Scars from a Previous Epidemic among White and Black Women: Social Proximity to Zika and Fertility Intentions During the Covid-19 Pandemic

Letícia J. Marteleto
University of Texas at Austin
Molly Dondero
American University
Andrew Koepp
University of Texas at Austin

Acknowledgments: This research was funded by grant R01HD091257, Reproductive Responses to the Zika Virus Epidemic in Brazil, awarded to PI L. J. Marteleto by the Eunice Kennedy Shriver National Institute of Child Health and Human Development. This research was also supported by grant P2CHD042849, Population Research Center, awarded to the PRC at The University of Texas at Austin by the Eunice Kennedy Shriver National Institute of Child Health and Human Development. This study was conducted under Institutional Review Board approval #2018-01-0055 from the University of Texas at Austin and the Brazilian National Commission for Research Ethics (also known as CONEP, or Comissão Nacional de Ética em Pesquisa) study approval CAAE: 34032920.1.0000.5149.

Introduction

The Covid-19 pandemic has led to a rise in morbidity and mortality, but its demographic consequences may not end there. Since the pandemic began, the public has experienced tremendous uncertainty and worry about SARS-CoV-2 infection, especially because scientific understanding of a *novel* disease takes time to develop and disseminate. During such periods of extreme uncertainty and worry, people may revise their fertility intentions (i.e. whether and when to have (more) children), with potential implications for both individuals and societies. In this environment, people may draw on their prior experiences, particularly prior epidemics, to shape their intentions. To investigate this possibility, we examine whether women's experiences during the Zika epidemic predict their fertility intentions during the Covid-19 pandemic. We hypothesize a scarring effect, such that women who experienced social proximity to Zika are more likely to postpone or forgo fertility during the Covid-19 pandemic.

To examine whether social proximity to disease in one novel infectious disease outbreak has scarring effects on fertility intentions in a subsequent outbreak of a successive novel infectious disease, as well as differential effects across racial groups, we turn to Brazil, which was the epicenter of the Zika virus (ZIKV) epidemic that ended in 2017. Three years later, Brazil was again an epicenter of another novel infectious disease outbreak, with one of the highest case count of Covid-19 in the world (as of April 2021) and with no sign of abating (Johns Hopkins Coronavirus Resource Center, 2021). As a result, Brazilian women of childbearing age are navigating fertility in the context of successive novel infectious disease outbreaks characterized by high levels of uncertainty and worry and that will likely exacerbate the country's entrenched and pervasive racial inequities.

Although ZIKV and SARS-CoV-2 are distinct in their modes of transmission and their symptomology, both viruses transmit novel infectious diseases that reached

epidemic proportions, generating high levels of individual and societal uncertainty and worry. Navigating fertility intentions during the Zika epidemic became especially fraught for women once scientists established that the ZIKV can cause serious birth defects including microcephaly and other types of congenital Zika syndrome (CZS) (Brasil et al., 2016; Rasmussen et al., 2016). Although scientific knowledge of the health impacts of Covid-19 on pregnant women and birth outcomes is still emerging, pregnant women are at higher risk of developing severe illness from Covid-19 (CDC, 2021), and there is evidence of increases in stillbirth and preterm birth during the pandemic (Khalil et al., 2020). While the devastating social and economic impacts of the Covid-19 pandemic are still unfolding, women in places affected by the Zika epidemic are again managing fertility intentions in contexts of high uncertainty and worry, this time coupled with heightened social and economic instability.

Given this context, our study examines three central research questions: Is social proximity to Zika during the ZIKV epidemic associated with intentions to postpone or forgo pregnancy due to the Covid-19 pandemic? Is this association mediated by perceived risk of contracting Covid-19 and worry about pregnancy and fetal complications due to Covid-19? Does this association differ between white and non-white women?

To examine these questions, we use unique microdata from 3,998 Brazilian women in Pernambuco, the state hardest hit by the Zika epidemic and that presented the highest declines in live births during the epidemic (Castro et al., 2018; Marteleto et al., 2017; Marteleto et al., 2020). We first test whether a woman's social proximity to Zika matters for fertility intentions during the Covid-19 pandemic, specifically whether she intends to postpone or forgo a pregnancy due to the Covid-19 pandemic. We construct a novel indicator of social proximity to Zika. We argue that regardless of whether a woman contracted Zika herself, the experience of social proximity to people with *confirmed* or *suspected* Zika infection during the epidemic can leave social-

psychological imprints that shape her fertility intentions in a subsequent novel infectious disease outbreak also characterized by high levels of uncertainty and worry.

We further argue that individual manifestations of worry regarding infection—which we operationalize as risk perceptions of contracting Covid-19 and worry regarding pregnancy and fetal complications due to Covid-19—are important social-psychological mechanisms that drive the association between social proximity to Zika and fertility intentions during the pandemic. Using structural equation models, we examine whether women's social proximity to Zika is associated with risk perception of Covid-19 infection and worry about pregnancy complications from Covid-19 and subsequently with decisions to postpone or forgo pregnancy because of the pandemic.

Finally, we test whether the scarring effects of social proximity to Zika on fertility intentions during the Covid-19 pandemic differ for white and non-white women, whose lived experiences prior to and during both crises differ in profoundly unequal ways due to Brazil's pervasive racial inequalities. As a result, non-white women might perceive the risks and consequences of Covid-19 and of pregnancy during the pandemic differently from white women and thus "scar" differently from them, leading to different intentions about whether and when to have (more) children.

Fertility intentions amid public health crises

Intentions about whether and when to have (more) children are dynamic and highly sensitive to changes in life conditions at the macro-level (Bhrolcháin & Beaujouan, 2011; Johnson-Hanks et al., 2011; Towriss et al., 2020; Sennott & Yeatman, 2018; Trinitapoli & Yeatman, 2018; Yeatman et al., 2013), such as large-scale novel infectious disease outbreaks. Fertility intentions are important because they can be key predictors of fertility behavior, which in turn determines fertility rates. Furthermore, regardless of whether they translate into behavior and rates, fertility intentions reflect social and health inequalities as well as differences on women's autonomy over their reproductive lives.

Public health crises can operate through various mechanisms that (re)shape fertility intentions. For example, the potential for a higher burden of care brought on by the health consequences of the disease may influence women to intend to have fewer children, particularly if resources are constrained. Indeed, the prospective burden of caring for a child with microcephaly or other CZS may have been a motivation to reduce childbearing during the Zika epidemic, driving down birth rates (Marteleto et al 2020; Rangel et al., 2020). In addition, novel infectious disease outbreaks often create a severe demand on health systems that can reduce available resources for other essential care such as pre-natal care, a factor that might also influence women to intend to postpone or forego childbearing.

On the other hand, in times of significant societal uncertainty and risk, such as during a novel infectious disease outbreak, women might intend to have (more) children if they view childbearing as a mechanism to reduce personal uncertainty (Friedman et al., 1994). Amid crises associated with high mortality, a desire to replace lost children can also lead to a desire for more children (Nobles et al., 2015). Indeed, childbearing has been found as a strategy to deal with the uncertainty regarding child survival generated by HIV in Malawi (Trinitapoli & Yeatman, 2011).

Social proximity to novel infectious diseases, risk perceptions, and fertility intentions

While there are studies on fertility responses to economic crises (Sobotka et al., 2011), natural disasters (Nobles et al., 2015) and wars (Agadjanian & Prata, 2002; Lindstrom & Berhanu, 1999), there is not much on how fertility *intentions* shift in response to epidemics. The few exceptions focus on how diagnosis of an infectious disease shapes fertility preferences (Hayford et al., 2012; Yeatman, 2009) or operationalize risk or proximity[1] to disease by calculating rates of confirmed cases of

[1] Whereas previous studies often use the term "exposure" to disease, we use the term "social proximity" to make it clear that we are referring to the number of people an individual knows who has had a confirmed *or* suspected case of Zika and not to an individual's pathogenic exposure to Zika.

the disease or another measure of exposure at an aggregate level of geography such as the community, municipality, state, or regional level (Lucas, 2013; Rangel et al., 2020; Terceira et al., 2003). To the best of our knowledge, no research has considered how fertility intentions shift across more than one disease.

We define social proximity to disease on a more granular level—as the number of people that an individual personally knows that has had a confirmed *or* suspected case of Zika or a confirmed case of microcephaly. We argue that this level of detail about confirmed *and* suspected cases in an individual's social network is important because it can shape social-psychological mechanisms such as perceptions of and worry about the risk and consequences of the disease, which in turn might shape how individuals make decisions during back-to-back outbreaks. The link between social proximity and such social-psychological mechanisms is especially important to consider during an outbreak of a *novel* infectious disease, when people might perceive a previously unknown disease as an abstract threat until they know someone who has been personally affected by it, when the risk of the disease then becomes a more concrete reality.

Given that Brazil is a highly racially stratified society, the ways in which social proximity to disease in one public health crisis impact fertility intentions during another outbreak may operate differently across racial groups. Non-white communities were disproportionately impacted by the Zika epidemic relative to whites (Mocelin et al., 2020) and are again bearing the disproportionate burden of Covid-19 health and socioeconomic consequences (Baqui et al., 2020). The conditions that made non-white communities more vulnerable to disease during these public health crises stem from a legacy of structural racism that pervades nearly all aspects of life, from education and employment to housing and health (Telles, 2004). The lived experiences of non-white, and particularly Black women both prior and during these

epidemics (Caldwell, 2017; Hogan et al., 2018) likely structure their risk of contracting Covid-19, their worry about it, and, in turn, their fertility intentions.

Results

Table 1 provides descriptive statistics for all variables in the analysis and for the items in the social proximity index. About three-fourths of the respondents know at least one person who had a suspected *or* confirmed case of Zika during the epidemic, reflecting the high prevalence of Zika in Pernambuco.

[Insert Table 1 here]

Figure 1, which shows the results from the structural equation models for the full sample, indicates that women with greater social proximity to Zika during the ZIKV epidemic are more likely to postpone or forego pregnancy during the current Covid-19 pandemic (b = 0.10, OR = 1.11, $p < .05$), suggesting a scarring effect of this previous epidemic. Women of childbearing ages who had greater social proximity to Zika during the ZIKV epidemic were also more likely to perceive a higher risk of infection of Covid-19 (b = 0.08, $p < .01$). Furthermore, women who perceive a greater risk of Covid-19 infection were more likely to report that they were worried about pregnancy and fetal complications due to Covid-19 (b = 0.03, $p < .001$). Women who reported being worried about pregnancy and fetal complications due to Covid-19 were also more likely to postpone or forgo pregnancy during the pandemic (b = 0.44, OR = 1.55, $p < .05$).

In addition to these direct paths, we also find that perceived risk of contracting Covid-19 and worry about pregnancy and fetal complications during the pandemic mediates the association between social proximity to Zika and childbearing intentions. Greater social proximity to Zika during the epidemic is associated with a higher perceived probability of infection and a higher likelihood of worry about adverse fetus and pregnancy effects during the Covid-19 pandemic (b = 0.003, $p < .05$). This indirect association extended to childbearing intentions, such that social proximity to Zika during the ZIKV epidemic predicts childbearing intentions during the Covid-19

pandemic through the perceived probability of infection with Covid-19 and concern about pregnancy and fetal complications due to Covid-19 (b = 0.01, p = .059).

Table 2 summarizes the direct, indirect, and total paths for the full sample with additional analyses. To better understand the nature of the association between social proximity to Zika and fertility intentions during the Covid-19 pandemic, we disaggregated fertility intentions into foregoing versus postponing childbearing. These results suggest that the total association between social proximity to Zika and childbearing intentions during the Covid-19 pandemic is stronger for foregoing pregnancy altogether (b = 0.14 p < .05) than for postponing (b = 0.10, p = .08).

Table 2 shows analogous further results, but separately for white and non-white respondents and separately for respondents who intend to postpone versus forego childbearing. Social proximity to Zika during the ZIKV epidemic has a strong association with white respondents' intentions to postpone childbearing during the Covid-19 pandemic (b = 0.291, p < 0.01) but not with their intentions to forgo childbearing (non-statistically significant). The opposite pattern exists for non-white women—social proximity to Zika is statistically significantly associated with intentions to foregoing childbearing altogether (b = 0.155, p < 0.05), but not with intentions to postpone childbearing (non-statistically significant). Parity or desired fertility do not explain these differences. Further results show that the operating mechanisms driving the indirect paths between social proximity to Zika during the ZIKV epidemic and fertility intentions during the Covid-19 pandemic also differ for white vis-a-vis non-white women.

Additional sensitivity analyses by age and SES levels are shown in Table A1 in the Appendix. Social proximity to Zika is a strong predictor of fertility intentions among younger women of childbearing ages, but not for older women of childbearing ages, likely because the latter has a smaller fecund window. The direct path is strong and driven mostly by intentions to forego fertility (b = 0.146, p < 0.05). The models

disaggregated by SES follow the overall trend of the race groups in that women with high SES intend to postpone childbearing.

Discussion

With the Covid-19 pandemic occurring only three years after the Zika epidemic ended, women of childbearing age in places affected by ZIKV are now navigating fertility during back-to-back novel infectious disease outbreaks characterized by high levels of uncertainty and fear. Our study used unique microdata from Brazil, the country most affected by the Zika epidemic, to understand whether a novel infectious disease outbreak left lasting imprints that shape fertility intentions during a subsequent novel infectious disease outbreak, the Covid-19 pandemic, and whether these scarring effects operate differently by race.

Our results demonstrate a scarring effect of one novel infectious disease outbreak to another such that a woman's social proximity to Zika during the ZIKV epidemic directly predicts fertility intentions three years later, during the Covid-19 pandemic. Regardless of whether a woman herself had or suspected that she had Zika, her social proximity to Zika during the ZIKV epidemic was associated with increased perceived risk of Covid-19 infection and worry about pregnancy and fetal complications from Covid-19, which in turn were associated with intentions to postpone or forgo pregnancy because of the Covid-19 pandemic. This points to the profound consequences of epidemics of novel infectious diseases that go beyond mortality and morbidity. Further results also show that the direct effect of social proximity to Zika operates through foregoing pregnancy among non-white women, while it operates through postponing pregnancy among white women. These findings remain despite controls for parity and ideal family size.

Broadly, our findings speak to the transformative consequences of novel infectious disease outbreaks that go beyond mortality and health. Our results have important general implications for understanding the scarring effects of novel

infectious disease epidemics and the importance of social proximity to a novel infectious disease, and specific implications for understanding overall and racially patterned individual- and population-level consequences of successive outbreaks for women's childbearing intentions and potentially, for fertility rates. We discuss each of these implications in turn.

First, our results provide strong evidence of a scarring effect across outbreaks. More than three years since the Zika epidemic ended, women who had greater social proximity to Zika during the epidemic perceived a greater risk of infection with Covid-19, were more likely to be worried about birth complications from Covid-19, and ultimately were more likely to postpone or forgo getting pregnant due to Covid-19. Had the Covid-19 pandemic not occurred or had it occurred many years after the Zika epidemic, the impacts of the Zika epidemic might have begun to fade given that Brazil has not faced a recurrence of a Zika outbreak since the end of the epidemic. However, the Covid-19 pandemic appears to have triggered a similar sense of worry and uncertainty that women of childbearing age lived with during the Zika epidemic. This finding highlights that the unexpected social-psychological effects of epidemics can spill over from one novel infectious disease outbreak to another. With scientists predicting an "era of pandemics" and a rise in novel infectious diseases (Lancet 2021) the occurrence of consecutive outbreaks may increase, with transformative impacts on how individuals navigate major life decisions such as childbearing.

Second, our results show that social proximity to Zika is an important predictor of how women perceive risk during a subsequent public health crisis. Whereas prior studies often capture social proximity or exposure to a disease at the municipality or state of residence level and over a single outbreak, our measure drills down to the more proximate level of women's own social networks. We argue that personally knowing people who have had Zika makes women perceive the risks of novel infectious diseases as more real rather than as an abstract and distant threat that they

hear about in the news. Our results show that social proximity to Zika—whether confirmed or suspected—matters in concrete ways for how women perceive infection risks, worry about pregnancy and fetal complications, and fertility intentions during the Covid-19 pandemic. Our study suggests that collecting data about social proximity to infectious diseases across multiple outbreaks and social networks could be central for understanding how individuals perceive public health risks and how they might modify their intentions and behaviors as a result.

Third, our findings point to potential individual-level effects for women's childbearing experiences. Even in the absence of a public health crisis, childbearing intentions are often wrapped in at least some worry due to the risks inherent in pregnancy, childbirth, and childrearing. Social proximity to Zika during the epidemic is associated with a heightened likelihood of pregnancy worries during the Covid-19 pandemic. These compounding worries about pregnancy and fetal complications during consecutive novel infectious disease outbreaks could translate into higher levels of stress during pregnancy and adverse mental health outcomes, which can also be associated with deleterious pregnancy and birth outcomes similar to the ones found regarding shocks (Torche & Echevarría, 2011).

Fourth, at the population level, our results point to the potential consequences of the Covid-19 pandemic on fertility behavior. As demographers document fertility rates during and post-pandemic, with some evidence pointing to a decline in live births in Brazil and elsewhere (Kearney and Levine, 2020), our ability to distinguish between intentions to postpone versus intentions to forgo pregnancy can provide insight into whether observed changes in fertility rates during and following the Covid-19 pandemic may represent tempo or quantum effects. That the association between social proximity to Zika and forgoing pregnancy during the pandemic is stronger than that of postponing pregnancy points to a potential quantum effect in fertility rates if most women are able to fulfill their childbearing intentions. That said,

fertility intentions are dynamic and may change in the period following the pandemic. For example, the documented declines during the ZIKV epidemic (Castro et al., 2018; Marteleto et al., 2017; Marteleto et al. 2020; Rangel et al. 2020) suggest women's ability to adjust their fertility intentions and behavior during a period of intense uncertainty and worry. These back-to-back public health crises involving novel infectious diseases are likely to impact fertility in significant ways.

Fifth, our findings show that white and non-white women have scarred differently from the Zika epidemic. Social proximity to Zika translates into intentions to postpone childbearing among white women and into intentions to forgo fertility among non-white women. In situations of heightened uncertainty and worry generated by novel infectious disease outbreaks, our findings show that non-white women react by intending to forego childbearing altogether, while white women react by intending to postpone, potentially suggesting that they perceive the public health crisis as a temporary barrier to childbearing. Fertility already takes place in highly contentious and uncertain circumstances among non-white women—unintended fertility is high among non-white women, who also face serious barriers to contraception (Goes et al., 2020), and institutional discrimination (Caldwell, 2017) including regarding reproductive health (Edu, 2018). In addition, non-white households in Brazil have borne the disproportionate burden of disease and economic consequences of both the Zika epidemic and the Covid-19 pandemic. In a context of back-to-back novel infectious disease outbreaks, non-white women might perceive the combined weight of these barriers as leaving them with little option but to forgo future childbearing.

The Covid-19 pandemic has reshaped our world in profound and unequal ways. Drawing evidence from a prior novel infectious disease outbreak, our study showed that the Zika epidemic has left scars that influence childbearing intentions years later and along racial lines. The effect of the Covid-19 pandemic will depend on

whether these intentions become reality, but may leave lasting scars that impact behavior for years to come.

Materials and Methods

Between May-October 2020, the DeCodE Project conducted a 25-minute phone interview with 3,998 women ages 18-34 in the state of Pernambuco, Brazil. To recruit a probabilistic sample we applied a Random Digit Dialing (RDD) technique using a list of all cell phone numbers from Brazil's governmental phone concession containing more than 19 million numbers [2]. Importantly, representative surveys conducted by Brazil's Census Bureau (Instituto Brasileiro de Geografía e Estatística, 2021) show that 94% and 88% of women in this age group own a cell phone in the metropolitan of Recife, and in the overall state, respectively.

Measures

The outcome variable is change in fertility intentions due to the COVID-19 pandemic, measured separately for respondents who report they want a(nother) child (postponing pregnancy because of the pandemic) versus do not want a(nother) child

[2] We used a dual frame sample design, in which the sample was selected through a list-assisted random-digit dialing (RDD) procedure with 70% from a list-assisted from a census of cell phones and 30% from a commercial credit database. We matched a cell phone database to the available 1,000 banks dedicated to cell phones in target area code 81, as informed by ANATEL, the telecommunication authority in Brazil, and stratified them into three strata based on i) region (Recife metropolitan area vs. not) based on the location of the plurality of the listed phones, and ii) stratum 3: if the 1,000-bank did not have any listed cell phone number. The sample was allocated proportionately to the number of 1,000-banks from each stratum. Within strata 1 and 2, the 1,000-banks were selected with probabilities proportionate to the number of listed cell phones, and within stratum 3 they were selected at random. All cell phone numbers were sampled from the selected 1,000 banks for a total of approximately 3,000,000 cell phone numbers. In the commercial credit database frame, cell phone numbers were selected at random. For 11.94% of the sample, the cell phone number of their partners (husbands, partners, boyfriends) were selected through RDD to reach out to female respondents. At least three attempts were made to complete an interview at every sampled telephone number, with all interviews recorded with time and date. The DeCodE team trained interviewers with the survey firm. All interviewers were female and conducted the interviews remotely in their own households due to the pandemic, using a system called *Soluções RP – Raptor*. Overall, we recruited a probability sample of 3,998 women to participate in baseline and subsequent follow-ups over a two-year period. Surveys weights were applied to adjust for unequal selection probabilities, integrate the samples from both frames and for nonresponse and coverage adjustments.

(foregoing pregnancy altogether because of the pandemic). If respondents reported that they changed their intentions but still intended a pregnancy within the next six months, we did not consider this a change in intentions.

The social proximity index summarizes whether respondents' social circles—including themselves, family and household members, and their children—had a suspected *or* confirmed Zika infection, the overall number of people they know with a suspected *or* confirmed case, and whether they know any child with microcephaly. Indices constructed using items in Table 1 through sum scores, principal components and factor analysis are highly correlated (r = .96- .99). Simple sum score of binary indicators showed the strongest association with Zika exposure correlates such as household water shortage. Importantly, a high level of social proximity to Zika is unrelated related to education (mean difference = .02, p = .60) or income (r = .004, p = .79.). Covid-19 risk perception is a self-assessment of the likelihood of infection measured through a 5-point scale coded as a dichotomous variable. Worry with pregnancy and fetal complications because of Covid-19 is a 5-point scale coded as a dichotomous variable. Additional covariates included in the models are age, race, education, income, living with partner, living in the metropolitan state capital area (Recife), has at least one child, and wants a(nother) child.

Methodology

To test for direct and indirect associations (i.e., mediation) between social proximity to Zika and fertility intentions, we conducted path models in Mplus version 8.2. We used maximum likelihood robust estimation to account for the dichotomous nature of the outcome variable. We employed full information maximum likelihood to handle missing values (Enders, 2013).

Figures and Tables

Table 1. Descriptive Statistics (N = 3,892)

	M/%	SD	Range
Zika proximity index	1.96	1.40	0 – 5
Perceived likelihood of contracting Covid-19	3.51	1.47	1 – 5
Worried/extremely worried pregnancy-fetal Covid-19 complications	83.5%		
Intends to postpone or forgo because of pandemic	21.6%		
Does not want another child	34.8%		
Has a child	48.6%		
Age 18 – 26	41.0%		
Race (non-white)	70.4%		
Completed high school or less	52.8%		
Lives in metro Recife	85.8%		
Income category (1 - 7)	4.22	1.72	1 - 7
Married or lives with partner	47.0%		
Zika proximity items			
Knows at least one person who had Zika (confirmed or suspected)	74.0%		
Someone in R's household or family had suspected or confirmed case	42.0%		
Knows at least five people who had Zika	36.1%		
Knows any children with microcephaly	25.1%		
Suspected or confirmed case	19.0%		

Source: DeCodE data. Non-pregnant women.

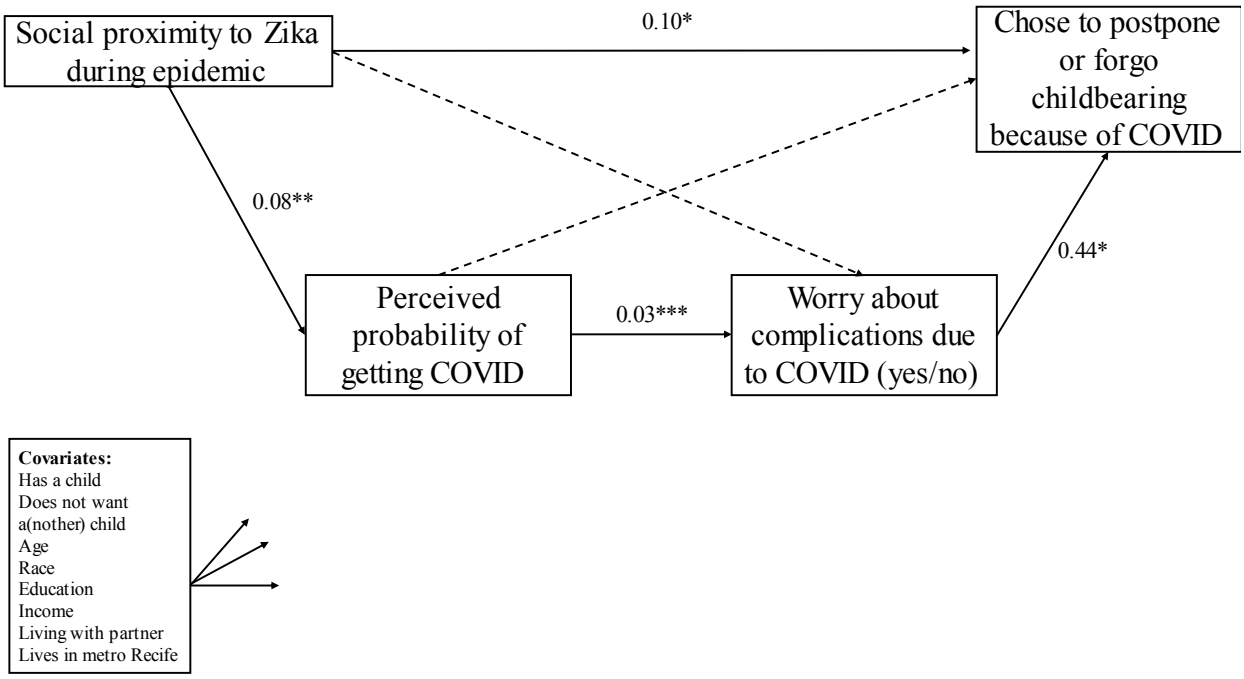
Table 2. Direct, Indirect, and Total Paths from Zika Proximity to Postponing or Forgoing Pregnancy due to the COVID-19 Pandemic.

	Direct path		Indirect path		Total path	
	Est.	*p*	Est.	*P*	Est.	*P*
Full sample (*N* = 3,892)	0.098	0.030	0.010	0.059	0.108	0.017
Postpone (*n* = 2,290)	0.093	0.104	0.010	0.174	0.102	0.076
Forgo (*n* = 1,602)	0.14	0.053	0.009	0.348	0.149	0.038
Non-white (*n* = 2,737)	0.062	0.233	0.011	0.093	0.074	0.161
Postpone (*n* = 1,557)	0.030	0.419	0.008	0.471	0.035	0.600
Forgo (*n* = 904)	0.155	0.067	0.018	0.284	0.173	0.036
White (*n* = 1,150)	0.193	0.023	0.077	0.472	0.200	0.019
Postpone (*n* = 748)	0.291	0.005	0.001	0.954	0.292	0.006
Forgo (*n* = 316)	-0.024	0.879	0.013	0.564	-0.011	0.945

Source: DeCodE data. Non-pregnant women. *Note:* Direct path reports the path from Zika proximity to postponing/forgoing fertility. Indirect path reports the mediated path from Zika proximity to postponing/forgoing through perceived probability of Covid-19 infection and worry about pregnancy-fetal complications due to Covid-19. Full sample reports models for postponing/foregoing childbearing combined (analogous to Figure 1). Postpone vs. forego reports models separately for each fertility intention.

Figure 1

Path Model Predicting Change in Childbearing Intentions (N = 3,892)



Note: Dashed lines indicate non-significant paths. AIC = 81852.62, BIC = 84210.35

Appendix A. Sensitivity Analysis

Table A1. Direct, Indirect, and Total Paths from Zika Proximity to Postponing or Forgoing Pregnancy due to the COVID-19 Pandemic.

	Direct path		Indirect path		Total path	
	Est.	*p*	Est.	*P*	Est.	*P*
Age 27-34 (*n* = 2,295)	.050	.319	.022	.031	.072	.156
Postpone (*n* = 1,134)	.038	.578	.017	.165	.055	.419
Forgo (*n* = 1,161)	.045	.582	.035	.140	.080	.331
Age 18-26 (*n* = 1,597)	.173	.019	.003	.725	.176	.019
Postpone (*n* =1,156)	.230	.124	.004	.775	.234	.120
Forgo (*n* = 378)	.146	.082	.002	.864	.148	.085
Education (Low; *n* = 2,053)	.104	.061	.012	.112	.116	.037
Postpone (*n* = 1,044)	.083	.245	.015	.260	.097	.181
Forgo (*n* = 767)	.178	.049	.011	.342	.190	.035
Education (High; *n* = 1,835)	.113	.124	-.003	.791	.110	.140
Postpone (*n* = 1,244)	.155	.056	-.002	.765	.152	.062
Forgo (*n* = 451)	-.133	.366	.011	.856	-.122	.485

Source: DeCodE data. Non-pregnant women. *Note:* Direct path reports the path from Zika proximity to postponing/forgoing fertility. Indirect path reports the mediated path from Zika proximity to postponing/forgoing through perceived probability of Covid-19 infection and worry about pregnancy-fetal complications due to Covid-19. Full sample reports models for postponing/foregoing childbearing combined (analogous to Figure 1). Postpone vs. forego reports models separately for each fertility intention.

References

Agadjanian, V., & Prata, N. (2002). War, peace, and fertility in Angola. *Demography*, *39*(2), 215–231. https://doi.org/10.1353/dem.2002.0013

Baqui, P., Bica, I., Marra, V., Ercole, A., & Schaar, M. van der. (2020). Ethnic and regional variations in hospital mortality from COVID-19 in Brazil: A cross-sectional observational study. *The Lancet Global Health*, *8*(8), e1018–e1026. https://doi.org/10.1016/S2214-109X(20)30285-0

Bhrolcháin, M. N., & Beaujouan, É. (2011). Uncertainty in fertility intentions in Britain, 1979-2007. *Vienna Yearbook of Population Research*, *9*, 99–129.

Brasil, P., Pereira, J. P., Moreira, M. E., Ribeiro Nogueira, R. M., Damasceno, L., Wakimoto, M., Rabello, R. S., Valderramos, S. G., Halai, U.-A., Salles, T. S., Zin, A. A., Horovitz, D., Daltro, P., Boechat, M., Raja Gabaglia, C., Carvalho de Sequeira, P., Pilotto, J. H., Medialdea-Carrera, R., Cotrim da Cunha, D., … Nielsen-Saines, K. (2016). Zika Virus Infection in Pregnant Women in Rio de Janeiro. *New England Journal of Medicine*, *375*(24), 2321–2334. https://doi.org/10.1056/NEJMoa1602412

Caldwell, K. L. (2017). *Health Equity in Brazil: Intersections of Gender, Race, and Policy*. University of Illinois Press.

Castro, M. C., Han, Q. C., Carvalho, L. R., Victora, C. G., & França, G. V. A. (2018). Implications of Zika virus and congenital Zika syndrome for the number of

live births in Brazil. *Proceedings of the National Academy of Sciences*, *115*(24), 6177–6182. https://doi.org/10.1073/pnas.1718476115

CDC. (2021, March 5). *Pregnant People: At increased risk for severe illness from COVID-19*. https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/pregnant-people.html

Edu, U. F. (2018). When Doctors Don't Tie: Hierarchical Medicalization, Reproduction, and Sterilization in Brazil. *Medical Anthropology Quarterly*, *32*(4), 556–573. https://doi.org/10.1111/maq.12475

Enders, C. K. (2013). Dealing with missing data in developmental research. *Child Development Perspectives*, *7*(1), 27–31. https://doi.org/10.1111/cdep.12008

Friedman, D., Hechter, M., & Kanazawa, S. (1994). A theory of the value of children. *Demography*, *31*(3), 375–401. https://doi.org/10.2307/2061749

Goes, E. F., Menezes, G. M. S., Almeida, M.-C. C., Araújo, T. V. B. de, Alves, S. V., Alves, M. T. S. S. B. e, Aquino, E. M. L., Goes, E. F., Menezes, G. M. S., Almeida, M.-C. C., Araújo, T. V. B. de, Alves, S. V., Alves, M. T. S. S. B. e, & Aquino, E. M. L. (2020). Racial vulnerability and individual barriers for Brazilian women seeking first care following abortion. *Cadernos de Saúde Pública*, *36*. https://doi.org/10.1590/0102-311x00189618

Hayford, S. R., Agadjanian, V., & Luz, L. (2012). Now or Never: Perceived HIV Status and Fertility Intentions in Rural Mozambique. *Studies in Family Planning*, *43*(3), 191–199.

Hogan, V. K., de Araujo, E. M., Caldwell, K. L., Gonzalez-Nahm, S. N., & Black, K. Z. (2018). "We black women have to kill a lion everyday": An intersectional analysis of racism and social determinants of health in Brazil. *Social Science & Medicine*, *199*, 96–105. https://doi.org/10.1016/j.socscimed.2017.07.008

Instituto Brasileiro de Geografía e Estatística. (2021). *Pesquisa Nacional por Amostra de Domicílios Contínua—PNAD*. https://www.ibge.gov.br/estatisticas/sociais/educacao/17270-pnad-continua.html?edicao=27138&t=o-que-e

Johns Hopkins Coronavirus Resource Center. (2021). *Coronavirus Resource Center*. https://coronavirus.jhu.edu/region/brazil

Johnson-Hanks, J. A., Bachrach, C. A., Morgan, S. P., & Koher, H.-P. (2011). *Understanding family change and variation: Toward a theory of conjunctural action*. New York: Springer.

Khalil, A., von Dadelszen, P., Draycott, T., Ugwumadu, A., O'Brien, P., & Magee, L. (2020). Change in the Incidence of Stillbirth and Preterm Delivery During the COVID-19 Pandemic. *JAMA*. https://doi.org/10.1001/jama.2020.12746

Kearney, M. and Levine, P. B. (2020, December 17). The coming COVID-19 baby bust: Update. *Brookings*. https://www.brookings.edu/blog/up-front/2020/12/17/the-coming-covid-19-baby-bust-update/

Lancet Planetay Health. Editorial. V5(1): January 01, 2021. https://doi.org/10.1016/S2542-5196(20)30305-3.

Lindstrom, D. P., & Berhanu, B. (1999). The Impact of War, Famine, and Economic Decline on Marital Fertility in Ethiopia. *Demography*, *36*(2), 247. https://doi.org/10.2307/2648112

Lucas, A. M. (2013). The Impact of Malaria Eradication on Fertility. *Economic Development and Cultural Change*, *61*(3), 607–631. https://doi.org/10.1086/669261

Marteleto, L. J., Guedes, G., Coutinho, R. Z., & Weitzman, A. (2020). Live Births and Fertility Amid the Zika Epidemic in Brazil. *Demography*, *57*(3), 843–872. https://doi.org/10.1007/s13524-020-00871-x

Marteleto, L. J., Weitzman, A., Coutinho, R. Z., & Valongueiro Alves, S. (2017). Women's Reproductive Intentions and Behaviors during the Zika Epidemic in Brazil: The Zika Epidemic in Brazil. *Population and Development Review*, *43*(2), 199–227. https://doi.org/10.1111/padr.12074

Mocelin, H. J. S., Catão, R. C., Freitas, P. S. S., Prado, T. N., Bertolde, A. I., Castro, M. C., & Maciel, E. L. N. (2020). Analysis of the spatial distribution of cases of Zika virus infection and congenital Zika virus syndrome in a state in the southeastern region of Brazil: Sociodemographic factors and implications for public health. *International Journal of Gynecology & Obstetrics*, *148*(S2), 61–69. https://doi.org/10.1002/ijgo.13049

Nobles, J., Frankenberg, E., & Thomas, D. (2015). The Effects of Mortality on Fertility: Population Dynamics After a Natural Disaster. *Demography*, *52*(1), 15–38. https://doi.org/10.1007/s13524-014-0362-1

Rangel, M., Nobles, J., & Hamoudi, A. (2020). Brazil's Missing Infants: Zika Risk Changes Reproductive Behavior. *Demography* 57(5), 1647-1680.

Rasmussen, S. A., Jamieson, D. J., Honein, M. A., & Petersen, L. R. (2016). Zika Virus and Birth Defects—Reviewing the Evidence for Causality. *New England Journal of Medicine*, *374*(20), 1981–1987. https://doi.org/10.1056/NEJMsr1604338

Sennott, C., & Yeatman, S. (2018). Conceptualizing Childbearing Ambivalence: A Social and Dynamic Perspective. *Journal of Marriage and Family*, *80*(4), 888–901. https://doi.org/10.1111/jomf.12489

Sobotka, T., Skirbekk, V., & Philipov, D. (2011). Economic Recession and Fertility in the Developed World. *Population and Development Review*, *37*(2), 267–306. https://doi.org/10.1111/j.1728-4457.2011.00411.x

Telles, E. E. (2004). Race in Another America. In *Race in Another America*. Princeton University Press. https://www.degruyter.com/document/doi/10.1515/9781400837434/html

Terceira, N., Gregson, S., Zaba, B., & Mason, P. (2003). The contribution of HIV to fertility decline in rural Zimbabwe, 1985-2000. *Population Studies*, *57*(2), 149–164. https://doi.org/10.1080/0032472032000097074

Torche, F., & Echevarría, G. (2011). The effect of birthweight on childhood cognitive development in a middle-income country. *International Journal of Epidemiology*, *40*(4), 1008–1018. https://doi.org/10.1093/ije/dyr030

Towriss, C. A., Beguy, D., Wringe, A., Hussein, B. H., & Timæus, I. M. (2020). Planning a family in Nairobi's informal settlements: Results of a qualitative study. *Journal of Biosocial Science*, *52*(2), 286–299. https://doi.org/10.1017/S0021932019000452

Trinitapoli, J., & Yeatman, S. (2011). Uncertainty and Fertility in a Generalized AIDS Epidemic. *American Sociological Review*, *76*(6), 935–954. https://doi.org/10.1177/0003122411427672

Trinitapoli, J., & Yeatman, S. (2018). The Flexibility of Fertility Preferences in a Context of Uncertainty: Flexibility of Fertility Preferences in a Context of Uncertainty. *Population and Development Review*, *44*(1), 87–116. https://doi.org/10.1111/padr.12114

Yeatman, S. (2009). HIV Infection and Fertility Preferences in Rural Malawi. *Studies in Family Planning*, *40*(4), 261–276. https://doi.org/10.1111/j.1728-4465.2009.00210.x

Yeatman, S., Sennott, C., & Culpepper, S. (2013). Young Women's Dynamic Family Size Preferences in the Context of Transitioning Fertility. *Demography*, *50*(5), 1715–1737. https://doi.org/10.1007/s13524-013-0214-4