Epidemics and Fertility Change: Responses to Zika and COVID-19 in Singapore

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Abstract

Using longitudinal survey data collected from 407 married women at peak childbearing ages, we compared self-reported changes to fertility plans in response to the 2016-2017 Zika and 2020 COVID-19 epidemics in Singapore. The Zika outbreak led to intentions to delay but not reduce childbearing, whereas the COVID-19 pandemic led to both. At the same time, some women reported accelerating and increasing childbearing due to COVID-19, with more intending to bring forward births as the pandemic dragged on. Educational background was more predictive of changes in fertility plans during the pandemic than during the Zika epidemic, and women who had already delayed childbearing due to Zika were more likely to further adjust timing of childbearing due to COVID-19. We considered three possible explanations for changes to fertility plans: fear of infection, change in subjective wellbeing, and income loss, and find stronger effects of perceptions of the virus on downward revisions of fertility plans during the Zika epidemic but a larger role for stress and income loss during the pandemic, reflecting the latter's wider economic and social impacts.

Funding This project was supported by funding from the Lee Kuan Yew School of Public Policy, National University of Singapore [R-603-000-190-133, R-603-000-347-115, R-603-000-237-133].

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Introduction

Changes in fertility have been observed after epidemics and disasters as individuals adjust their childbearing plans in response to the implications of changing circumstances for the expected survivorship and wellbeing of new offspring and existing family members. More generally, the strategic flexibility of fertility allows individuals to alter their prior intentions in both the short and long terms to accommodate the ongoing complexities and uncertainty of their external environments (Johnson-Hanks 2011; Trinitapoli and Yeatman 2011). Hence, both theory and data indicate the importance of contingencies, inputs, and shifts that occur both at the micro and macro levels (Trinitapoli and Yeatman 2018), including shocks such as natural disasters and epidemics, in the study of fertility behavior and intentions.

In this paper, we used a longitudinal dataset to compare self-reported changes in childbearing plans among 407 married women aged 25-34 in 2018 in response to two separate but closely spaced disease outbreaks in Singapore: the Zika epidemic of 2016-2017 and the COVID-19 pandemic of 2020. Using surveys conducted in April 2018, two years after the start of the Zika epidemic, in May 2020 during the COVID-19 lockdown, and in November 2020 six months after the end of the lockdown, we compared the proportions who reported delaying and reducing childbearing due to each of the two events, and also examined whether some women chose to accelerate or increase their intended childbearing during the pandemic. Next, we compared selection into adjustment of childbearing plans in terms of background variables, including achievement of fertility goals, length of marriage, and educational and income levels. We also took into account the close chronological order of the two epidemics and the potential accumulative effect of exposure to the COVID-19 crisis shortly after adjustments to fertility plans caused by the Zika epidemic. Finally, we considered three possible explanations for changes to fertility plans: fear of infection, change in subjective wellbeing, and income loss.

Zika and COVID-19 epidemics in Singapore

In 2016, the Zika virus outbreak in Brazil was declared a public health emergency of international concern by the World Health Organization after evidence emerged that infection led to serious health complications. Infection during pregnancy was associated with fetal congenital malformations and abnormalities, notably microcephaly, and other adverse pregnancy outcomes, including fetal loss, stillbirth and preterm birth (World Health Organization 2018). While past studies on the fertility impact of the Zika virus have focused on Latin America as the epicenter of the global health crisis (Castro et al. 2018; Marteleto et al. 2020; Rangel, Nobles and Hamoudi 2020), the virus has also surfaced in other parts of the world, albeit not accompanied by a large-scale rise in microcephaly cases. The Southeast Asian city state of Singapore suffered one of the first large outbreaks in Asia. Owing to its tropical climate and chronic presence of Aedes mosquitos, a total of 458 confirmed Zika cases were reported by the end of 2016 (Ministry of Health 2017), leading to swift public health responses, including patient isolation, widespread media coverage, and measures to prevent mosquito breeding (Ho et al. 2017). Although it was understood early on in the epidemic that infections in Singapore were caused by the local Zika strain (H/PF13), which is closely related but not identical to the South American strain (BE H 815744), the risks of microcephaly were unknown and believed to be similar to that in Brazil (Ungku and Nee 2016), resulting in widespread public concern. Unlike the Brazilian Ministry of Health, which took the unprecedented step of suggesting that women should delay pregnancy during the Zika crisis (Marteleto et al. 2017), the Singaporean government did not issue any general advisory against getting pregnant, instead only recommending the use of insect repellents and other precautions among couples planning for pregnancy (Ministry of Health 2021), perhaps in view of longstanding concerns over low fertility.

Less than three years after the 2016-2017 Zika epidemic, Singapore was again at the frontier of an epidemic with one of the first confirmed positive cases of the novel coronavirus COVID-19 outside of China in January 2020. In March, the government imposed border restrictions, barring entry to all short-term visitors and requiring a mandatory 14-day quarantine for all individuals entering the country. In April, as detected cases continued to rise, the government implemented a lockdown, locally known as a 'circuit breaker'. During this period, schools, childcare centers and all non-essential businesses were required to close by law. Essential services such as supermarkets, delivery services, food suppliers, energy manufacturers, and medical services remained open, although these essential services were suspended if any staff member were known to be infected (Ministry of Health 2020). The general population was advised to exit the home only to procure essential goods and services or to exercise, which had to be done alone in open spaces. Formal sanctions were also introduced where violations of lockdown guidelines resulted in fines up to $10,000 (approximately US$7,500), and/or up to six months' imprisonment. In June 2020, the lockdown formally drew to a close and movement restrictions were relaxed in incremental phases (Government of Singapore 2020).

The COVID-19 pandemic has extensively disrupted individuals' work and social lives, resulted in the worldwide unemployment of a large proportion of the adult population for many months at a time (Parker, Minkin, and Bennett 2020), and singlehandedly precipitated a deep global recession with lasting deleterious effect on human capital development arising from interruptions in schooling and primary healthcare access (The World Bank 2020). Being a small open economy, Singapore entered into one of its worst recessions in 2020 (Figure 1). By contrast, the Zika epidemic was not associated with unusually low economic growth rates compared to surrounding years.

[Figure 1 about here]

Previous research on external shocks and fertility

To adjust for unforeseen changes and for ongoing uncertainties in external environments, individuals employ a strategically flexible orientation towards childbearing intentions, which allows for differential responses to a wide set of events (Trinitapoli and Yeatman 2011). In the aftermath of natural disasters, fertility can experience a short-term increase in direct response to mortality shocks. Due to a desire to contribute to rebuilding families and communities, women who lose children during disasters are more likely to bear additional children afterwards, and this effect is stronger among younger and more educated women (Nobles, Frankenberg, and Thomas 2015). The same 'replacement motive' is observed in the immediate aftermath of other natural disasters: residents affected by a high-mortality earthquake tend to experience larger increases in fertility (Finlay 2009); similarly, after a hurricane, women in areas that received higher precipitation have higher birth rates although the effects subside in the longer-run (Davis 2017). Other studies on the impacts of tsunamis suggest an opposite trajectory, where a short-run negative decline in fertility preferences immediately follows in response to short-run economic volatility before increasing above pre-tsunami levels (Weeratunga and Dissanayake 2010).

Hence, while some individuals adjust their fertility preferences upward due to a desire to recuperate or contribute to the community, the effects may be mitigated by economic uncertainty arising from the disruptive nature of natural disaster, and also subject to the individual's ability to absorb the shock vis-a-vis their socioeconomic constraints. Individuals with more secure access to resources tend to be the dominant drivers behind fertility increases, whereas individuals of lower socioeconomic status tend to report lower fertility as a result of being disproportionately

affected by disruptions from natural disasters, including displacement and loss of income (Seltzer and Nobles 2017). At the same time, the latter group is also more vulnerable to reduced access to contraceptives through health care services and may have lower ability to negotiate contraceptive use in partnerships (Behrman and Weitzman 2016), flattening the socioeconomic gradient.

Climate change, while drawn out over a longer time period and with an indeterminable end, introduces a different layer of uncertainty into the future which might have a different role in shaping fertility intentions. Eissler, Thiede, and Strube (2019) found that women opt to adjust their fertility preferences downwards during periods of unfavorably high temperatures but only in the short-term, and that this impact on fertility preferences is more pronounced among those with lower socioeconomic and educational status. By contrast, fertility intentions tend to increase in response to short-term delays in monsoon onset, but decrease in response to longer-term temperature shocks. These responses vary by socioeconomic status, where women of higher status report higher fertility intentions for short-term climate anomalies while women of lower status report lower fertility intentions for longer-term shocks (Sellers and Gray 2019). While displaying mixed responses in fertility adjustments in response to climate change, both studies together again highlight the divergence of responses that occurs along socioeconomic dimensions.

Similar to climate anomalies, public health shocks in the form of disease outbreaks can occur over a more prolonged period of time and are therefore likely to generate more uncertainty about the future and have more pervasive effects on individuals' lives outside of mortality shocks. Where epidemics have resulted in shocks to child mortality, total fertility tends to increase due to a replacement or hoarding effect, while shocks to adult mortality tend to achieve the opposite (Boucekkine, Desbordes, and Latzer 2009). Work on the HIV epidemic found heterogenous effects where younger women are more likely to have their first child while older women who have already given birth are less likely to have subsequent births (Durevall and Lindskog 2011). In examining disease-induced uncertainty, studies found that the higher the individual's perceived likelihood of HIV infection—independent of how accurate that perception is—the higher their desire to stop childbearing, although this relationship is pronouncedly weaker among individuals in their early ages of fecundity (Trinitapoli and Yeatman 2011). The same study also found that older adults tend towards accelerating childbearing while others who were married, already had children, or had higher socioeconomic status and educational attainment opt to delay childbearing. Furthermore, the authors showed that individuals who perceive likelihood of infection within the next year also accelerate childbearing to optimize a perceived limited window of sufficiently good health for having a healthy baby.

Beyond the immediate responses to disease outbreaks, which are driven by short-lived replacement and hoarding motives, disruptions to marriage and labour markets ultimately decrease fertility levels in the long term (Boberg-Fazlic et al. 2017). Voluntary pregnancy delays due to perceived risk of infection do not necessarily translate into higher birth rates at a later period (Mizumoto and Chowell 2020), especially in demographic settings with below-replacement birth rates and an aging population, where uncertainty about the future plays an important role in explaining the contemporary below-replacement fertility levels (Vignoli et al. 2020). Even though general declines in fertility are most pronounced among younger cohorts of women who opt to delay childbearing, cohorts who have recently completed childbearing can also ultimately fall short of meeting fertility intentions (Gemmill and Hartnett 2020). Hence, public health management plays an important role in recovering pre-outbreak fertility levels, as demonstrated by the association between length of non-pharmaceutical interventions aimed at reducing viral transmissions during outbreaks and strength of fertility rebounds (Wagner et al. 2020).

Fertility responses to Zika vs COVID-19

The Zika epidemic largely affected tropical and subtropical regions where the disease vector—the Aedes mosquito—thrived (WHO 2018). Brazil was most heavily affected and saw an unambiguous decline in fertility (Borges et al. 2018; Coelho et al. 2017; Diaz-Quijano, Pelissari, and Chiavegatto Filho 2018; Diaz-Quijano et al. 2018; Ryu 2020; Taitson, de Souza, and Santos 2017). The overall decline in birth rates following the onset of the epidemic was especially pronounced among more highly educated and older women (Marteleto et al. 2020; Rangel, Nobles, and Hamoudi 2020) who likely had greater access to family planning services. The long-term fertility effects of Zika are less clear, with some suggesting prior to the COVID-19 pandemic that fertility decline is unlikely to continue (Castro et al. 2018).

Unlike the Zika virus, the novel coronavirus COVID-19 does not present a disproportionate burden of adverse health outcomes to pregnant women or in-utero children and therefore arguably has a less direct impact on individuals' adjustment of fertility preferences in response to health risks associated with childbearing. In fact, COVID-19 saw higher mortality rates among higher age groups while children and infants remained relatively unscathed (Lee et al. 2020), removing the replacement and hoarding motives that explain fertility spikes documented by past literature on natural disasters and health shocks (Aassve et al. 2020). Another key distinction between the COVID-19 and Zika outbreaks is the extent of disruption on individuals' daily lives at the societal level. On top of mortality shocks, widespread and prolonged periods of lockdowns, school closures, and migratory restrictions have resulted in large economic losses (Aassve et al. 2020). School closures imposed heavier burdens on parents by reducing access to formal childcare outside the home while home isolation had the potential to both improve and deteriorate familial relationships (Voicu and Bădoi 2021). The larger economic impact of the pandemic also caused more uncertainty for the future which in turns negatively impacts fertility decisions (Lebel et al. 2020; Trinitapoli and Yeatman 2018). Contextualized within these wide-ranging fallouts from COVID-19, individuals might adjust their fertility preferences in the face of higher levels of uncertainty regarding their futures despite the relatively lower health risks associated with childbearing when compared to the Zika epidemic. Consistent with theory, recent data revealed a fertility decline (Aassve et al. 2020; Berrington et al. 2021; Levine 2020), which is predicted to be larger among women with lower educational attainment (Wilde, Chen, and Lohmann 2020). Moreover, low-fertility settings are at particular risk of lower birth rates induced by the COVID-19 pandemic (Luppi, Arpino, and Rosina 2020).

Recent work has also studied possible interactions between the two epidemics, which are clearly separate but tightly paced. Marteleto, Dondero, and Koepp (2021) found that women who had higher social exposure to Zika express more pregnancy-related concerns arising from COVID-19 and tend towards delaying childbearing during the pandemic. Moreover, women who were reminded of the pregnancy-related risks of Zika are more likely to agree that childbearing during COVID-19 should be avoided (Marteleto, Dondero, and Maia 2021), suggesting that when faced with the new disease outbreak COVID-19, women draw from their experiences from the recent Zika outbreak to inform their present fertility intentions and behaviors.

Our contributions

This paper is most closely related to Marteleto, Dondero, and Koepp (2021), who examined the back-to-back effects of the two epidemics on the fertility decision making of the same group of women. Our work, which also took into account the close chronological order of the two epidemics and the potential accumulative effect of exposure to the COVID-19 crisis shortly after adjustments to fertility plans caused by the Zika epidemic, departs from their study in a number

of important ways. First, we examined whether the Zika epidemic may not only deepen concerns towards childbearing during the pandemic, but may also spur a subset towards accelerated childbearing due to a catch-up motive. Second, we provided evidence on whether these fertility responses evolved over time after the lockdown ended and the pandemic continued to drag on. Third, we explicitly tested three explanations for changes to fertility plans during both epidemics: fear of infection, change in subjective wellbeing, and income loss.

In addition, very few studies have examined the fertility impact of the Zika epidemic in Singapore, yet the experience of this less-studied region is important to include in the literature due to key contextual differences. In contrast to Brazil, where nearly half of pregnancies in 2006 were unintended (Borges et al. 2018), Singapore has one of the world's lowest fertility rates, driven by high rates of involuntary non-marriage and childlessness (Jones 2007) as well as an extremely low incidence of non-marital childbearing, with only 3% of citizen births born to unmarried women at the time of birth registration (Ministry of Social and Family Development 2018; National Population and Talent Division 2015). Another key feature of the local demographic landscape is high and rising ages at childbearing, characterized by declines in fertility among women in their 20s with little recuperation among women in their 30s (Frejka, Jones, and Sardon 2010). In view of these contextual factors, this study focuses on changes in the fertility plans of married women aged 25-34 in 2018, the peak childbearing age groups. Given the expected disproportionate impact of the pandemic on birth rates in low-fertility settings (Luppi, Arpino, and Rosina 2020), evidence from this region can help to provide a more complete and diverse picture of how childbearing plans shifted in the face of these two epidemics.

Data Collection

Sample

Our longitudinal dataset consists of three main survey waves. The first wave of data was collected between April and July 2018. A total of 660 female participants were recruited using street intercept at public central locations such as Mass Rapid Transit (MRT) train station exits, walkways of bus interchanges, spaces outside shopping malls and Housing Development Board (HDB) town centers, stratified by the five main regions of Singapore: Central, North, Northeast, West and East. Participants met the following inclusion criteria: currently married; aged 25-34 in 2018; either a Singaporean citizen or married to a Singaporean citizen, and able to read, write and speak in English. Of the 3,038 potential participants who were approached, 660 (21.7%) met the inclusion criteria and were recruited, 558 (18.4%) did not meet the inclusion criteria, and 1,820 (59.9%) declined to participate (1,143 declined prior to introduction and 677 declined after introduction to the study). Each recruited participant received up to SGD 120 (USD 88) for their participation in the first wave. Of the 660 participants, 500 consented to be re-contacted for follow-up surveys. 416 (83.2%) completed a follow-up online survey in May 2020 in the midst of the lockdown (additional data on income levels were retrospectively collected in June 2020 after the lockdown ended), and 378 (75.6%) completed the last wave in November 2020 six months after the lockdown. The timeline for each wave of data collection in proximity to major events during the two epidemics is provided by Figure 2. Recruited participants received SGD 25 (USD 19) for their participation in May-June 2020 and SGD 15 (USD 11) for their participation in November 2020. The study was approved by the [anonymous] Institutional Review Board.

[Figure 2 about here]

All interviews were conducted face-to-face in English without the presence of third parties, either in nearby public spaces, or alternatively, at the respondents' homes at a time of their convenience.

The baseline survey collected information on individual and household characteristics, including age, education, income levels, ethnicity, date of current marriage and respondents' self-reported marital satisfaction. Confidential information, including income levels and marital satisfaction, was collected through a computerized self-administered questionnaire to avoid embarrassment and elicit greater honesty. Dates of birth of all children and current pregnancy status were collected during the baseline survey and all subsequent waves, and income levels in December 2019 and May 2020 were retrospectively collected in June 2020. In 2018, each respondent was asked about their perceptions of infection risks for Singaporean women, and how anxious they felt about being infected by the Zika virus on a 5-point scale, and in 2020, similar questions were asked about the COVID-19 virus. In all waves, respondents were also asked to rate their current stress and fatigue levels, and whether the events had affected their fertility decision making, discussed in more detail below.

Couples who divorced between 2018 and 2020 were excluded from analysis (N = 5). The final sample sizes were 407 for 2018 and May 2020, and 345 for November 2020 due to follow-up loss. Observations with missing income data (for either husband or wife) were excluded from econometric analyses.

Key variables

The key dependent variables were married women's changes in fertility intentions, self-reported in all survey waves. In mid-2018, respondents were asked whether the Zika epidemic had led to "delayed childbearing" or "decided to have fewer children". Respondents were allowed to select both options, only one of the options, or neither of the options. In May 2020, respondents were asked how much the COVID-19 lockdown had affected their childbearing intentions, whereby they could respond yes or no to "brought forward childbearing", "decided to have more children", "delayed childbearing" and "decided to have fewer children". In November 2020, respondents were again asked how much their childbearing intentions had changed compared to before the COVID-19 lockdown, whereby they could respond yes or no to "brought forward childbearing", "decided to have more children", "delayed childbearing" and "decided to have fewer children". In both May and November 2020, respondents were allowed to select all options, any subset of the options, or none of the options.

To examine selection into adjustment of childbearing plans in terms of background variables, we examined the following individual and household characteristics. Both spouses' age, education and income levels were coded as binary variables for whether they were older than 30, held a college degree and had an income level of SGD 4,000 (USD 3,000) or higher during the baseline survey respectively. Wife's ethnicity was coded as a binary variable for whether the female respondent was Chinese, the majority ethnic group in Singapore. Years married was recorded at baseline in 2018. High marital satisfaction was coded as a binary variable for whether the female respondent reported being very satisfied with the marriage (the maximum score of 5 on a scale of 1 to 5). Achievement of fertility ideals was coded as a binary variable for whether the number of children (including ongoing pregnancies) was equal to or exceeds both spouses' ideal number of children as reported by the female respondent in the baseline survey.

We considered three explanations for changes to fertility plans: fear of infection, change in subjective wellbeing, and income loss. Fear of infection was measured using two variables. First, respondents were asked to estimate the probability that a Singaporean woman would be infected (by the Zika virus in 2018 and COVID-19 virus in 2020). Second, respondents were asked about their anxiety regarding infection on a scale of 1 to 5, with 1 representing "very anxious" and 5 representing "not anxious at all", which was subsequently recoded on an ascending scale. Change

in subjective wellbeing was measured using similarly phrased questions with five-point scales ranging from "very" to "not at all" in 2018 ("In general, how would you rate the stress level in your lives?" and "In general, how tired do you feel?") and in 2020 ("In general, how would you rate how stressed you are in the past two weeks?" and "In general, how would you rate how tired you are in the past two weeks?"), and recoded on an ascending scale. A binary variable for income loss was generated for both spouses based on whether their monthly income, measured on a linear scale from 1 to 12 (1 = no income, 2 = monthly income less than SGD 1,000 and 12 = monthly income SGD 10,000 or more), shifted to a lower bracket relative to December 2019 (retrospectively collected in June 2020), available only for May and November 2020. Data on income loss were not available for the 2018 baseline survey as well as less applicable to the Zika epidemic (see Figure 1), and hence omitted. The exact wording of questions pertaining to fertility responses and explanatory variables are provided in the Appendix.

Model

Descriptive statistics were computed for all self-reported changes in fertility intentions across all waves. We further compared changes in fertility intentions during the COVID-19 pandemic between two groups: those who had reported delaying childbearing delay due to Zika, and those who did not report delaying childbearing, and tested for significance in differences using Pearson's chi-square statistics.

Logit regressions were used to test whether background and explanatory variables were significant predictors of changes in fertility plans. We considered each type of change (delay, reduce, accelerate, increase) separately using individual regressions for each survey wave (April-July 2018, May 2020, and November 2020). As respondents were only asked about downward revisions to childbearing intentions in 2018, and very few respondents indicated that they reduced childbearing (0.60%), only one type of change (delay) was explored for this wave. All regressions include background variables either as independent variables of interest or as controls.

Pseudo-sampling weights were constructed among respondents who completed the May 2020 follow-up survey, in order to obtain a more representative sample with respect to the age, racial, and educational distributions of the married female residents in this age range, based on published statistics from the 2015 General Household Survey conducted by the Singapore Department of Statistics.

Findings

Table 1 presents descriptive statistics for the background and explanatory variables. On average, wives were younger than husbands. Although wives were more likely to have a college degree compared to their husbands (around 50% compared to around 40%), only one third earned above of SGD 4,000 (USD 3,000) or higher compared to around 50% of husbands. Around 70% of wives were of Chinese ethnicity. Approximately half of couples had been married for 5 years or longer in 2018. Around one third of wives reported being highly satisfied with their marriages, which fell to less than one quarter during the pandemic. Unsurprisingly, the number of couples who had achieved their fertility ideals grew from around 20% in 2018 to around 35% in 2020.

Perceived probability of a Singaporean woman being infected with the Zika virus was lower on average in 2018, compared to probability of being infected with the coronavirus in May 2020 (under 0.25 compared to around 0.35). However, levels of anxiety about the virus, as well as stress and fatigue levels, were similar in both periods. Over 15% and over 20% of wives and husbands respectively suffered income loss during the pandemic.

[Table 1 about here]

Changes in fertility plans: delay and reduce

Table 2 presents the proportions of female respondents who reported changing childbearing plans due to the two epidemics. Across all survey waves, the proportions who reported delaying rather than reducing childbearing were higher. This is especially true in response to the Zika epidemic, with 7.5% indicating pushing back childbearing but only 0.6% of respondents stating that it affected their intended number of children. Hence, the preference to shift timing rather than quantum of childbirth reflects the intention to avoid childbearing specifically during a period of heightened disease-related risks. By contrast, when surveyed during the COVID-19 lockdown, over 15% indicated delaying childbearing, and more than 5% reported downward revisions in the intended number of children.

The stronger negative fertility responses to the pandemic may reflect two factors: first, the survey was asked during the height of the epidemic event itself, rather than one year afterwards, which may elicit stronger responses under a higher level of distress and uncertainty. Second, as noted, the COVID-19 outbreak differed in that while the risks of adverse health outcomes were arguably lower for pregnant women or in-utero children, the economic shock and disruption to daily lives were more wide-ranging and likely to be longer-lasting, resulting in a more permanent revision of planned family size. To weaken the influence of the first factor and hence focus on differences on behavioral responses to the two epidemics, we turn to survey responses collected in November 2020, six months after the end of the lockdown when movement restrictions were relaxed, the economy had seen a significant rebound (Ministry of Trade and Industry 2020) and the efficacy of at least one vaccine candidate had been confirmed (Pfizer 2020), leading to hopes that the end of the pandemic was in sight. During this more optimistic period, the proportions who reported delaying and reducing childbearing were similar to those reported in May, suggesting that the stronger negative fertility responses during COVID-19 may not simply be due to the length of time elapsed between the epidemic event and data collection.

[Table 2 about here]

Changes in fertility plans: accelerate and increase

Table 2 also shows the proportions of respondents who reported upward revisions in fertility plans in May and November 2020. While the proportions who stated that they planned to increase number of children remained stable at above 5%, more respondents reported wanting to accelerate childbearing as the pandemic wore on, from 2.4% in May to 6.6% in November. In both time periods, the proportions who planned to bring forward births were dwarfed by those who planned to delay them. Nevertheless, the responses reflect heterogeneity in responses, with respondents almost equally as likely to report wanting more versus wanting fewer children.

Selection into adjustment of childbearing plans: background variables

To look further into divergence of responses along household characteristics and socioeconomic dimensions, Tables 3 and 4 present multivariate results for upward and downward revisions in fertility respectively. Age was not a significant predictor of adjustment of childbearing plans during either epidemic. In addition, educational background and income levels were predictive of revisions in fertility plans during the pandemic, but not during the earlier disease shock. College educated wives were more likely to report delaying childbearing and less likely to report

increasing number of intended children during the lockdown in May 2020, while husband's college education was associated with reducing number of intended children during the same period, significant at the 5% level. Patterns by income levels are more gendered: women earning above-median wages were less likely to report delaying childbirth during the lockdown, while having a husband with above-median wages was associated with lower probability of accelerating childbirth in November 2020, significant at the 1% level. With the exception of husband's income, socioeconomic coefficients tend to be larger and significant only in May 2020, indicating stronger selection effects during the peak of the crisis that year.

Among household characteristics, achievement of fertility ideals was consistently significant and strongly indicated that, unsurprisingly, couples who had already met their fertility ideals were much less likely to report any changes to childbearing plans in either direction, compared to those who may still desire more children. Length of marriage was negatively associated with delaying childbirth during the lockdown, significant at the 5% level, while wife's marital satisfaction was not predictive of any type of change in fertility plans.

[Table 3 about here]
[Table 4 about here]

Selection into adjustment of childbearing plans: prior response to Zika

Tables 3 and 4 also present evidence on the potential accumulative effect of exposure to the Zika crisis prior to the COVID-19 pandemic. Respondents who had previously stated that they had already delayed childbearing due to Zika were both more likely to report delaying childbearing (odds ratio (OR) = 4.02) *and* to report accelerating childbearing (OR = 6.67) during the COVID-19 lockdown in May 2020, significant at the 5% level. Once again, the coefficients are smaller and insignificant six months after the lockdown, indicating weaker selection after the peak of the crisis.

There are a number of possible reasons why respondents who had reported delaying childbearing in 2018 were also more likely to report changes in childbearing plans in 2020: first, these individuals may be selected in terms of risk aversion or ambiguity towards having a child, leading to similar attitudes and responses towards both events. Second, as noted in the literature review, higher prior social exposure to Zika as reflected through behavioral responses may reinforce pregnancy-related concerns, increasing the propensity to avoid childbearing during the pandemic. Third, there may be an opposite accumulative effect where women who had previously already put off having a child may be less willing to do so again, and may perceive that the second crisis has pushed them into a 'now-or-never' situation. In support of this 'catch-up motive', we note that none of the respondents who had delayed childbearing due to the Zika epidemic reported an increase in number of intended children (as reflected by the missing coefficients in columns (3) and (4)). Hence, the results reflect a preference to shift the timing of childbearing forward, rather than any perceived conduciveness in childbearing conditions.

Explanations: infection fears, change in subjective wellbeing, and income loss

To explore the potential roles of three explanations for why women might choose to change fertility intentions: fear of infection, change in subjective wellbeing, and income loss, Figure 3 presents log odds for upward and downward revisions in fertility, controlling for individual and household covariates. While perceived probability of being infected by the virus was not a significant predictor, women who were more anxious about the virus during the Zika epidemic were more likely to state that they delayed childbearing (OR = 1.78, significant at the 1% level).

Female respondents' stress levels during the lockdown and husband's income loss after the lockdown were more likely to predict intending to have fewer children, significant at the 1% and 5% levels respectively.

[Figure 3 about here]

On the other hand, fear of being infected with the COVID-19 virus is associated with the decision to accelerate fertility: women who perceived higher risks of being infected during the lockdown and who were less anxious about the virus six months after the lockdown ended were more likely to report bringing forward childbearing, significant at the 1% and 5% levels respectively. While the results appear contradictory, it may be noted that although higher perceived risks may lead to greater anxiety, it can also produce a sense of urgency to have a baby before any impending health shocks occur . Unsurprisingly and consistent with the results in Table 4, women who reported income loss or higher fatigue levels were less likely to bring forward childbirth or increase number of intended children in November 2020, significant at the 5% level.

The results reflect the natures of the two epidemics, with the virus itself driving fear of adverse pregnancy outcomes during the Zika virus, whereas the coronavirus not only carried health risks, including mortality, but also unleashed heavier burdens on workers and parents due to the economic fallout, home isolation and an uncertain outlook for the future.

Self-reported delays vs. observed childbearing behavior

The above analysis focuses on self-reported changes in fertility plans. To assess whether these statements reflect changes in observed childbearing behavior, we checked whether the proportion who reported becoming pregnant between the May and November 2020 waves was indeed lower among respondents who reported that they planned to delay childbearing. Consistent with these stated intentions, only 5.1% of these women did so, compared to 9.1% of women who did not plan to delay childbearing. This difference is all the more remarkable given that couples who had already achieved their fertility ideals and hence less likely to contribute births tended to belong to the second group (see Table 3).

Discussion

This paper examines the back-to-back effects of two recent epidemics on the fertility decision making of the same group of women in Singapore, a highly affected but less-studied city state in Asia. Taking into account the close chronological order of the epidemics and the potential accumulative effect of exposure to the earlier Zika crisis, we examined whether the Zika epidemic may not only deepen concerns towards childbearing during the pandemic, but may also spur a subset towards accelerated childbearing due to a catch-up motive. We also contributed to the literature by presenting evidence for three explanations behind changes to fertility plans during both epidemics: fear of infection, change in subjective wellbeing, and income loss.

We found that the COVID-19 pandemic likely precipitated a larger negative fertility response, which may be due to the pandemic having far greater economic fallout and wider reaching disruption to everyday life within Singapore, casting a greater sense of uncertainty about the future. More respondents reported delaying or reducing childbearing compared to the Zika crisis, a result which persisted six months after the lockdown despite the improvements in economic conditions and the outlook for the pandemic. At the same time, the evidence suggests that the responses at least during the COVID-19 shock were heterogenous, with more than 5% stating that they planned to increase childbearing, and the proportion who reported wanting to accelerate childbearing

increasing as the event wore on. Unlike the case of HIV outbreaks, due to the relatively low coronavirus-related mortality rates among younger age groups, upward revisions in fertility intentions are unlikely to be due to a replacement or hoarding motive, but may reflect key consequences unique to the pandemic, such as the transition to remote work among a large proportion of workers, which may be seen as an opportunity to spend more time with any new offspring.

Consistent with this argument, the results suggest that while both spouses' college education were associated with negative fertility responses during the pandemic, the patterns by income levels were more gendered, with women earning above-median wages less likely to report delaying childbirth during the lockdown. Studies from Japan and Western countries consistently find that high income fixed-salary workers in permanent positions were more heavily shielded from the economic fallout, through greater job flexibility in terms of ability to perform tasks from home as well as more generous leave mandates (Adams-Prassl et al. 2020; Kikuchi, Kitao, and Mikoshiba 2021), and may hence be better placed to navigate changes in work-life balance. While our finding that more educated women were more likely to avoid childbearing during negative health shocks generally agreed with the literature (Marteleto et al. 2020; Rangel et al. 2020; Trinitapoli and Yeatman 2011), the effects were statistically significant only during the COVID-19 crisis. In contrast to other work (Durevall and Lindskog 2011; Gemmill and Hartnett 2020), we did not find significant differences by age, perhaps due to the sample's narrow age range.

A key advantage of this dataset is the ability to examine the potential accumulative effect of exposure to the Zika crisis prior to the COVID-19 pandemic, and our results indicate that married women who had previously taken steps to avoid childbearing during the Zika outbreak were both more likely to delay *and* to accelerate childbearing during the lockdown. The results provide some support for the 'scarring' effects arising from higher prior exposure to Zika (Marteleto, Dondero, and Koepp 2021; Marteleto, Dondero, and Maia 2021) on the one hand, as well as for an opposite accumulative 'catch-up motive' on the other hand, where women may be less willing to delay childbearing for a second time.

Our analysis also looked into differences in potential drivers of changes in fertility plans between the two epidemics: while anxiety about the virus was the only significant predictor of delayed childbearing during the Zika epidemic, changes in stress levels and income loss predicted downward revisions in childbearing plans during the pandemic, reflecting the latter's wider economic and social impacts in addition to health risks. Interestingly, perceived probability of being infected with the COVID-19 virus is associated with the decision to accelerate fertility while anxiety about the virus reduces the probability of doing so, in line with Trinitapoli and Yeatman (2011)'s work which found that perceived likelihood of HIV infection increases individuals' desire to avoid childbearing, but may also result in acceleration in order to maximize chances of having a healthy baby within a perceived limited window of good health.

This paper contributes to the growing literature on fertility changes in the wake of the COVID-19 pandemic (Aassve et al. 2020; Berrington et al. 2021; Levine 2020), and seeks to place these changes in relation to a key epidemiological event occurring at this time. We found a larger negative fertility response compared to a previous event, which largely persisted towards the end of 2020 despite improvements in economic conditions and the announcement of least one efficacious vaccine candidate. At the same time, there was a small but growing proportion of respondents who planned to accelerate childbearing as the pandemic wore on, and selection effects in terms of background characteristics and prior response to the Zika epidemic were weakened six months after the peak of the crisis during the lockdown.

Policy implications

The stronger fertility response to the pandemic carries serious demographic implications for Singapore, which like other high-income societies in Asia, has an extremely low fertility rate and rapidly aging population. Our survey data suggest that respondents who stated that they planned to delay childbearing during the lockdown were indeed less likely to become pregnant six months later, compared to other married women. Although most of these respondents indicated a preference to shift timing rather than quantum of childbearing, the literature suggests that long-term fertility rates may not necessarily recover from disease-induced short-term declines due to delayed fertility (Mizumoto and Chowell 2020). The results highlight the importance of effective public health management, which plays a crucial role in recuperating previous fertility levels (Wagner et al. 2020), and in the longer term, sustainable policies that can help families to gain amidst a potentially long-lasting movement towards working from home in light of poor pre-pandemic work-life balance in Singapore (Jones 2012, Tan 2021).

Study limitations

One of the most important limitations of the study is that the sample may not be nationally representative, due to non-probabilistic sampling and selective attrition over follow-up survey waves. While the use of pseudo design-based weighting increases its representativeness with respect to age, racial, and educational distributions of married women in this age range, it relies on the strong assumption that respondents are representative of non-respondents within these categories (Buelens et al., 2015), which may not be valid. A second data-related weakness is that whereas the baseline survey was conducted approximately one year after the end of the Zika epidemic, the follow-up surveys were completed during the COVID-19 epidemic event itself. Although the results suggest that fertility responses remained stable over time even after considerable improvements in social, economic and public health conditions, the differences in length of time elapsed between the epidemic event and data collection remains an important caveat. Third, while the questions about perceived infection risks, anxiety and subjective wellbeing are similarly worded in all surveys, questions about how the epidemics had affected childbearing were not identically phrased. In particular, respondents were not asked if they had revised their fertility intentions upwards during the Zika epidemic (as it had not occurred to us that a separate epidemiological event might follow), and the fertility questions in 2020 were phrased relative to the lockdown as a key event during the pandemic, whereas no analogous event occurred during the earlier shock. In addition, the measures of changes in fertility plans do not fully capture the nuances and complexities of family planning, including more ambiguous "wait and see" attitudes, which can be difficult to quantify.

Nevertheless, the insights may still be useful by allowing a comparison of how two epidemics affected the same group of individuals; whether responses to the initial shock led to spillover effects on reactions to a future unrelated crisis; and differences in factors that influenced changes to fertility plans. In addition, this study is one of very few that have examined the fertility impact of the two disease outbreaks in Singapore, yet the contextual differences make it important to include the experience of this less-studied region for a more complete picture of the global fertility impacts.

Conclusion

In countries already grappling with below-replacement fertility and aging populations, disease outbreaks may exacerbate demographic trends if public health interventions are not implemented in a timely manner (Nee 2016). While it remains to be seen how the ongoing pandemic will affect

long-term fertility levels, studies around the world strongly suggest that in response to the disruptions to work and life, including those due to measures to contain the disease, individuals have adjusted fertility behavior in order to accommodate these changes in their external circumstances (Aassve et al. 2020; Berrington et al. 2021; Levine 2020). Our paper contributes to the literature by contextualizing this response within other surrounding epidemiological events. It presents evidence of accumulative effects of exposure to the Zika crisis prior to the COVID-19 pandemic, and provides a comparative perspective effect that suggests a stronger role for stress and income loss during the pandemic in addition to infection fears, reflecting its wider economic and social impacts.

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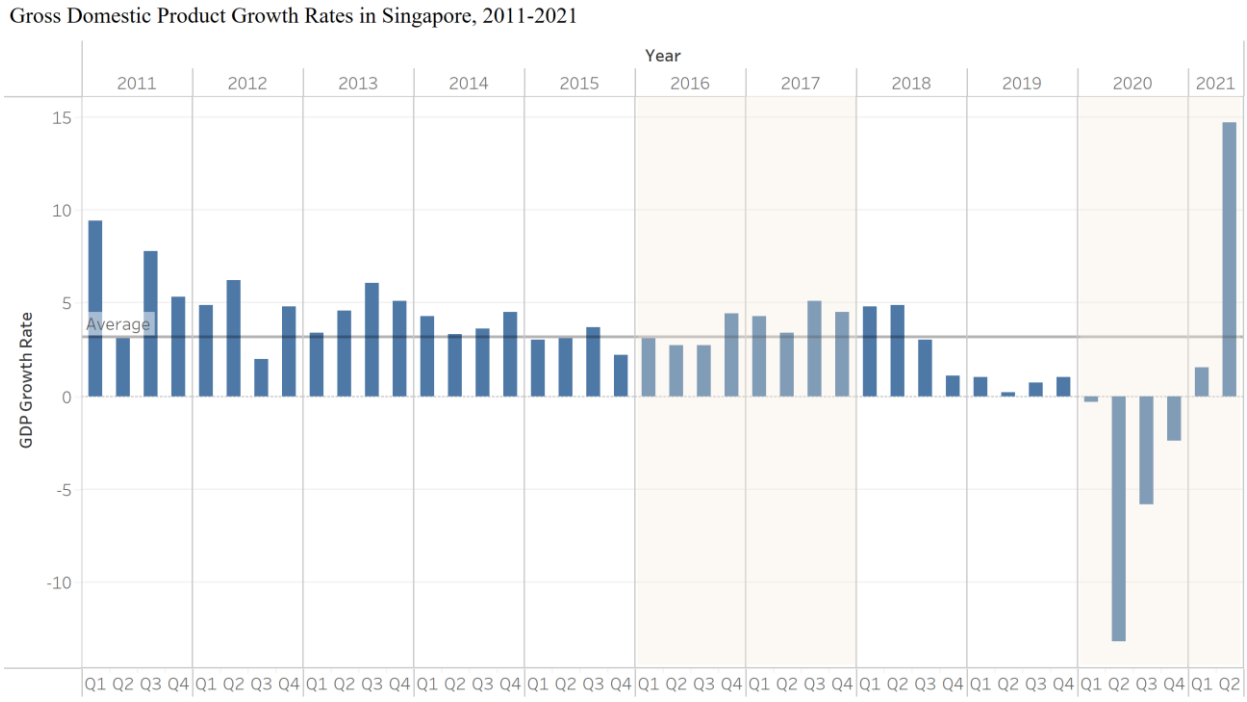
Figure 1: Gross Domestic Product growth rates in Singapore, 2011-2020Q2



Notes: Highlighted years indicate periods of exposure to the Zika (2016-2017) and COVID-19 epidemics (2020).

Figure 2: Timeline of data collection

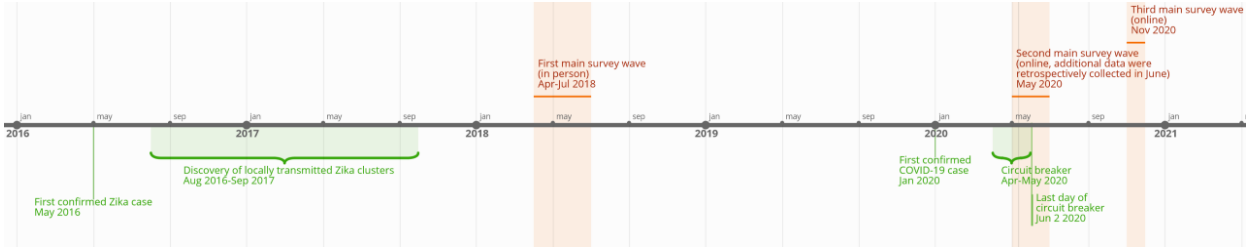
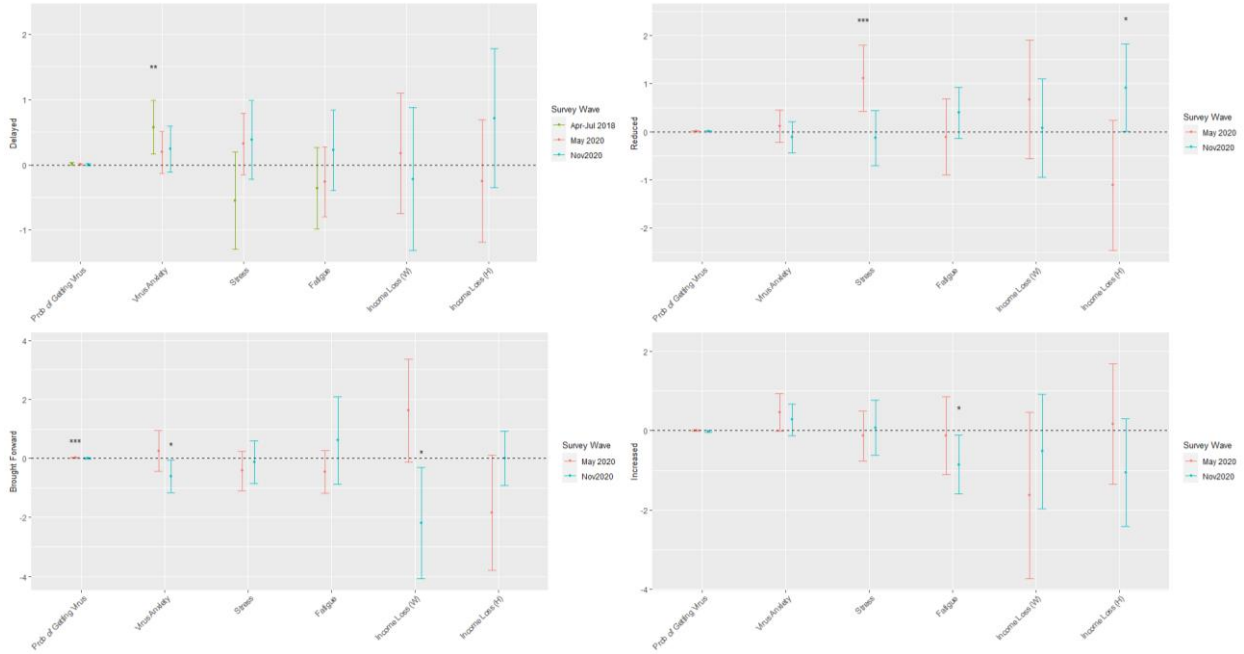


Figure 3: Potential explanations for revisions in fertility plans



Notes: Estimates are log odds and 95% confidence intervals adjusted using pseudo sample weights. W=Wife, H=Husband, C=Couple.
*** p<0.001, ** p<0.01, * p<0.05.

Table 1: Descriptive statistics

	Apr-Jul 2018	*May 2020*	*Nov 2020*
Individual characteristics			
Age>30 (W) (%)	60.68		
Age>30 (H) (%)	81.23		
Degree (W) (%)	49.58		
Degree (H) (%)	40.7		
Income>=4k (W) (%)	32.46	30.50	38.06
Income>=4k (H) (%)	53.92	53.64	60.21
Chinese (W) (%)	68.64		
Household characteristics			
Years married >=5 (C) (%)	53.51		
High marital satisfaction (W) (%)	35.55	23.04	16.22
Fertility ideals met (C) (%)	20.01	34.15	32.24
Explanatory variables			
Probability of getting virus (0-100) (W) (%)	22.61	35.92	34.72
Virus anxiety (1-5) (W)	3.31	3.39	3.05
Stress (1-5) (W)	3.52	3.54	3.44
Fatigue (1-5) (W)	3.96	3.99	3.94
Income loss (W) (%)	-	17.45	15.87
Income loss (H) (%)	-	21.71	21.43

Notes: Estimates adjusted using pseudo sample weights. Mean reported for continuous variables. W=Wife, H=Husband, C=Couple.

Table 2: Percent reporting change in fertility plans in response to epidemics

	Zika	**COVID-19**	
	Apr-Jul 2018 (year after epidemic)	May 2020 (during lockdown)	Nov 2020 (6 months post-lockdown)
Delayed (%)	7.46	16.61	17.31
Reduced (%)	0.62	6.45	8.53
Brought forward (%)	-	2.41	6.63
Increased (%)	-	6.78	7.54
N	407	407	345

Notes: Estimates adjusted using pseudo sample weights. Respondents were not asked if they brought forward or increased childbearing in response to the Zika epidemic.

Table 3: Downward revisions in fertility plans during epidemics

	Delay			Reduce	
	Apr-Jul 2018	May 2020	Nov 2020	May 2020	Nov 2020
	(1)	(2)	(3)	(4)	(5)
Age>30 (W)	-0.069	-0.135	-0.512	0.198	-0.004
	(0.702)	(0.402)	(0.571)	(0.502)	(0.477)
Age>30 (H)	0.110	0.440	0.139	-0.346	0.439
	(0.697)	(0.452)	(0.593)	(0.511)	(0.550)
Degree (W)	-0.466	1.328*	-0.126	-0.090	0.254
	(0.528)	(0.517)	(0.586)	(0.611)	(0.505)
Degree (H)	-0.249	-0.179	-0.020	1.540*	0.635
	(0.523)	(0.443)	(0.535)	(0.715)	(0.467)
Income>=4k (W)	-0.019	-1.202**	-0.578	-0.535	-0.356
	(0.477)	(0.455)	(0.562)	(0.477)	(0.437)
Income>=4k (H)	0.161	-0.212	0.007	0.105	0.768
	(0.738)	(0.494)	(0.487)	(0.461)	(0.512)
Chinese (W)	0.063	-0.218	-0.959	1.826	
	(0.742)	(0.468)	(0.539)	(1.099)	
Years married >=5 (C)	0.521	-0.872*	-0.237	-0.076	-0.432
	(0.640)	(0.409)	(0.505)	(0.449)	(0.433)
High marital satisfaction (W)	-0.034	-0.523	-0.151	-1.198	-1.248
	(0.696)	(0.520)	(0.562)	(0.720)	(0.647)
Fertility ideals met (C)	-0.769	-1.896***	-1.333*	-0.914*	-0.417
	(0.597)	(0.480)	(0.554)	(0.458)	(0.477)
Delayed due to Zika		1.391*	0.595	0.021	-2.074
		(0.574)	(0.732)	(0.655)	(1.060)
Constant	-2.561***	-1.302**	-0.111	-4.417***	-3.075***
	(0.629)	(0.500)	(0.574)	(1.180)	(0.604)
N:	407	397	345	397	345
Pseudo-R^2:	.03	.18	.12	.16	.08

Notes: Estimates adjusted using pseudo sample weights. Standard errors in parentheses.
W=Wife, H=Husband, C=Couple. Race omitted for (5) as it perfectly predicts the outcome.
*** p<0.001, ** p<0.01, * p<0.05.

Table 4: Upward revisions in fertility plans during epidemics

	Bring forward		Increase	
	May 2020	Nov 2020	May 2020	Nov 2020
	(1)	(2)	(3)	(4)
Age>30 (W)	-1.170	-0.181	0.788	-0.535
	(0.910)	(0.894)	(0.841)	(0.566)
Age>30 (H)	1.638	-0.367	1.093	0.903
	(0.899)	(0.944)	(0.991)	(0.677)
Degree (W)	-0.665	-0.837	-1.235*	-0.072
	(0.602)	(0.720)	(0.581)	(0.775)
Degree (H)	1.082	-0.691	0.497	-0.016
	(0.899)	(0.621)	(0.750)	(0.556)
Income>=4k (W)	-1.022	0.295	0.982	-0.907
	(0.679)	(0.611)	(0.736)	(0.620)
Income>=4k (H)	0.051	-1.709**	-0.884	-0.603
	(0.984)	(0.624)	(0.777)	(0.427)
Chinese (W)	0.475	-0.658	-1.785	0.381
	(1.250)	(0.583)	(1.075)	(0.654)
Years married (C)	-0.676	-0.084	0.327	-0.896
	(0.625)	(1.094)	(0.671)	(0.523)
High marital satisfaction (W)	-0.295	0.969	-0.165	-1.023
	(1.006)	(0.786)	(0.749)	(0.750)
Fertility ideals met (C)	-0.111	-1.728	-0.227	-2.329***
	(0.669)	(0.954)	(0.816)	(0.658)
Delayed due to Zika	1.897*	1.421		
	(0.817)	(0.901)		
Constant	-4.743***	-0.834	-2.775**	-1.667*
	(1.210)	(1.044)	(0.869)	(0.690)
N:	397	345	397	345
Pseudo-R^2:	.12	.24	.17	.14

Notes: Estimates adjusted using pseudo sample weights. Standard errors in parentheses. W=Wife, H=Husband, C=Couple. Delayed due to Zika omitted for (3) and (4) as it perfectly predicts the outcome.

*** p<0.001, ** p<0.01, * p<0.05.

Appendix

Questionnaire Survey Items on Zika Virus (April – July 2018)

1. To the best of your ability, estimate the probability of the following happening: [FOR EACH OF THE FOLLOWING STATEMENTS, INSERT A PERCENTAGE FROM 0% TO 100%]

		Percentage
1	Probability that a Singaporean woman will be infected by the Zika virus	

2. On a scale of 1 to 5, where 1 is very anxious at all and 5 is not anxious at all, how anxious would you say you are about getting infected by the Zika virus?

Very anxious				Not anxious at all
1	2	3	4	5

3. Has the Zika virus ever affected your decision to have children in any way?

1	Yes	2	No [SKIP Q4]

4. How has it affected your decision to have children? [MULTPLE ANSWERS]

1	Delayed childbearing
2	Decided to have fewer children

5. Think about your life in general for a few seconds. In general, how would you rate the stress level in your life?

Very relaxed	5
Quite relaxed	4
Neither relaxed nor stressful	3
Quite stressful	2
Very stressful	1

6. In general, how tired do you feel?

Not tiring at all	5
Not tiring	4
Average	3
Quite tiring	2
Very tiring	1

7. What is you/your husband's monthly personal income?

	7. Self	8. Husband
No income	1	1
Less than $1,000	2	2
$1,000 to $1,999	3	3
$2,000 to $2,999	4	4
$3,000 to $3,999	5	5
$4,000 to $4,999	6	6
$5,000 to $5,999	7	7
$6,000 to $6,999	8	8
$7,000 to $7,999	9	9
$8,000 to $8,999	10	10
$9,000 to $9,999	11	11
$10,000 or more	12	12

Questionnaire Survey Items on COVID-19 (May 2020)

1. In general, how would you rate how stressed you are in the past two weeks?

1	Very stressed
2	Quite stressed
3	Average
4	Not stressed
5	Not stressed at all

2. In general, how would you rate how tired you are in the past two weeks?

1	Very tiring
2	Quite tiring
3	Average
4	Not tiring
5	Not tiring at all

3. In general, how much has the following been affected by the circuit breaker? Childbearing intentions. Please select all that apply.

1	Brought forward childbearing
2	Decided to have more children
3	Delayed childbearing
4	Decided to have fewer children
5	No change

4. To the best of your ability, estimate the probability: **[INSERT A PERCENTAGE FROM 0% TO 100%]** Probability that a Singaporean woman will be infected by the coronavirus

5. On a scale of 1 to 5, where 1 is very anxious and 5 is not anxious at all, how anxious would you say you are about getting infected by the coronavirus?

1	Very anxious
2	2
3	3
4	4
5	Not anxious at all

Questionnaire Survey Items on COVID-19 (November 2020)

1. In general, how would you rate how stressed you are in the past two weeks?

1	Very stressed
2	Quite stressed
3	Average
4	Not stressed
5	Not stressed at all

2. In general, how would you rate how tired you are in the past two weeks?

1	Very tiring
2	Quite tiring
3	Average
4	Not tiring
5	Not tiring at all

3. How much has the following changed, **compared to <u>before</u> the circuit breaker**?
Childbearing intentions - **Currently**

1	Brought forward childbearing
2	Decided to have more children
3	Delayed childbearing
4	Decided to have fewer children
5	No change

4. To the best of your ability, estimate the probability: **[INSERT A PERCENTAGE FROM 0% TO 100%]** Probability that a Singaporean woman will be infected by the coronavirus

5. On a scale of 1 to 5, where 1 is very anxious and 5 is not anxious at all, how anxious would you say you are about getting infected by the coronavirus?

1	Very anxious
2	2
3	3
4	4
5	Not anxious at all