time. The empirical marriage hazard can be derived from retrospective cohorts constructed from cross-sectional surveys (Appendix A).

A bespoke library was written in the R programming language (*childmarriager*) to implement specific multicohort versions of Markov models for child marriage projection [7]. This package was built as extensions to the *heemod* package, version 0.0.0.9000 [8]. The *childmarriager* package was used to implement projection models in the R language and environment for statistical computing.

The specific structure of the Markov model implemented to simulate demographics over time is shown in Figure 1.

The model illustrates that although marriage in general can be thought of as a transitory state, child marriage is nonreversible because its definition depends on age at first marriage or union. In addition, the model has one absorbing state—death—that children and women can enter from either the unmarried or married state.

Causal pathways and empirical estimates of impact

Table 1 provides a summary of the estimated direction and amount of impact from each pathway, along with notes on the rationale and sources of evidence used to support the assumptions. It should be noted that because of the limited amount of

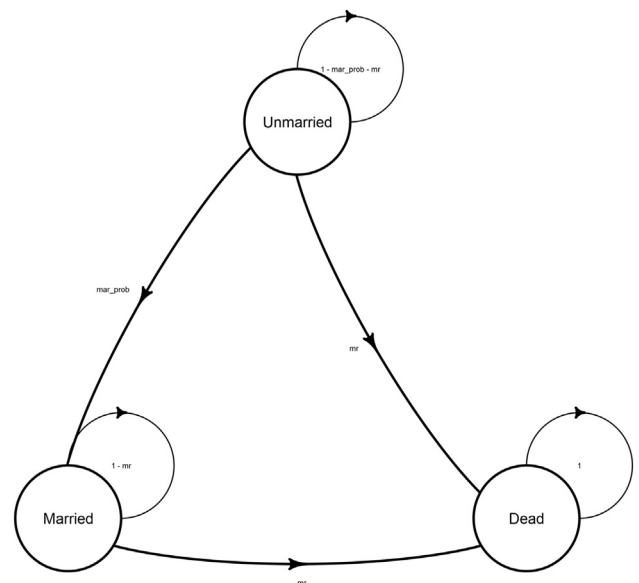


Figure 1. Schematic of the Markov model.

Table 1
Summary of the estimated direction and amount of impact from each pathway

Condition/parameter	Impact	Duration of impact	Age group impacted	Scenario	Rationale and notes on source of evidence
Trend	Empirically fit to historical data	NA	All	All	Status quo trend
School closure (without dropout risk)	25% increase in the marriage hazard per annum	Until age 18	10–11 and 15–17 in 2020	All	A quasi-experimental evaluation of a two-year program to delay child marriage in rural Ethiopia. Data collection included a baseline survey in 2004 and an endline survey in 2006 in one intervention and one control district. The surveys included measures of school enrollment, years of schooling, marital status, previous pregnancies and births, sexual and reproductive health literacy, and sociodemographic characteristics [9]. See abovementioned information [9].
School closure (with dropout risk)	27.5% increase in the marriage hazard per annum	Until age 18	12–14 in 2020	All	
LAYS lost due to closure	0.6	Until age 18	All younger than 18 years	All	A simulation of the impact of school closures during COVID-19 using the World Bank's Learning Adjusted Years of Schooling (LAYS) from the Human Capital Index database and the Organization for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA). Accounting for uncertainty about school closures, remote learning, and mitigation strategies, the authors simulate optimistic, intermediate, and pessimistic scenarios of schooling during the pandemic. The intermediate estimate has been used here [10].
Probability of drop out	2%	Until age 18	All younger than 18 years	All	See abovementioned information [10].
Teenage pregnancy	Included through school closure	Until age 18	10–17 in 2020	All	A review of policies and programs on child marriage and adolescent pregnancy with case studies from Bangladesh, Guatemala, Ethiopia, and Kenya [11].
Income shock (bride price countries)	+4% per annum	Until age 18	12–17 in 2020	All	A duration model to measure the impact of weather shocks on timing of marriage to determine how economic conditions, measured as rainfall shocks, affect child marriage in sub-Saharan Africa and India [12,13].
Income shock (dowry countries)	-3% per annum	Until age 18	12–17 in 2020	All except sensitivity	See abovementioned information [12,13].
Income shock sensitivity (dowry countries)	+1% per annum	Until age 18	All younger than 18 years	Sensitivity	See abovementioned information [13]
Access to programs (delay)	One-year increase in the marriage hazard modified by coverage	One year	All	All	Trend does not include increased reduction due to increased prevention programming
Access to programs (mitigation)	Effective programs are chosen and widely applied to all at risk, leading to 33% reduction in excess risk	Two years	All	Mitigation	A summary of a systematic review that was conducted by the International Center for Research on Women (ICRW) on all child marriage prevention programs implemented between 1973 and 2009 [14]. A review of studies since 1997 that used randomized control trials (RCTs), natural experiments, and quasi-experimental study designs to measure the impact of interventions on prevalence of child marriage and/or age at first marriage [15]. A systematic review of 30 evaluation studies published from 2000 to 2019 on child marriage prevention programs [16]

empirical evidence on the magnitude of the effects of previous crises on child marriage, we do not have access to sufficient evidence to justify country-specific assumptions. As a result, we chose to extrapolate the assumptions across all five countries.

Death of a parent. Death of a parent(s) and, more generally, prime-age adult mortality, may increase the risk of child marriage; however, findings are mixed [17–19]. At the start of the COVID-19 pandemic, most mortality due to the novel coronavirus was found in the highest age brackets, among a population that are not likely to be the primary caregivers of children younger than 18 years [20]. Although younger people make up a greater share of COVID-19 deaths in low- and middle-income countries [21–23], we assume that death of a parent from COVID will have little direct impact on child marriage risk.

Income loss/economic shock. It has been well documented that income shocks and poverty are related to child marriage risk [12,24–27]. The COVID-19 pandemic may affect household finances through loss of employment/income due to lockdowns as well as extended economic recessions or slowdowns. In addition, costs of care for illness or death in families can result in economic shocks and loss of household wealth.

Economic shocks may affect child marriage primarily through household consumption smoothing (e.g., measures to remedy the short-term effects of the income loss). Because of this behavior, it has been shown that in societies with dowry traditions, marriages of girls may be postponed to delay the dowry payment, whereas in societies with bride price traditions, child marriages may accelerate because of the increased household revenue they provide [12,13]. Corno et al. [13] demonstrate that shocks to agricultural output on the order of 10%–15% due to drought result in equilibrium increases in the annual marriage hazard of 4% for girls aged 12 to 17 in sub-Saharan African settings where bride price is common, and they reduce the hazard by approximately 3% in South Asian settings with dowry traditions.

The World Bank estimates the pandemic will result in a 2.5% decline in gross domestic product (GDP) in developing countries [28]. The impact on national GDP is expected to vary, and in an amplified scenario, it is projected to result in a 3%–10% loss in 2020. These losses are smaller than those found by Corno et al. [13]. However, impacts are expected to be borne heterogeneously and most severely by those in the lowest socioeconomic brackets. Therefore, we apply the Corno et al. results directly to the baseline marriage hazard, applying an increase of 4% per annum in sub-Saharan Africa and Latin America, but a reduction of 3% per annum in South Asia.

Economic impacts could also accrue in the longer term, for example, on the perceived prospects of employment or the return on education for girls, in turn affecting the relative value of marriage for girls. This mode cannot be well captured using evidence from previous short-term shocks; however, because no empirical evidence on which to base longer-term changes is

available, we have assumed the effect is captured through the economic and educational factors already taken into account.

Sensitivity analysis. In a sensitivity analysis, we assume an increase of 1% per annum in South Asia [2,13]. The evidence discussed previously indicates that income shocks may be protective against child marriage in societies practicing dowry. However, it is also possible that the economic impact extends beyond considerations of dowry payment and results in families' shifting behavior toward patterns seen among poorer households, including an increased level of child marriage [29]. The sensitivity analysis considers the possibility that the net effect of economic shock in South Asian countries is a slight increase in the risk of child marriage.

Interruption of education. School dropout or lack of formal education is strongly associated with increased risk of child marriage, although the direction of causality is not always clear [30,31]. School closures due to COVID-19 have already resulted in a loss of learning and are likely to increase school dropout because some children, especially those at the critical juncture between primary and secondary school, do not return to school and thus remain at higher risk of marriage for the duration of their childhood [32].

For an empirical translation of potential effects, we rely on estimates of the hazard ratio for one year of education on child marriage derived from an empirical study of a child marriage prevention program in Ethiopia—the Berhane Hewan program [9]. Erulkar and Muthengi [9] identified a hazard ratio of approximately .8 associated with additional years of educational attainment or an increase of approximately 25% in the marriage hazard for the loss of a year of schooling. We have translated this impact into a 25% relative increase in marriage hazard applied after the economic shock risk for all girls who experience at least one year of educational loss. We also include an additional 25% relative increase in the annual marriage hazard multiplied by the fraction of girls aged 10 to 17 who are assumed not to return to school after a closure. This increased risk due to dropout continues for the remainder of their period of risk (up to age 18).

To tailor the model to country-specific school closure data, we utilized simulations of COVID-19 impact on Learning-Adjusted Years of Schooling (LAYS). We found that the pandemic was expected to result in the loss of approximately .2–.6 LAYS per child. The World Bank also found that the distribution of school closure duration was bi-modal, with mean duration of closure lasting ~100 days, but with peaks around 80 days and 180 days [10]. We therefore expect that the loss of education will be less than one year for most students that do return but that many students will drop out, losing all remaining expected educational attainment. For each cohort, we calculate the impact of the COVID-19 pandemic by using the following relationship to adjust the marriage hazard for the remaining years of childhood, including and following the year 2020.

$$a(\text{year}, \text{cohort}) = \{ h(\text{year}, \text{cohort}) * (1 + (lp(\text{cohort}) * (\frac{0.25}{(18 - \text{age}(2020, \text{cohort}))})) + (0.25(1 - p(\text{cohort}))(18 - \text{age}(2020, \text{cohort}))) \}$$

$$\text{if } \geq \text{year} \geq 2020 h(\text{year}, \text{cohort}) \text{ otherwise}$$

where $a(\text{year}, \text{cohort})$ is the adjusted marriage hazard due only to school closures for a specified *year* and *cohort*, $h(\text{year}, \text{cohort})$ is the baseline marriage hazard for the same *year* and *cohort*, l is the expected LAYS lost due to COVID-19 school closures, $p(\text{cohort})$ is the expected probability of dropout due to the COVID-19 pandemic in each *cohort*, and $\text{age}(2020, \text{cohort})$ is the age of each cohort in the year that the pandemic occurs (in this case, we assume 2020).

Adolescent pregnancy. The relationship between early pregnancy and child marriage is also well documented, although the direction of the relationship varies by context. Most adolescent pregnancies occur within pre-existing unions, and girls who marry at a young age often become pregnant soon after [11,31,33]. However, because of the globally declining age of menarche and increasing age at first marriage, premarital sex and unintended adolescent pregnancy may be more common [11,34–36].

Based on research on the Ebola epidemic in Sierra Leone, we expect school closures to lead to an increase in the risk of pregnancy by changing the way some children allocate their time [37]. Interruptions to contraceptive supply and adolescent-friendly sexual and reproductive health programming may also lead to increases in pregnancy among adolescent girls.

While adolescent pregnancy may be expected to lead to marriage in some contexts, most adolescent pregnancies occur within existing unions, and this route is expected to be a minor contributor to increased child marriage and to be largely mediated through the effects of interrupted schooling, which are already reflected in the model [11]. For this reason, we have not included additional risk of child marriage due to adolescent pregnancy in these projections, although we acknowledge that there may be some increase via this mechanism. It is overwhelmingly likely that the reverse will be true, and the increase in child marriage predicted by these models might increase the number of adolescent pregnancies.

Access to programs and services. Finally, many countries implement programs and services to prevent child marriage and adolescent pregnancy. The COVID-19 pandemic and related mitigation measures have resulted in delays or stoppages in the implementation of such programs [38]. Although the evidence base on effective child marriage prevention programming is limited and heterogeneous, there are several programs and services with demonstrated effects [14–16]. Interruption of effective prevention programming may lead to increases in child marriage [2]. However, the scale-up of effective child marriage prevention interventions may mitigate some of the increased risk of child marriage due to COVID-19.

Delayed implementation. In our analysis, we consider broad historical trends in child marriage as the underlying assumption for child marriage hazard trends. We consider interruptions in programming to prevent child marriage as delaying any existing downward trend due to programming for one year only. We assume that effective programming can prevent 33% of child marriages but that such programming reaches only about 25% of girls. A one-year delay thus results in loss of impact for only one year.

Mitigation. Effective child marriage prevention programming has been developed and tested [14–16]. This programming uses

a range of strategies, including girls' empowerment, community education, girls' participation in formal schooling, economic incentives, and supportive legislation and policy. Often, these strategies are used in combination [14]. Systematic reviews of the literature on the evaluation of such programs have revealed a high level of heterogeneity in the interventions, methods of evaluation, and estimated effects [14,15]. One such program showed an increase in age at first marriage of a full year and a 20% absolute reduction in prevalence of child marriage [39]. This reduction corresponded to an approximately 33% reduction in the probability of child marriage. We consider this as an upper bound on potential effectiveness and therefore assume that effective mitigation at scale may at most remove approximately one third of the risk of child marriage. In addition, in mitigated scenarios, we assume that interruptions to existing programming had no impact on child marriage rates.

Scenarios

This section outlines three main scenarios for projection: (1) a baseline scenario, (2) a scenario with a pandemic effect that is unmitigated by child marriage prevention programming, and (3) a scenario in which substantial effective child marriage prevention programming is deployed. The unmitigated and mitigated scenarios are modeled in two ways for Bangladesh and India, including a standard projection and a sensitivity projection.

Baseline. The baseline scenario includes only propagation of historical rates of child marriage decline. These rates are estimated by fitting the underlying projection model to estimates of child marriage prevalence derived from all recently available Demographic and Health Survey (or similar) data sets for each of the five countries (Appendix A). As such, no additional pandemic effects are incorporated. This baseline is thereafter used to calculate excess child marriages and counterfactual child marriage prevalence trends by comparing it with predictions that include pandemic effects, as described in the following.

Unmitigated. This scenario includes all pandemic effects at the best estimate of their impact based on assumptions derived from the literature on the relationship of similar mechanisms to child marriage risk. In this scenario, no specific actions or programs are anticipated to be delivered to reduce the impact of the COVID-19 pandemic on child marriages, making this in some sense a best estimate of a worst-case scenario. This scenario also assumes that although the pandemic may be short-lived, the effects of the economic and social shocks may persist.

Mitigated. This scenario builds on the unmitigated scenario to add specific actions and/or programs that are anticipated to be delivered to reduce the impact of the COVID-19 pandemic on child marriages.

Results

The models described previously were run for each of the five countries, resulting in a range of projections across countries and scenarios. Figure 2 displays the impact of each model on the prevalence of child marriage. In all countries, the unmitigated scenario results in an increase compared with the baseline trend, which lasts for several years before returning to the baseline

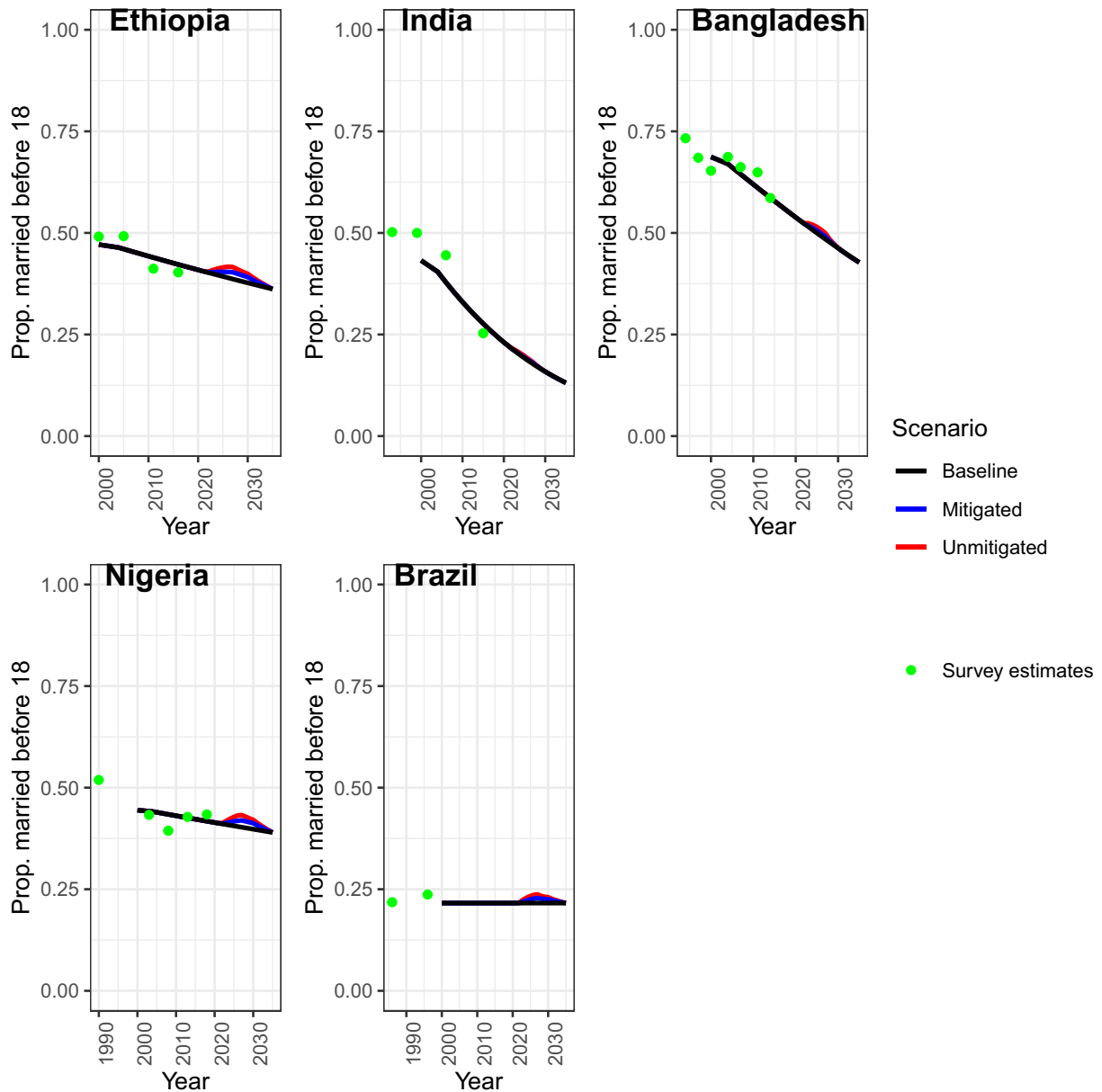


Figure 2. Percentage of women aged 20–24 years who were first married or in union before age 18, observed and projected.

trend between 2030 and 2035. In Brazil, Ethiopia, and Nigeria, the impact results in an absolute increase in the prevalence of child marriage for a period of at least five years, whereas in Bangladesh and India, the impact is not an increase but a reduced rate of decline.

In addition, the number of excess child marriages compared with the baseline was predicted for each scenario, summarized in Table 2. The total number of excess child marriages is estimated to range from 3.5 million to 4.9 million in the unmitigated scenario and from 1.8 million to 2.7 million in the mitigated scenario.

The sensitivity analysis did not appreciably change the projections (results not presented).

Discussion

The COVID-19 pandemic has affected the well-being of people around the world, including girls vulnerable to child marriage. The exact impact of the pandemic on child marriage is highly uncertain and for the time being cannot be precisely quantified. That said, a number of anecdotal reports as well as theoretical and empirical research on previous crises make the compelling case that the COVID-19 pandemic may affect the global incidence and prevalence of child marriage.

We project that these impacts (as measured in child marriage prevalence) will be seen over the period 2020 to 2035. While prevalence is measured through 2035, no additional child

Table 2
Number of additional child marriages projected due to the impact of COVID-19

Scenario	Country	Excess marriages before age 18	
		Standard	Sensitivity
Unmitigated	Ethiopia	649,696	-
Unmitigated	India	688,048	1,643,772
Unmitigated	Bangladesh	232,006	605,576
Unmitigated	Nigeria	1,551,417	-
Unmitigated	Brazil	428,550	-
Unmitigated	Total	3,549,717	4,879,011
Mitigated	Ethiopia	373,742	-
Mitigated	India	195,772	816,816
Mitigated	Bangladesh	84,998	330,825
Mitigated	Nigeria	891,548	-
Mitigated	Brazil	250,532	-
Mitigated	Total	1,796,591	2,663,463

marriages in these predictions can occur after 2028 (when the cohort of children who were 10 years old at the start of the pandemic can no longer be married as children). The prediction window has been extended because we consider not only the incidence of child marriage but also its prevalence, which, as per standard convention, is measured among adult women aged 20 to 24. To fully capture the time course of the effects of COVID-19 on child marriage prevalence, we must consider the full period through which the youngest affected children at the time of the pandemic will age out of child marriage prevalence measurement. This means that the impacts of COVID-19 on child marriage prevalence could be seen until 2035 or at least a full period of 14 years after the start of the pandemic. Therefore, while we expect the bulk of incident excess child marriages due to COVID-19 to occur in the near term, including those that have already taken place since the pandemic began, the full effects will play out over a longer time scale.

The projections in this study include the impact on child marriage in the five countries that together account for approximately 50% of the world's child marriages. This implies that if similar patterns hold and similar impacts of the pandemic are seen globally, we might expect the figures projected by our model to be approximately half of all child marriages due to COVID-19. This means that, in an unmitigated scenario, we might expect up to 10 million marriages for girls due to the pandemic [4].

Comparison with other estimates

A few attempts to project the magnitude of the impact of COVID-19 on child marriage have been made to date, including those by the United Nations Population Fund (UNFPA) [2], which predicts an excess of nearly 13 million child marriages globally, and those by Save the Children, which predicts an excess of approximately 2.5 million child marriages [3]. These predictions vary in methodology, time frame, and scope of countries, yet this range in results reinforces the level of uncertainty inherent in such projection efforts.

One difference across estimates is the time frame considered. The UNFPA projections consider the period 2020–2030, and the Save the Children predictions consider 2020–2025, whereas our model continues through 2035 [2,3].

Another key difference is how programmatic impacts are modeled. The UNFPA projects that around seven million excess child marriages will occur in 2020–2021 due to delayed implementation of child marriage prevention programs [2], whereas

our projections assume the impact of programming is smaller. In the baseline scenario, an estimated number of 12 million girls will marry in childhood each year globally, and although our model reflects evidence that approximately 33% of these marriages might be averted if highly effective prevention programs were delivered at scale [39], this still falls short of seven million.

Although all three models take economic impact into account, the mechanism and magnitude differ. The UNFPA model considers that the reduction in GDP per capita would increase the child marriage rate by 1.4 percentage points across all settings, whereas our model differentiates the impact between countries with a practice of bride price versus dowry. Although our assumptions result in significantly fewer projected child marriages, the numbers are clearly highly uncertain. For this reason, we have also incorporated scenarios in which the economic impact of COVID-19 is to increase child marriage in South Asia. These scenarios result in higher numbers of child marriages, although still fewer than those projected by the UNFPA. The model for economic impact used by Save the Children estimates a redistribution of the population by wealth, with more households shifting toward poorer quintiles, and recalculates total child marriage prevalence accounting for this new distribution, based on pre-COVID levels of child marriage in each quintile [3]. This approach, however, does not account for absolute shifts in income—for example, the poorest quintile becoming yet poorer—nor does it account for response to shocks, which may be different than having less wealth in a static scenario.

Although the projections differ substantially in scale, all estimate that the potential magnitude of the impact of COVID-19 on child marriage could be millions of excess child marriages. It may take years to unravel and understand the full impact of the pandemic on these outcomes, but the potential is without question large. Measures to mitigate these impacts, if they are to be effective, must begin soon. In addition, although the outcomes will take a decade or more to assess, the harm has likely already begun.

Limitations

Projections of the impacts of the COVID-19 pandemic are highly uncertain because of both the difficulty of assessing impact in relation to child marriage and the limited amount of empirical literature on which to scale the assumptions about the effects of each pathway. This prevented the ability to incorporate country-specific assumptions into the projections approach, and as a result, common assumptions were used across the five countries. To the extent that the current event is unlike the past, our models and our approach will produce incorrect results. The modeling approach also does not make any assumptions about "social interactions". We acknowledge the effects of the COVID pandemic on child marriage are uncertain, and as a result, we chose to base the projections on past events.

The projections can be improved in the future once additional country-specific evidence becomes available. In addition, pathways that are incorporated into the projection approach are treated as additive, rather than as interactive. As a result, interactive effects, if they exist, could result in greater or fewer effects. Future projection efforts would benefit from systematic research evidence of the impact of the pandemic on the various pathways and, in turn, child marriage rates. Panel studies that follow households and girls over time would be particularly useful.

Importantly, the predictions of future child marriage prevalence are contingent on baseline scenarios of trends in child marriage. These scenarios may be drastically different from what occurs in the real world due to other events. For instance, Ethiopia is currently experiencing a desert locust invasion along with serious civil conflict as part of an ongoing complex emergency. Such events may result in dramatic differences in background trends in child marriage. They could, in addition to simply changing the background, also interact with the COVID-19 pandemic in unforeseen ways, making the impact of the pandemic itself different than anticipated. Although we believe these projections can be useful to help policymakers understand the potential scope and timing of the impact of COVID-19 on child marriage, caution should be taken that policymakers utilize these projections in the context of the evolving nature of the pandemic and national and local responses. These projections are made from the perspective of one specific point in time and will need to be updated as the pandemic changes.

Funding Sources

The research was made possible through funding provided to UNICEF.

Supplementary Data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jadohealth.2021.07.037>.

References

- World Health Organization. WHO coronavirus (COVID-19) dashboard. Available at: <https://covid19.who.int/>. Accessed June 8, 2021.
- United Nations Population Fund. Impact of the COVID-19 pandemic on family planning and ending gender-based violence, female genital mutilation and child marriage. UNFPA Information Note. New York: UNFPA; 2020.
- Szabo G, Edwards J. The global girlhood report 2020: How COVID-19 is putting progress in peril. London: Save the Children; 2020.
- United Nations Children's Fund. COVID-19: A threat to progress against child marriage. New York: UNICEF; 2021.
- United Nations Children's Fund. Child marriage: Latest trends and future prospects. New York: UNICEF; 2018.
- Sonnenberg F, Beck J. Markov models in medical decision making: A practical guide. *Med Decis Making* 1993;13:322–38.
- Joshua-Yukich/childmarriager: Child marriage projection Markov models. R Package Version 0.0.0.9000. 2020. Available at: <https://rdrr.io/github/Joshua-Yukich/childmarriager/>. Accessed June 8, 2021.
- Filiipovic-Pierucci A, Zarca K, Durand-Zaleski I. Markov models for health economic evaluation: The R package heemod. R package version arXiv:1702.03252v2 [stat.AP]. 2017. Available at: <https://arxiv.org/abs/1702.03252>. Accessed June 8, 2021.
- Erukhar AS, Muthengi E. Evaluation of Berhane Hewan: A program to delay child marriage in rural Ethiopia. *Int Perspect Sex Reprod Health* 2009;35:6–14.
- Azevedo J, Hasan A, Goldemberg D, et al. Simulating the potential impacts of COVID-19 school closures on schooling and learning outcomes: A set of global estimates. Policy Research Working Paper No. 9284. Washington, DC: World Bank; 2020.
- Psaki S. Addressing child marriage and adolescent pregnancy as barriers to gender parity and equality in education. *Prospects* 2016;46:109–29.
- Corno L, Voena A. Selling daughters: Age of marriage, income shocks and the bride price tradition. IFS Working Paper W16/08. London: Institute for Fiscal Studies; 2016.
- Corno L, Hildebrandt N, Voena A. Age of marriage, weather shocks, and the direction of marriage payments. NBER Working Paper No. 23604. Cambridge, MA: National Bureau of Economic Research; 2017.
- Malhotra A, Warner A, McGonagle A, et al. Solutions to end child marriage: What the evidence shows. Washington, DC: International Center for Research on Women; 2011.
- Chae S, Ngo T. The global state of evidence on interventions to prevent child marriage. Girl Center Research Brief No 1. New York: Population Council; 2017.
- Malhotra A, Elnakib S. 20 years of the evidence base on what works to prevent child marriage: A systematic review. *J Adolesc Health* 2021;68:847–62.
- Beegle K, Krutikova S. Adult mortality and children's transition into marriage. *Demographic Res* 2008;19:1551–74.
- Chae S. Timing of orphanhood, early sexual debut, and early marriage in four sub-Saharan African countries. *Stud Fam Plann* 2013;44:123–46.
- Ueyama M, Yamauchi F. Marriage behavior response to prime-age adult mortality: Evidence from Malawi. *Demography* 2009;46:43–63.
- Dowd J, Andriano L, Brazel D, et al. Demographic science aids in understanding the spread and fatality rates of COVID-19. *Proc Natl Acad Sci* 2020;117:9696–8.
- Demombynes G. COVID-19 age-mortality curves are flatter in developing countries. Policy Research Working Paper No. 9313. Washington, DC: World Bank Group; 2020.
- Laxminarayan R, Wahl B, Dudala SR, et al. Epidemiology and transmission dynamics of COVID-19 in two Indian states. *Science* 2020;370:691–7.
- Chauvin J, Fowler A, Herrera LN. The younger age profile of COVID-19 deaths in developing countries. IDB Working Paper Series No. 1154. Washington, DC: Inter-American Development Bank; 2020.
- Molotsky A. Income shocks and partnership formation: Evidence from Malawi. *Stud Fam Plann* 2019;50:219–42.
- Hoogeveen J, Van der Klaauw B, Van Lomwel G. On the timing of marriage, cattle, and weather shocks in rural Zimbabwe. Policy Research Working Paper No. 3112. Washington, DC: World Bank; 2003.
- Kumala Dewi LPR, Dartanto T. Natural disasters and girls vulnerability: Is child marriage a coping strategy of economic shocks in Indonesia? *Vulnerable Child Youth Stud* 2019;14:24–35.
- Trinh T-A, Zhang Q. Adverse shocks, household expenditure and child marriage: Evidence from India and Vietnam. *Empir Econ* 2020;61:1617–39.
- Maliszewska M, Mattoo A, Van Der Mensbrugge D. The potential impact of COVID-19 on GDP and trade: A preliminary assessment. World Bank Group Policy Research Working Paper. Washington, DC: World Bank; 2020.
- Scott S, Nguyen P, Neupane S, et al. Early marriage and early childbearing in South Asia: Trends, inequalities, and drivers from 2005 to 2018. *Ann N Y Acad Sci* 2020;1491:60–73.
- Birchall J. Early marriage, pregnancy and girl child school dropout. K4D Helpdesk Report. Brighton, UK: Institute of Development Studies; 2018.
- Brown G. Out of wedlock, into school: Combatting child marriage through education. London: The Office of Gordon and Sarah Brown; 2012.
- United Nations Educational, Scientific and Cultural Organization. Education: From disruption to recovery. Available at: <https://en.unesco.org/covid19/educationresponse>. Accessed June 11, 2021.
- Erukhar A. Adolescence lost: The realities of child marriage. *J Adolesc Health* 2013;52:513–4.
- Hindin M, Fatusi A. Adolescent sexual and reproductive health in developing countries: An overview of trends and interventions. *Int Perspect Sex Reprod Health* 2009;35:58–62.
- Presler-Marshall E, Jones N. Charting the future: Empowering girls to prevent early pregnancy. London: Overseas Development Institute & Save the Children; 2012.
- Mensch B, Grant M, Blanc A. The changing context of sexual initiation in sub-Saharan Africa. *Popul Dev Rev* 2006;32:699–727.
- Bandiera O, Buehren N, Goldstein M, et al. The economic lives of young women in the time of Ebola: Lessons from an empowerment program. Policy Research Working Paper No. WPS 8760. Washington DC: World Bank; 2019.
- United Nations Children's Fund, United Nations Population Fund. Adapting to COVID-19: Pivoting the UNFPA-UNICEF Global Programme to End Child Marriage to respond to the pandemic. New York: UNICEF and UNFPA; 2020.
- Pande R, Kurz K, Walia S, et al. Improving the reproductive health of married and unmarried youth in India: Evidence of effectiveness and cost from community based interventions—Final report on the adolescent reproductive health program in India. Washington, DC: International Center for Research on Women; 2006.