Gendered Infant Mortality in the Year of the Fire Horse

David Ernst*

Graduate School of Economics, Kyoto University

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Abstract

This study examines the impact of social norms on gendered infant mortality by analyzing an exogenous, temporary shift in child-specific sex preferences during 1966 in Japan when female children were considered less desirable due to the Fire Horse superstition. Using a newly compiled dataset and an event study design, I estimate an effect of 1,747 excess female infant deaths, representing 16.6% of all female infant mortality in the birth cohort. This effect is evident nationwide in both rural and urban areas and especially pronounced in regions around the Seto Inland Sea, where excess female infant mortality accounts for up to half of all female infant deaths in the most severely affected prefectures. Decomposing infant mortality by cause and location of death suggests that differential neglect, rather than deliberate infanticide, primarily drives the observed gendered mortality gap.

Keywords: Gender Inequality; Discrimination; Infant Mortality; Fire Horse.

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*Address: Graduate School of Economics, Kyoto University, Yoshida-Honmachi, Sakyo-Ku, Kyoto, 606-8501, Japan, e-mail: *davidernst.321@gmail.com*

1 Introduction

Since Amartya Sen's seminal "100 Million Missing Women" statement Sen (1992), significant advances in healthcare and societal awareness have been achieved. Yet, disparities in prenatal and early childhood mortality across gender lines persist, underscoring the enduring influence of deeply rooted social and cultural norms Almond et al. (2013). These inequalities represent a fundamental challenge to gender equality and development Duflo (2012), driven primarily by two key factors: sex-selective abortion and gendered infant mortality. While the effects of social norms on sex-selective abortion are well-documented, particularly in the contexts of India and China Jayachandran (2017), the drivers of gendered infant mortality remain less understood. The multidimensional nature of gendered infant mortality—encompassing individual behaviors, cultural expectations, and medical developments—makes disentangling the effects of social norms particularly challenging Qian (2008).

One of the main obstacles to understanding the relationship between gender norms and gendered infant mortality is the difficulty of identifying short-term changes in these norms within a causal framework. Social norms are often deeply entrenched and slow to evolve, limiting opportunities for causal identification. I propose to measure the impact of child-specific sex preferences on gendered infant mortality by leveraging a temporal shift in social norms stemming from the Fire Horse superstition in Japan in 1966. According to this superstition, women born in the Year of the Fire Horse are believed to bring misfortune and discord to their families Hashimoto (1974). This belief led to a sharp decline in birth rates, from 2.1 children per woman in 1965 to 1.6 in 1966 1, as families chose to delay or avoid childbirth altogether.

In this study, I exploit this unique historical context to measure the impact of short-term changes in child-specific sex preferences on gendered infant mortality. Using a novel dataset and an event study design, I estimate that excess female infant mortality during the Year of the Fire Horse accounted for 1,747 deaths, representing 16.58% of all female infant deaths in the 1966 birth cohort. The treatment-switch nature of the Fire Horse effect enables

a relaxation of the conventional parallel trends assumption to a linear trend assumption. Under this framework, the robust linear trends estimate suggests that excess female infant deaths in 1966 range from 1,070 (under the average parallel trends violation) to 851 (using the upper bound robust estimator).

While the effect is observed nationwide across both rural and urban areas, it is particularly pronounced in regions surrounding the Seto Inland Sea, where excess female infant mortality accounts for up to half of all female infant deaths in the cohort in the most severely affected prefectures. A decomposition of infant mortality by cause and place of death further suggests that neglect—rather than deliberate gendered infanticide—drives the observed gendered mortality effect. These findings highlight the profound influence of social norms on gendered infant mortality and underscore the importance of integrating social norms into policy frameworks aimed at reducing gender disparities.

The remainder of the study is organized as follows. Chapter 2 provides an overview of the Fire Horse Year in Japan and the broader literature on postnatal gendered mortality. Chapter 3 describes the dataset and presents descriptive statistics. Chapter 4 outlines the main empirical strategy for analyzing gendered infant mortality in 1960s Japan, with results and robustness checks discussed in Chapter 5. Chapter 6 offers a discussion of the underlying mechanisms driving the observed effects, followed by concluding remarks in Chapter 7.

2 Background and Literature

2.1 Background

The "Year of the Fire Horse" (hinoe uma in Japanese) is the 43rd combination in the sexagenary cycle, which pairs 12 zodiac animals with five elements. This specific combination, the Horse and the element Fire, recurs once every 60 years—most recently in 1966, with previous occurrences in 1906, and 1846, and the upcoming one in 2026. In Japan, a unique superstition surrounds this year: women born in a Fire Horse year are believed to

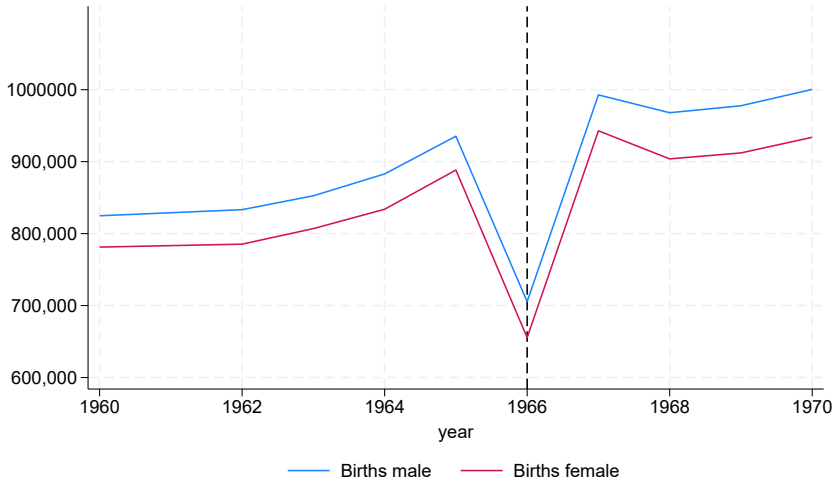


Figure 1

Total number of births by gender in 1960s Japan

possess bad personality traits, cause marital discord, and bring misfortune to their families Azumi (1968) Hashimoto (1974). Notably, this belief applies exclusively to women; there are no superstitions regarding men born in a Fire Horse year. Though rooted in the broader Chinese zodiac system, Japan adopts the Western calendar, with the year beginning on January 1st and ending on December 31st, rather than aligning with the lunar calendar. While the Chinese zodiac and its associated beliefs, such as the Year of the Dragon Lau (2019), Agarwal et al. (2021) and the Year of the Horse in Korea Lee and Paik (2006), are widely recognized across East and Southeast Asia, the superstition surrounding Fire Horse Women is a uniquely Japanese phenomenon Kaku and Matsumoto (1975). Regarding pregnancy and birth control in 1960s Japan, fertility control was the primary method of contraception, and abortion was widely accessible. The relevant statistics will be examined in Chapter 3.1.

2.2 Literature

This paper contributes to the literature on the effects of child-specific sex preferences, particularly son preferences over daughters, on gendered infant mortality. The impact of son preferences can manifest through both direct and indirect mechanisms. Directly, dispro-

portionately high female infant mortality rates may result from abandonment or violence. Indirectly, neglect plays a significant role, with female infants receiving fewer resources, such as less frequent medical visits, cheaper or no medication, and reduced breastfeeding Jayachandran and Kuziemko (2011).

A key challenge in studying the effects of child-specific sex preferences on gendered infant mortality within a causal framework is the persistent nature of these preferences. While changes in social norms can shift these preferences, in the long run, Jensen and Oster (2009), short-term changes in these norms are scarce. Though Qian (2008) and Almond et al. (2019) discuss the impact of exogenous shocks on gendered infant mortality, their studies focus on shifts in economic conditions rather than changes in child-specific sex preferences themselves.

In this context, the Year of the Fire Horse presents a unique opportunity to examine a temporary disruption in child-specific sex preferences in 1966, which reverted in 1967. This natural experiment allows for isolating the impact of these preferences on gendered infant mortality. To the best of the author's knowledge, this study is the first to investigate the causal effects of a short-term shift in social norms—specifically, child-specific sex preferences—on gendered infant mortality.

Regarding the broader literature on son preference and its relationship to sex-selective abortion DasguptaSharma2022, although abortion was legally available in Japan in 1966, the absence of pre-birth sex detection at the time precluded gendered abortion effects during the Year of the Fire Horse. However, this phenomenon may reemerge as a significant topic in the next Fire Horse year 2026, with the advent of modern prenatal technologies.

Additionally, this research contributes to the literature on the socioeconomic and cultural impacts of superstitions, particularly those surrounding the Fire Horse year. Akabayashi (2008) and Yamada (2013) examine the long-term outcomes for women born in Fire Horse years, finding no adverse effects on labor market outcomes or marriage prospects. Other research, including Rohlfs et al. (2010), compares the historical effects of different Fire Horse years on birth rates, noting similar birth shocks in 1906 and 1846.

3 Data

To carry out the empirical analysis to test whether the Fire Horse year impacted gendered infant mortality, I constructed a novel dataset focusing on prenatal, birth, and infant mortality data in 1960s Japan. The core of this dataset is drawn from the Japanese Vital Statistics Yearbook[1], which provides monthly, prefecture-level data. These yearbooks are available only as scanned documents (see example Table 1) and the relevant data was extracted using a deep learning-based image analysis tool tailored to Japanese yearbook statistics developed by Arimoto (2022). I supplemented this dataset with abortion data sourced from the Maternal Protection Statistical Report (Eugenic Protection Statistical Report[2]) and additional information on medical infrastructure and demographic variables from the Japan Statistical Yearbook[3].

3.1 Child Avoidance and Birth in 1960s Japan

To gain a comprehensive understanding of the key prenatal and postnatal birth indicators around the Fire Horse year in 1960s Japan, it is essential to consider the various stages through which families might have sought to avoid having a female child, including birth control, abortion, and other decisions. As discussed in Chapter 2.1, prenatal sex detection or similar measures were not available at the time. Thus, while avoiding female children motivated many families' decisions, the prenatal measures themselves do not contain a gendered component associated with the Fire Horse year.

Starting with the first measure of child avoidance, birth control, Figure 1 presents the total number of pregnancies in Japan during the 1960s. The figure illustrates the overarching trends and highlights significant deviations in the number of pregnancies leading up to, during, and after the Fire Horse year. This trend indicates that birth control played a substantial role in shaping birth outcomes during this period.

[1] www.mhlw.go.jp/toukei/list/81-1.html
[2] www.mhlw.go.jp/toukei/list/botaihogo.html
[3] https://d-infra.ier.hit-u.ac.jp/English/govstat-database/statistical-yb/index.htmll

The second measure of child avoidance involves abortion. To delve deeper into this aspect Figure 2 examines abortion rates alongside other prenatal characteristics, including fetal deaths. While the absolute number of abortions did not deviate significantly from the trend, the abortion-to-birth ratio experienced a marked increase in 1966, underscoring the intensified use of abortion as a measure to avoid births during this year. Following the birth of a child in the Fire Horse year, the first gendered effect concerns deliberate gendered birth date manipulation. In this regard, Figure **??** highlights changes in the male-to-female birth ratio during the transitions from 1965 to 1966 and from 1966 to 1967. These shifts suggest deliberate gendered birth date manipulation to avoid the birth of a female child being registered in the Fire Horse year. Nevertheless, these register manipulation measures only concern a minor share of the overall births in the Fire Horse year. Hence, these measures are not visually visible or statistically detectable on a yearly level.

Figure 4 shows key birth indicator developments in 1960s Japan. The main takeaways in this regard are: a major decline in the number of births in 1966 for both genders with a full back-to-trend recovery in 1967 and a countrywide birth decline for all prefectures with no strong regional tendencies. Decomposing the main birth statistics by age cohort of the mother and birth order in Figure 5 reveals that the birth shock impacted all age cohorts. However, there was a sharp increase in the rate of firstborn children in 1966, indicating that child avoidance measures were more commonly employed by families who already had one or more children at the time.

3.2 Infant mortality

Infant mortality is defined as the death of a child under one year of age. This measure inherently mixes year effects, as infant deaths in any given year partly include those of children born in the preceding year. This is especially relevant when considering infant mortality rates and addressed through various adjustments in the analysis. Figure 6 illustrates the trends in infant mortality by gender. Both absolute and relative infant mortality

rates (infant deaths per birth) exhibit a declining trend over the observation period, with male infant mortality consistently higher than female mortality in both measures. However, during the Year of the Fire Horse, a distinct pattern emerges: absolute infant mortality declines for both genders, while relative infant mortality increases. The monthly breakdown of infant mortality by gender further highlights the seasonality of infant deaths during this period. Additionally, the trend in neonatal deaths—those occurring within the first four weeks of life—demonstrates that early infant deaths are a significant driver of the overall infant mortality trend.

4 Empirical strategy

The main empirical approach is to estimate the effect of the social norm shift caused by the Fire Horse year on gendered infant mortality by the following linear panel model with dynamic treatment effects:

$$Y_{igt} = \sum_{s=1963}^{1968} \beta_s \times 1[t = s] \times D_{ig} + \phi_i + \rho_g + \lambda_t + \epsilon_{igt}, \tag{1}$$

where Y_{igt} is the number of infant deaths for prefecture i and gender g in year t; D_{ig} is an indicator for gender (female = 1) in prefecture i; and ϕ_i, ρ_g, and λ_t are prefecture, gender, and year fixed effects. The coefficient β_{1965} is normalized to 0; standard errors are clustered at the prefecture level. As discussed in the previous chapter, infant mortality is defined as death below one year of age. Thus, the Fire Horse infant mortality effect will be captured both in β_{1966} and in β_{1967}.

5 Estimation results

5.1 Main results

Plotting the estimates of Equation (1), Figure 2 illustrates how gendered infant mortality evolves around the year of the Fire Horse. The figure illustrates four points. First, there is no significant pre-treatment trend in gendered infant mortality. Second, the Fire Horse year 1966 is associated with a relative increase in female infant mortality of around 22 excess female infant deaths per prefecture. Third, 1967 exhibits an effect of excess female infant mortality, though smaller than in 1966. This is in line with the prediction as by construction of the dataset, infant deaths of the Fire Horse cohort who died below the age of one but in 1967 are captured here. Fourth, there is no significant evidence of an effect in 1968 when all children of the Fire Horse cohort were at least one year of age. As for the magnitude of the effect, the estimates of β_{1966} and β_{1967} for 46 prefectures (excluding Okinawa) sum to an excess female infant mortality of overall 1,747 for the Fire Horse Cohort. The data allows to recover all male and female infant deaths for children born in 1966. Using this approach the excess female infant mortality associated with the year of the Fire Horse is 16.58% of the overall female infant mortality of the cohort.

5.2 Regional variation

Consider estimating a model of the form of Equation (1) for each prefecture, Figure 3a plots the β_{1966} and the respective effects expressed in the percentage of overall female infant mortality in 1966. For example, a value of 180 on the x-axis for Tokyo represents 180 excess female infant deaths in 1966. The corresponding y-value of approximately 18% indicates that these 180 excess deaths accounted for around 18% of Tokyo's total female infant mortality in 1966. Figure 3b maps these percentages of excess female infant mortality in 1966 across Japan. The figures reveal that, while there is no clear regional trend, the prefectures around the Seto Inland Sea exhibit higher relative effects. In particular, excess female mortality in

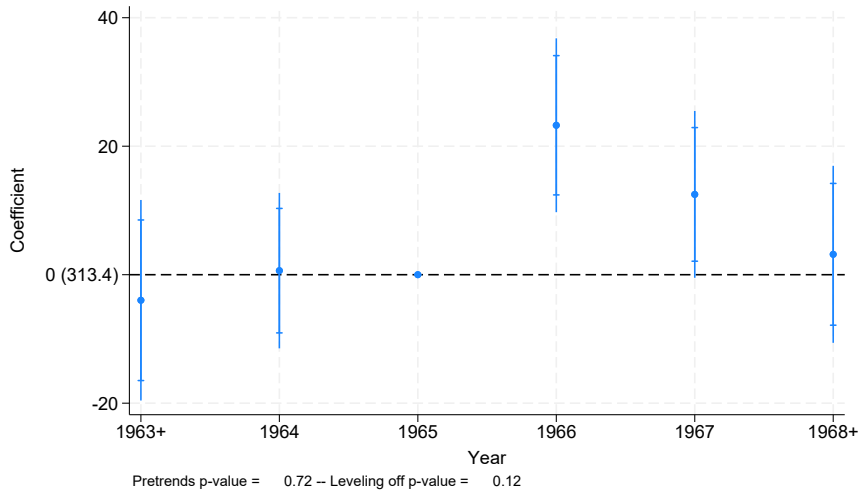


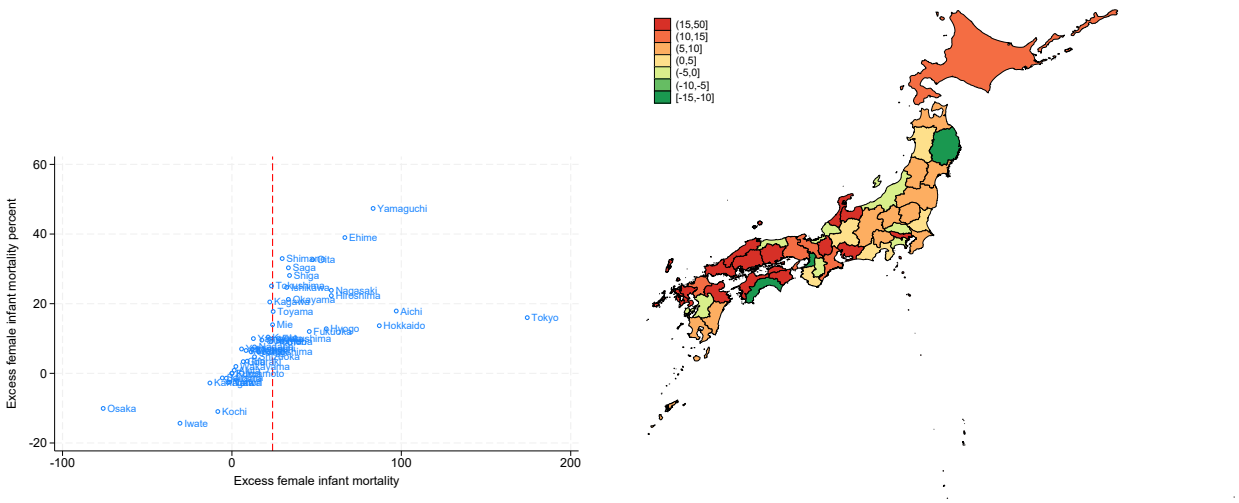
Figure 2

Event-study coefficients $\{\beta_s\}$ for gendered infant mortality, estimated using the event-study specification in (1)

Yamaguchi and Ehime is as high as 47% and 39%, respectively, meaning that the excess female infant mortality accounts for nearly half of the total female infant mortality in those prefectures for that year. Regarding the two major urban prefectures, Tokyo shows an above-average excess female infant mortality shock, while Osaka, in contrast, exhibits a negative shock, indicating disproportionately higher male infant mortality. While these estimates are already striking, it is important to note that the 1966 infant mortality statistics also include children born in 1965, when there were more births. As a result, the actual percentage figures for the cohort are even higher. Further, plotting the estimates of Equation (1) separately for urban and rural populations, Figure 1 illustrates that the effect is evident both in urban and rural areas with smaller absolute effects for rural areas which is, however, in line with the population and number of births differences.

5.3 Robustness

Following the discussion on the Fire Horse effect on gendered infant mortality is the Adjusting the event study results for robust confidence intervals Rambachan and Roth



(a) Prefectural Effects on Gendered Infant Mortality

(b) Regional Variation in Gendered Infant Mortality

Figure 3

Effects on gendered infant mortality regional variation. Panel (a) shows the event-study coefficients β_{1966} for gendered infant mortality by prefecture, estimated using the event-study specification in (1) on the x-axis, and on the y-axis divides the respective estimates by the total number of female infant deaths in 1966 for each prefecture. Panel (b) translates the negation of the y-axis of Panel (a) to the map of Japan.

(2023), Figure 3 shows the breakdown value for a significant effect is $\overline{M} \approx 1.5$, indicating the effect in 1966 is robust to allowing violation of parallel trends up to 1.5 as big as the max violation in the pre-treatment period.

However, imposing a greater post-treatment violation of parallel trends $\overline{M}$, would inevitably lead to a contradiction concerning the effect of β_{1968}. In this case, the estimates of β_{1968} would imply a gendered infant mortality shock for boys in the 1968 cohort, illustrated in Figure 4. Given all children of the Fire Horse cohort were at least one year of age in 1968, there is no reasonable explanation for such a reverse effect. Thus, in contrast to the existing literature, assuming no effect in 1968 allows to compare the Fire Horse effect against the linear trend that would lead to the observed effect in 1968. Figure 5a plots the gendered infant mortality event study estimates against the parallel trends violation assuming no effect in 1968. The observed gendered trend is slightly upward-sloping resulting in the estimates of 3.17 for β_{1968}. This trend adjustment reduces the Fire Horse effect β_{1968} from 23.26 excess

female infant deaths per prefecture (∼1070 national) to 22.17 (∼1019).

In addition to the average violation in parallel trends, the treatment switch design allows to define an upper bound based on the confidence interval enclosed by the β_{1968} estimates. In that case, the upper confidence bound of β_{1968} is 14.28. The resulting adjusted upper bound trend violation is illustrated in Figure 5b. Compared to the previous specifications, the parallel trends upper bound adjusted effect β_{1966} reduces to 18.5 (∼851) but remains significant and considerably high. Thus, assuming no effect in 1968 allows to soften the common parallel trends assumption to a linear trends assumption. In other words, the estimated Fire Horse effect on gendered infant mortality in 1966 is robust against any linear parallel trends violation.

In addition to linear trend violation, Figure 6 shows the least wiggly part that would be needed to ensure no significant effect in the post-treatment period Freyaldenhoven et al. (2021). The wiggly confounding dynamics required to explain the event-time path of the outcome make it implausible that a confound is driving the observed effects. This strengthens the case that the Fire Horse superstition indeed has a causal impact on gendered infant mortality. The results are furthermore robust against: restricting to neonatal deaths, 1964 as the base period, omitting December and January in case of potential manipulation effects, and excluding major cities 7.

5.4 Confounding effects

Besides the parallel trends violation, the most natural concern of an event study specification is concurrent effects. This would, for instance, concern a temporal disease outbreak that disproportionally affects female infant mortality. I address this concern in two ways. First, modify the main specification Equation (1), changing the outcome from infant deaths to child deaths from 1-2 years of age. Figure 2 shows the event study estimates of the 1-2 year gendered child death specification. The Figure illustrates no gendered effect during the Fire Horse year and a slight positive effect in 1967 which also includes Fire Horse cohort

children.

While this supports the main results, early childhood mortality (ages 1–2) and infant mortality (under 1 year) can differ significantly in their causes and trajectories, meaning this approach remains insufficient to fully address concerns about concurrent effects. Therefore, the second approach examines a different dimension of the data. The vital statistics dataset includes national-level mortality data by year of birth and gender, which I leverage in the following modified event study specification with dynamic treatment effects:

$$Y_{gbmt} = \sum_{s=1963}^{1968} \beta_s \times 1[t = s] \times D^1_{gm} \times D^2_{bm} + \cdots + \epsilon_{gbmt}, \tag{2}$$

The new index b indicates whether infant deaths occurred in the year the infants were born. Thus, Y_{gbmt} is the number of infant births for gender g, birth year death indicator b, month m, and year t. Treatment indicator D^1_{gm} is again the gender indicator equal to 1 for female infant deaths in month m; D^2_{bm} is the birth year death indicator equal to 1 for infant deaths that occurred in the year the infants were born and month m. The specifications further include gender, birth year death indicator, year, and their respective interaction fixed effects. The specification is at the national monthly level, as the vital statistics dataset does not include this dimension at the prefecture level.

Figure 4 shows the estimates of (2). The estimates illustrate that there is an excess of female infant mortality in 1966 for the infants actually born in the Fire Horse year compared to the infants, born in 1965. This indicates that being born in the Fire Horse year is associated with higher gendered infant mortality, rather than being driven by other unobserved confounders that may have influenced gendered infant mortality in 1966. Comparing the estimates from (2) with the main specification shows that $\beta_{1968} \times 12$ (months) results in 1,103 excess female infant deaths, which is very close to the estimated effect of 1,080 excess female infant deaths in 1966 from the main specification.

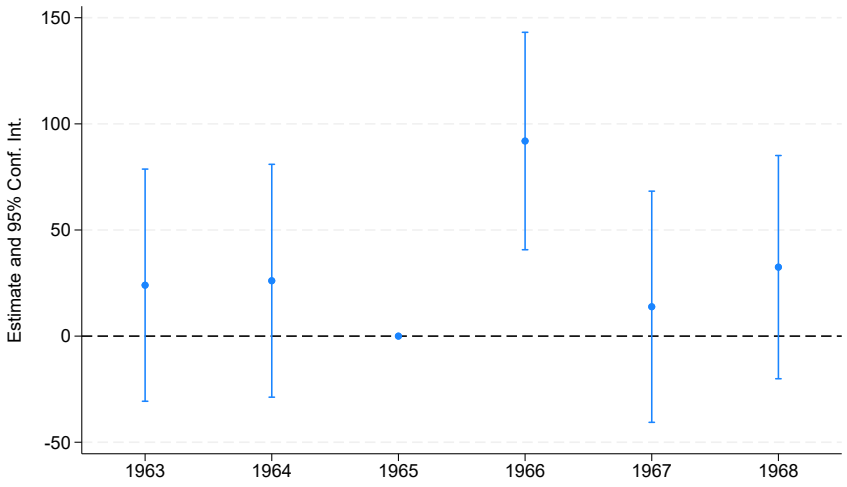


Figure 4

Gendered infant mortality × year of birth. Event-study coefficients $\{\beta_s\}$ for gendered infant mortality, estimated using the event-study specification in (2)

5.5 Selection effects

While the previous specification accounts for confounding effects in 1966, it does not directly examine the Fire Horse birth cohort and, therefore, does not address the nature of the gendered infant mortality shift itself. There are two possible explanations. First, the observed gendered effects are caused by the temporal change in sex-selective child preferences as previously discussed. Second, during Fire Horse year there is a higher share of children born in families where female infant mortality is more likely while the change in child-specific sex preferences themselves did not have an influence. Following this reasoning, the excess female infant mortality is a result of selection rather than preference change, caused by the 1966 cohort not being representative of a regular birth cohort.

To address this concern, Figure 5 plots the percentage excess female infant mortality against the year-over-year change of births during the Fire Horse year. If the Fire Horse effect is selection rather than a preference change, a higher year-over-year change in births (birth drop) should be associated with a higher excess female infant mortality. However, Figure 5 illustrates a higher drop in births during the Fire Horse year does not result in a higher

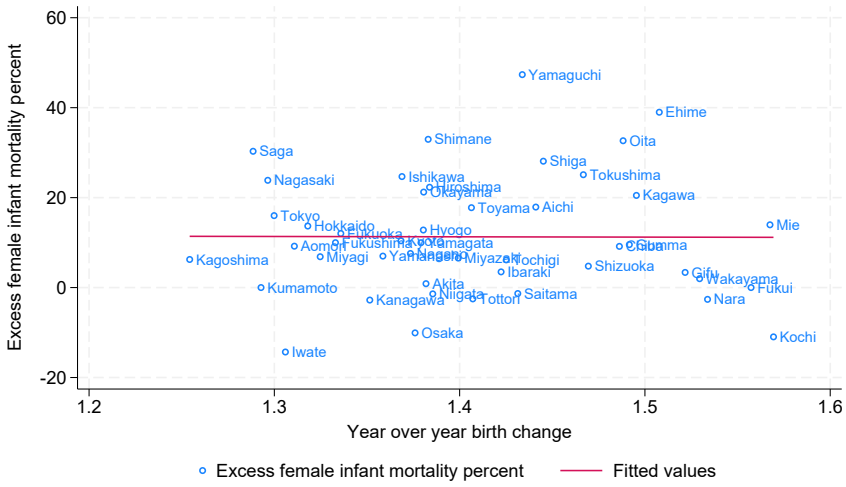


Figure 5

Gendered infant mortality and year-over-year birth change in 1966. The graph plots the year-over-year birth changes $(1966_{\text{births}} \times 2)/(1965_{\text{births}} + 1967_{\text{births}})$ for each prefecture on the x-axis against the event-study coefficients β_{1966} for gendered infant mortality by prefecture, estimated using the event-study specification in (1) and divided by the number of female infant deaths in 1966 for each prefecture on the y-axis.

gendered infant birth effect, which is a strong argument against the selection hypothesis.

6 Drivers of excess female infant mortality

Focusing on potential drivers of the effect, as discussed in Chapter 2.1, there are two potential mechanisms: infanticide and neglect. First, as for infanticide, the vital statistical yearbook contains data on the cause of death of infants. Figure 6 plots the estimates of Equation (1) when restricting the sample to infant deaths that can be associated with active infanticides such as violence and poisoning. The figure illustrates no indication of active gendered infanticide associated with the year of the Fire Horse.

Second, as for disproportion neglect of female infants associated with Fire Horse year, the dataset furthermore contains information on the place of death of infant deaths. Here the data allows to separate the infant deaths into two categories, infants who died in a medical institution and infants who died at home. The hypothesis is that, in case of neglect,

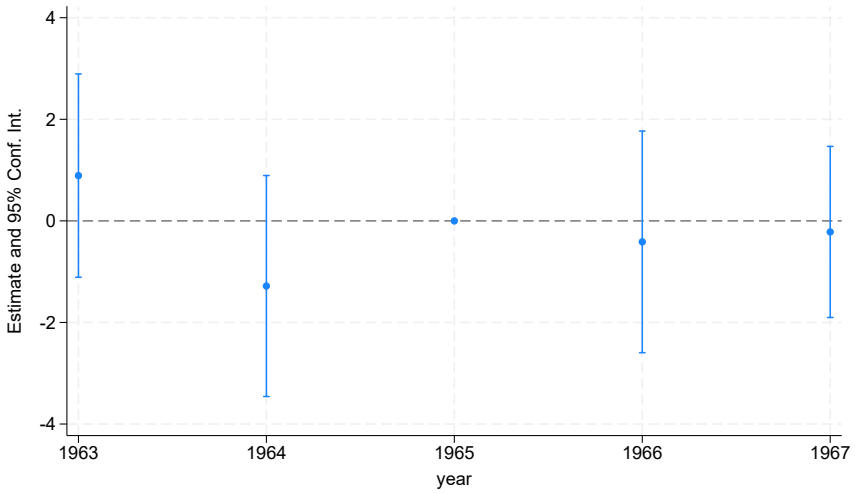


Figure 6

Drivers of excess female infant mortality: infanticide Event-study coefficients $\{\beta_s\}$ for gendered infant mortality, when restricting the sample to deaths associated with infanticide, estimated using the event-study specification in (1).

parents are less likely to bring their infants to a medical institution if there are potential signs of illness or similar. Unfortunately, while the place of death infant data allows for an urban-rural comparison, the data is not available by gender either on the prefecture or on a national level. Thus, the estimates can only be seen as a possible indicator for a gendered infant death driver.

$$Y_{itp} = \sum_{s=1963}^{1968} \beta_s \times 1[t = s] \times D_{ip} + \phi_i + \rho_p + \lambda_t + \epsilon_{itp} \tag{3}$$

In order to explore the dynamics, I adjust the main model of Equation (1) by changing the outcome to $Y_{i,t,p}$, the number of infant deaths in prefecture i in year t, and the place of death p in Equation (3). The new treatment identifier is D_p, which equals 1 for infant deaths at home and 0 for infant deaths in a medical institution. As before the specification includes prefecture and year-fixed effects and standard errors are clustered at the prefecture level.

Plotting the estimates in Figure 7a illustrates the changes in infant deaths by place of

death around the Fire Horse year. The figure highlights two points. First, an increase in the rate of infant deaths at home in 1966. Second, the plot exhibits a strongly declining pre-event trend indicating a confound problem. In this case, there is a trend in a higher share of infants dying in a medical institution compared to dying at home, which is a reasonable trend associated with medical advances in 1960s Japan. Following Freyaldenhoven et al. (2021), I extend Equation (3) with the cofound $\xi\eta_{it}$, where η_{it} is an unobserved scalar with coefficient ξ:

$$Y_{itp} = \sum_{s=1963}^{1968} \beta_s \times 1[t = s] \times D_{ip} + \phi_i + \rho_p + \lambda_t + \xi\eta_{it} + \epsilon_{itp}, \tag{4}$$

where

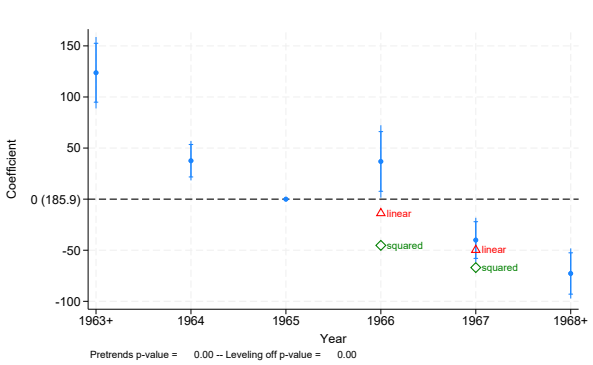
$$\eta_{it} = \tilde{\phi}_i + \tilde{\lambda}_t + q'_{it}\tilde{\psi} + \sum_{s=1963}^{1968} \gamma' f(s)\beta_s \times 1[t = s] \times D_i p \tag{5}$$

and $\tilde{\phi}_i$, $\tilde{\lambda}_t$, $\tilde{\psi}$, and γ are unknown parameters. As for $f(\mathrm{s})$, assume two cases, a linear one where $f(\mathrm{s})$ equals 1 when $s \in [1963, 1968]$ and a quadratic basis function. Assuming the Fire Horse shock had no effect on the infant's place of death before 1966 and the effect turned off in 1968, the trend in the outcome can be used to estimate the cofound $\xi\eta_{it}$. Similar to Dobkin et al. (2018), extrapolating $\xi\eta_{it}$ to 1966 and 1967 allows to account for the cofound. However, compared to the previous literature on confound extrapolation, assuming no effect in 1968 allows estimating a cofound by extrapolation using both the pre-and post-treatment periods.

In Figure 7a, the red (linear) and green (squared) symbols plot the extrapolated proxy, which mirrors the latent confound during the Fire Horse shock. Both the linear and the quadratic extrapolation are negative in 1966 and 1967, indicating that the cofound biases the actual Fire Horse effect downwards. Subtracting the rescaled event-study coefficients for the confound from those for the outcome in Figure 8 indicates the unconfounded event-study plot for the linear and quadratic adjusted unconfounded event-study plot.

The figure highlights a shock in `at home` infant mortality associated with the Fire Horse

Figure 7: Driver of Excess Infant Mortality



(a) Effects on hospitalization deaths



(b) Effects on hospitalization deaths - subtract rescaled confound from outcome

Figure 8

Drivers of excess female infant mortality: neglect. Panel (a) shows the event-study coefficients $\{\beta_s\}$ for `at home` infant deaths, estimated using the event-study specification in (3). The red and green symbols show the extrapolations of a linear and squared event-time trend from the three immediate pre-event periods, as well as the post-event period in 1968. In Panel (b), the estimated effect is the deviation of the event-time coefficients for `at home` infant deaths from the extrapolated linear and squared trends, respectively.

year for both specifications. Comparing the two specifications, reveals, that the quadratic adjusted event study exhibits a stronger effect in 1966 and a significant effect in 1967 similar to gendered infant mortality consideration. Following on the previous argumentation, this can be interpreted as an indicator of infant neglect for the Fire Horse cohort. However, while the extrapolation allows for identification of the Fire Horse effects, it does not reveal, whether a higher probability of gendered neglect is driving those effects or other idiosyncratic local factors concerning hospitalization associated with the Fire Horse year. For instance, if the cohort of Fire Horse children is born to families of lower-income cohorts this might drive the effect other than a higher probability of gendered neglect. Those concerns are further discussed in the next chapter.

7 Concluding remarks

Social norms continue to be a significant driver of gender inequality, hindering progress toward gender equality in critical ways. This paper demonstrates the profound impact of social norms on gendered infant mortality by examining the temporal shift in social norms during 1966 in Japan when female children were considered less desirable than male children due to the Fire Horse superstition. Using a novel dataset on pre-and postnatal statistics from 1960s Japan, the study finds substantial effects of the superstition on excess female infant mortality, using an event study with dynamic treatment effects. The analysis further explores regional heterogeneity, showing stronger effects around the Seto Inland Sea. When restricting the analysis to infant deaths that could be linked to infanticide, such as poisoning or drowning, no gendered effect is found, suggesting that infanticide was not the primary driver of the observed gendered mortality. Instead, by decomposing the effect by place of death, the findings indicate that, during the Fire Horse year, a disproportionate number of infants died at home rather than in medical institutions, which can be interpreted as a sign of infant neglect.

While this study highlights the significant role of social norms in shaping gendered outcomes, it also raises several questions for future research. Effect heterogeneity across income levels, maternal age, and social class appears crucial but could not be fully explored due to data limitations. The use of prefecture-level data, while valuable, restricts the ability to conduct a more micro-level analysis. Additionally, understanding prenatal effects, including fetal mortality and abortion, is essential to fully explain the sharp decline in births in 1966. As the next Fire Horse year approaches in 2026, this research also prompts new questions about the superstition's influence in a modernized society. In particular, the potential impact on gendered prenatal choices, such as sex-selective abortion, warrants further investigation. Addressing these questions could provide deeper insights into the persistence and evolution of gender inequality.

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A Appendix Descriptive Statistics

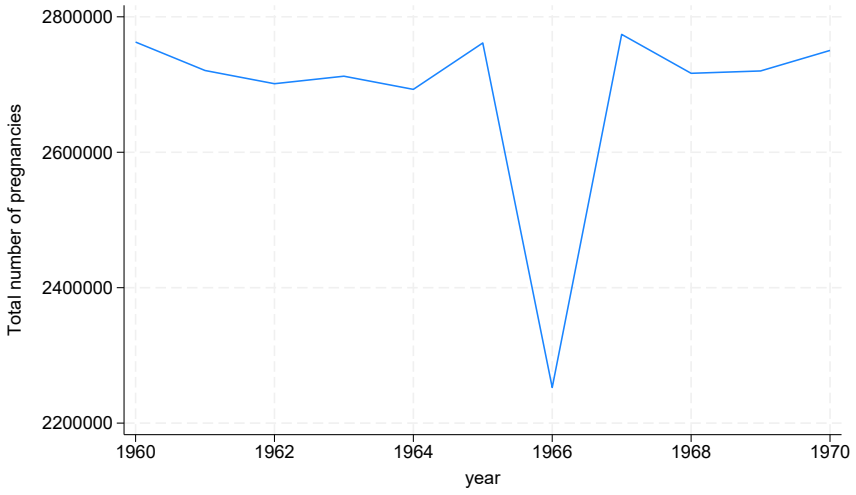
Appendix A Table 1: Demographic Key Numbers by Prefecture

	Population (in thousand)	Population Density	Urban Share (%)	Births tot	Birth/Population	Female Births/All Births
Japan	98275	265.56	68.09	1716761	.018	48.57
Hokkaido	5172	65.87	57.5	92800	.018	48.8
Aomori	1417	147.36	54.64	27776	.019	48.64
Iwate	1411	92.38	50.39	25261	.018	47.84
Miyagi	1753	240.56	48.45	28695	.016	48.69
Akita	1280	110.24	42.51	20307	.016	48.78
Yamagata	1263	135.45	62.03	18970	.015	48.08
Fukushima	1984	143.95	50.33	32989	.017	48.23
Ibaraki	2056	337.78	45.34	34140	.017	48.73
Tochigi	1522	237.25	59.78	24387	.016	48.46
Gumma	1606	252.62	58.89	26183	.016	48.22
Saitama	3015	793.56	62.86	58323	.021	48.76
Chiba	2702	531.96	64.58	49255	.019	48.34
Tokyo	10869	5076.45	95.14	207567	.019	48.48
Kanagawa	4431	1857.97	91.78	85101	.021	48.23
Niigata	2399	190.74	56.79	38852	.016	48.58
Toyama	1025	241.16	65.24	15940	.015	48.31
Ishikawa	980	233.72	64.01	16327	.017	48.97
Fukui	751	179.21	60.03	12439	.017	49.15
Yamanashi	763	170.99	48.67	12320	.016	49.25
Nagano	1958	144.14	52.99	29860	.015	48.66
Gifu	1700	160.48	57.49	30018	.018	48.36
Shizuoka	2913	374.83	70.4	51435	.018	48.17
Aichi	4799	943.88	78.97	91898	.02	48.87
Mie	1514	262.39	61.31	25484	.017	48.07
Shiga	853	212.5	40.51	13735	.016	48.31
Kyoto	2103	455.92	81.5	34258	.017	48.2
Osaka	6657	3590.62	94.66	131994	.021	48.6
Hyogo	4310	516.11	79.77	76725	.018	48.67
Nara	826	223.71	58.55	13657	.017	48.51
Wakayama	1027	217.64	56.46	16975	.017	49.03
Tottori	580	166.07	50.24	8694	.015	48.24
Shimane	822	124	50.25	12136	.014	48.81
Okayama	1645	232.43	58.26	24649	.015	48.69
Hiroshima	2281	270.04	58.35	36286	.016	48.3
Yamaguchi	1544	253.67	70.33	24040	.015	48.05
Tokushima	815	196.69	41.79	12460	.015	48.43
Kagawa	901	481.72	49.2	13445	.015	48.99
Ehime	1446	255.64	58.83	23692	.016	48.74
Kochi	813	114.37	57.43	11719	.014	49.39
Fukuoka	3965	805.44	68.46	64653	.016	48.88
Saga	872	361.64	49.35	14237	.016	49.08
Nagasaki	1641	400.69	56.26	30349	.018	49.2
Kumamoto	1771	239.82	49.31	29018	.016	48.58
Oita	1187	187.76	57.48	18471	.015	48.65
Miyazaki	1081	139.73	58.97	18540	.017	48.14
Kagoshima	1854	202.68	47.53	30701	.016	49

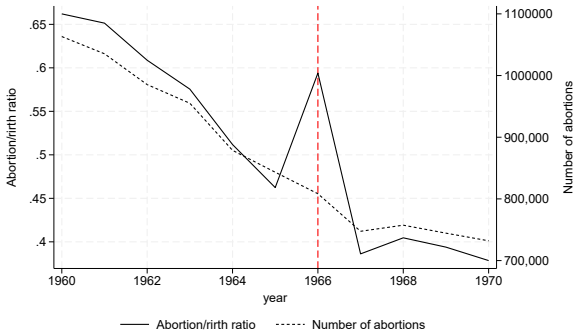
Appendix A Table 1: (Continued) Demographic Key Numbers by Prefecture

	Infant mortality tot	Infant mortality/All Births	Female Inf. Mort./Male Inf Mort. 1966	Female Inf. Mort./Male Inf Mort. 1965
Japan	34967	.020368	43.02628	42.73606
Hokkaido	1987	.0214116	42.92904	41.83945
Aomori	876	.031538	42.80822	42.09246
Iwate	804	.0318277	44.15423	43.98869
Miyagi	618	.0215369	39.64401	43.56775
Akita	547	.0269365	46.4351	47.74194
Yamagata	480	.0253031	43.33333	39.58944
Fukushima	855	.0259177	42.5731	44.47439
Ibaraki	825	.0241652	42.66667	43.53349
Tochigi	618	.0253414	43.3657	40.30612
Gumma	587	.0224191	42.07837	42.27504
Saitama	1300	.0222897	43.92308	42.50742
Chiba	1004	.0203837	39.24303	42.95432
Tokyo	3174	.0152914	42.69061	42.38454
Kanagawa	1284	.015088	42.75701	43.27062
Niigata	886	.0228045	45.59819	44.39306
Toyama	405	.0254078	45.92593	42.96875
Ishikawa	378	.0231518	43.91534	44.79769
Fukui	293	.0235549	43.00341	41.31147
Yamanashi	220	.0178571	43.63636	43.39622
Nagano	531	.017783	45.76271	40.14466
Gifu	652	.0217203	44.01841	42.41071
Shizuoka	894	.0173812	42.50559	42.6097
Aichi	1728	.0188035	40.97222	43.06749
Mie	541	.021229	44.91682	46.36015
Shiga	363	.0264288	47.10744	39.65015
Kyoto	612	.0178644	42.64706	42.7598
Osaka	2248	.0170311	44.12811	42.48137
Hyogo	1337	.0174259	44.50262	43.62364
Nara	282	.0206488	48.93617	40.76923
Wakayama	408	.0240353	43.62745	37.78409
Tottori	184	.021164	41.84783	46.55172
Shimane	262	.0215887	46.1832	45.72491
Okayama	452	.0183375	42.47787	40.5467
Hiroshima	712	.0196219	43.39888	42.43282
Yamaguchi	521	.0216722	42.99424	40.04149
Tokushima	337	.0270465	41.24629	43.17343
Kagawa	368	.0273708	41.84783	43.84858
Ehime	530	.0223704	40.56604	42.73859
Kochi	292	.0249168	41.09589	46.8
Fukuoka	1138	.0176017	42.79438	42.98093
Saga	338	.023741	42.60355	40.59406
Nagasaki	754	.0248443	41.51194	41.033
Kumamoto	735	.0253291	43.80952	41.44543
Oita	465	.0251746	39.56989	44.42013
Miyazaki	406	.0218986	40.8867	43.85246
Kagoshima	727	.02368	42.91609	43.44147

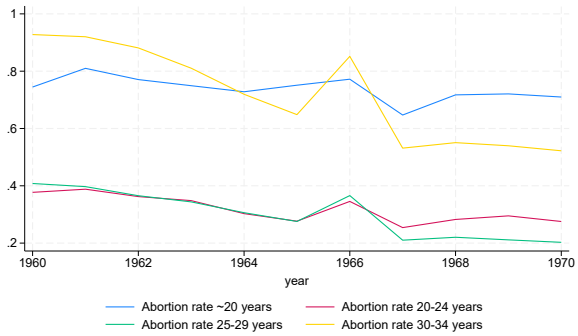
Appendix A Figure 1: Total Number of Pregnancies



Appendix A Figure 2: Driver of Excess Infant Mortality

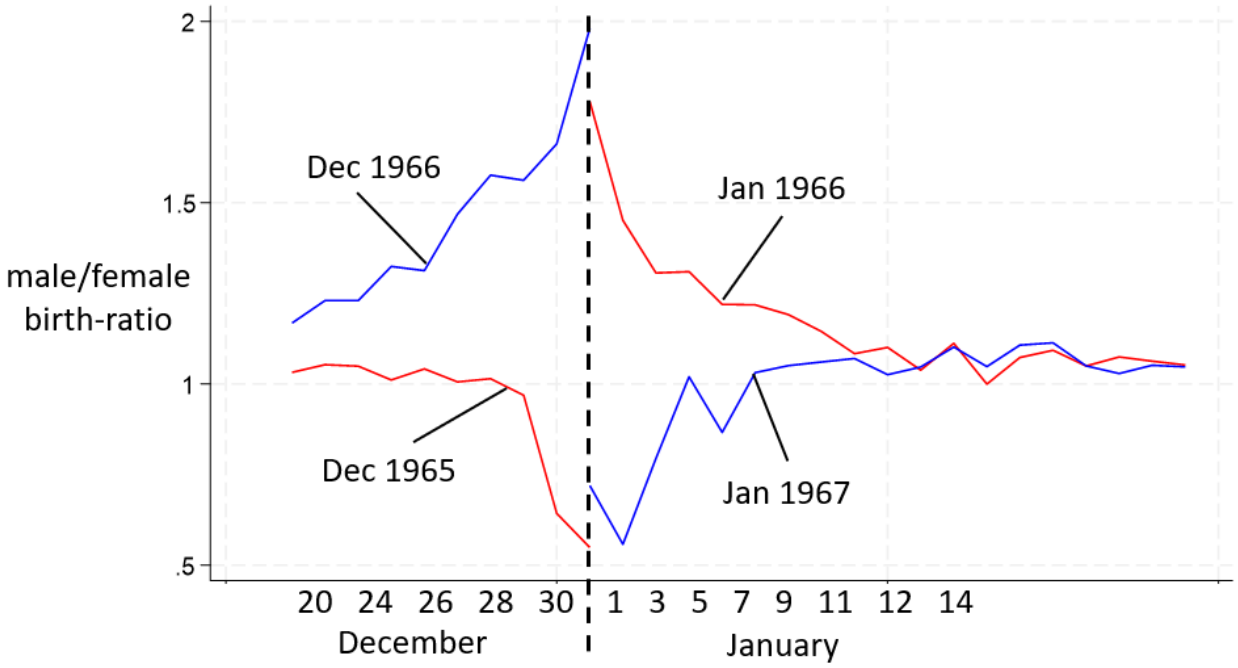


(a) Abortion in 1960s Japan

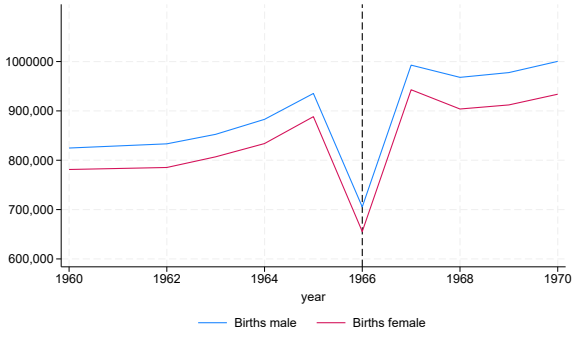


(b) Abortion by Age Cohort

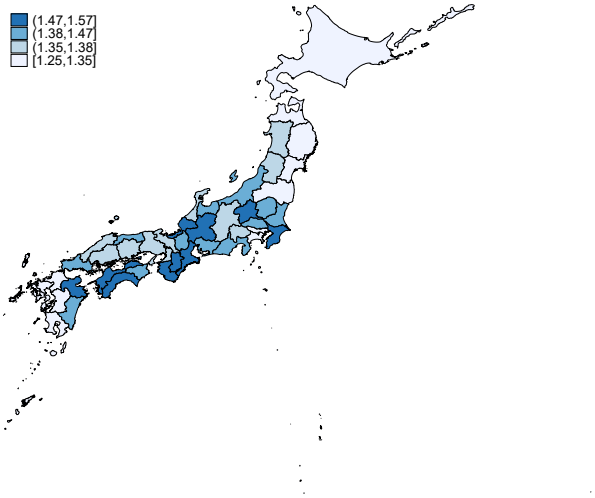
Appendix A Figure 3: Birthdate Manipulation



Appendix A Figure 4: Births and Year-Over-Year Birth Change in the Fire Horse Year

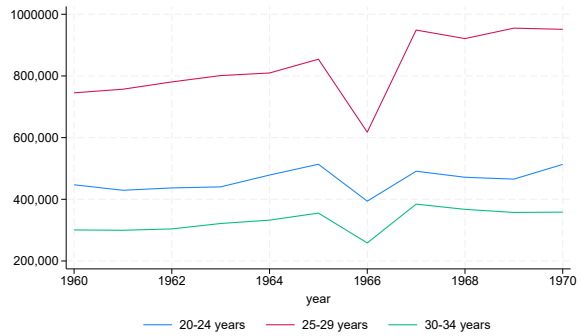


(a) Absolute Number of Births by Gender

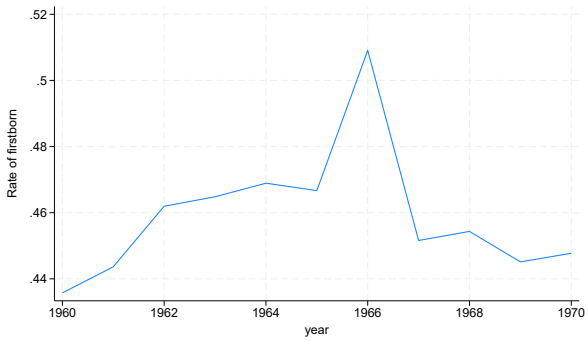


(b) Year-Over-Year Birth Change in 1966

Appendix A Figure 5: Births Decomposition

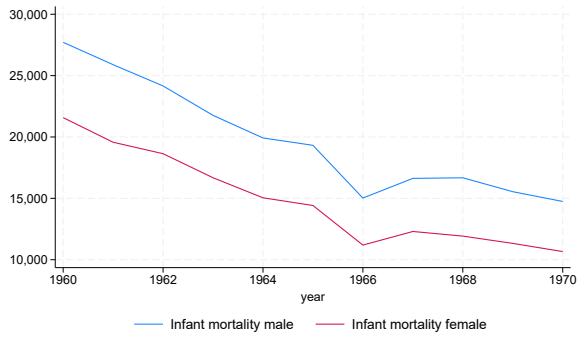


(a) Births by Age Cohort of Mother

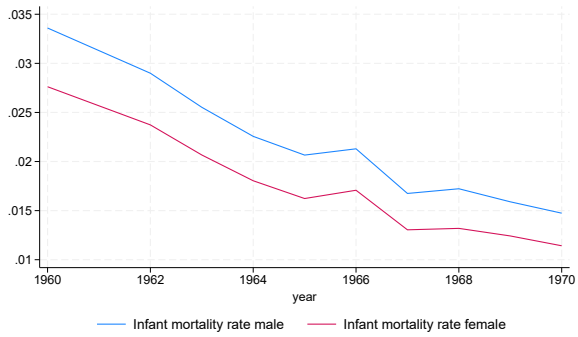


(b) Rate of Firstborn Children

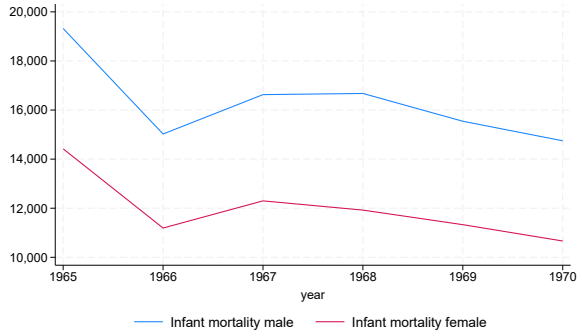
Appendix A Figure 6: Infant and Neonatal Mortatliy in 1960s Japan



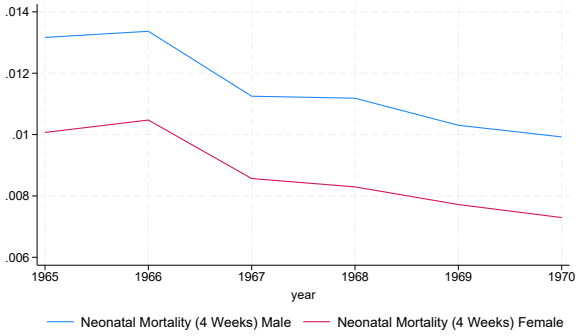
(a) Absolute Number of Infant Deaths



(b) Infant Deaths Rate



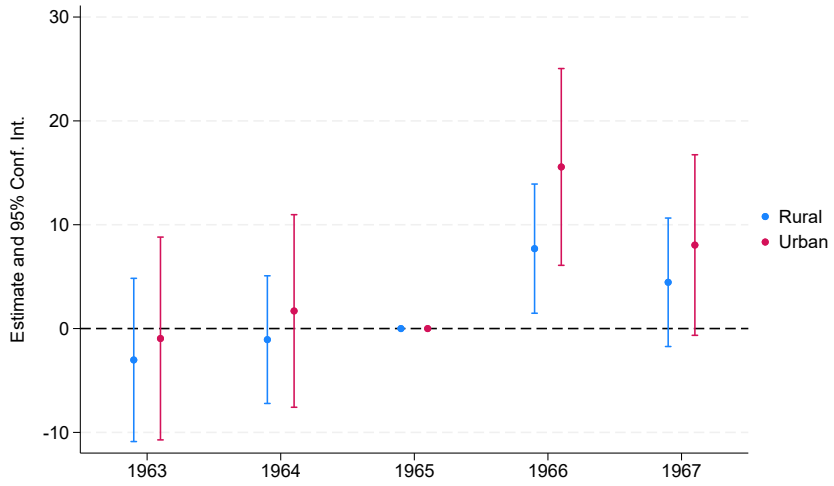
(c) Absolute Number of Neonatal Infant Deaths



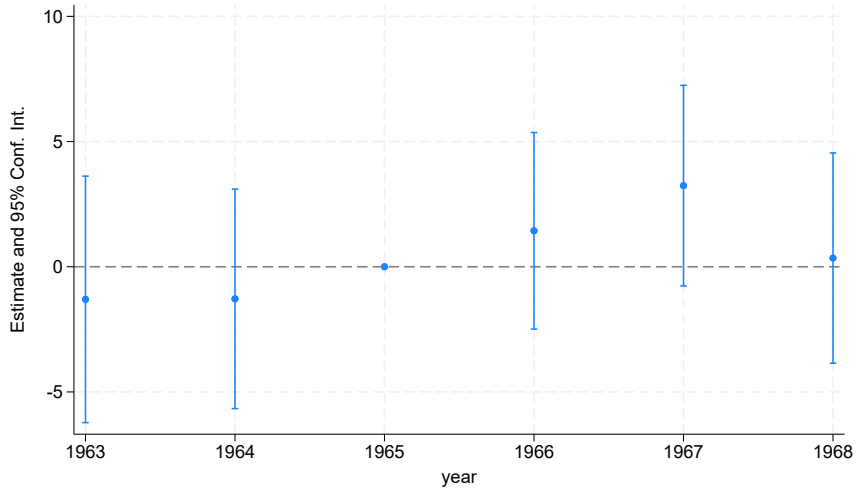
(d) Neonatal Infant Deaths Rate

B Empirical Analysis

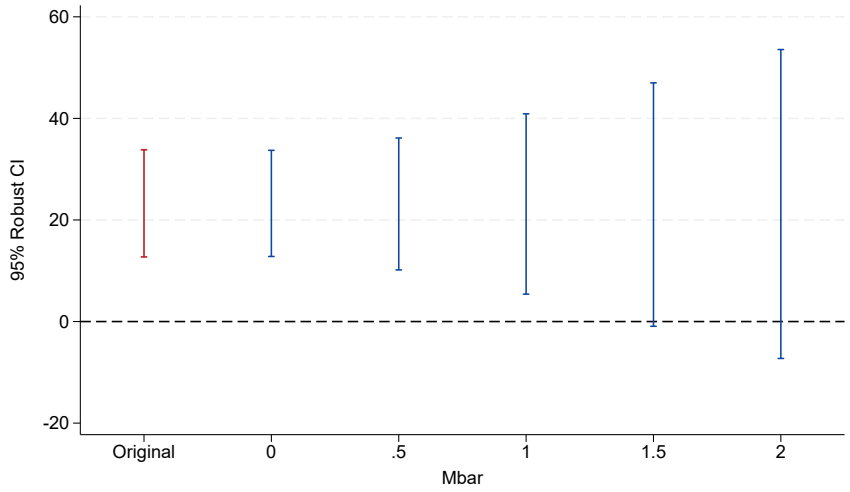
Appendix B Figure 1: Effects on Gendered Infant Mortality- Urban and Rural Areas



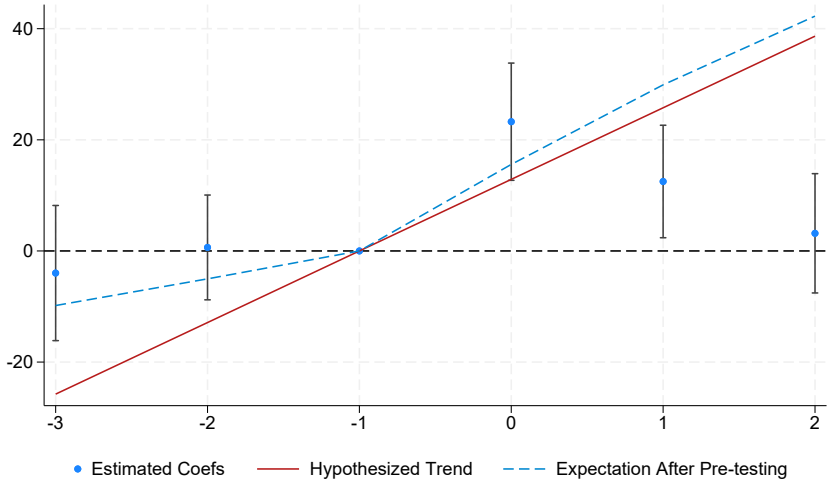
Appendix B Figure 2: Effects on Gendered Child Mortality 1-2 Years of Age



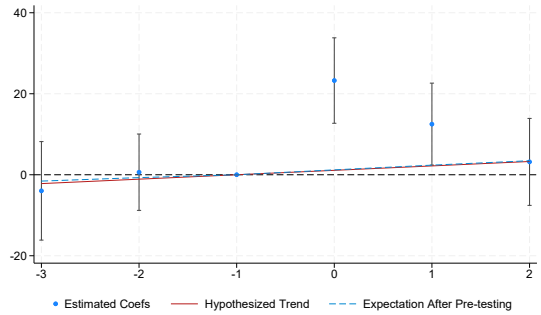
Appendix B Figure 3: Gendered Infant Mortality in 1966



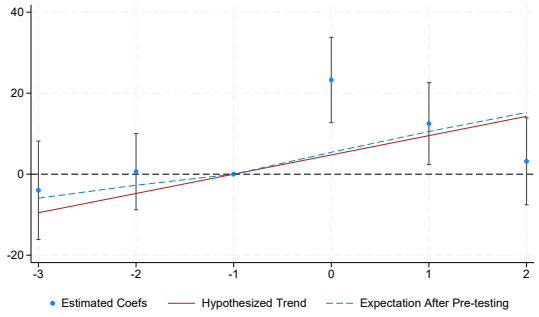
Appendix B Figure 4: Parallel Trends Violation Needed for Null Effect in 1966



Appendix B Figure 5: Violations in Parallel Trends in Accordance with Null Effect in 1968

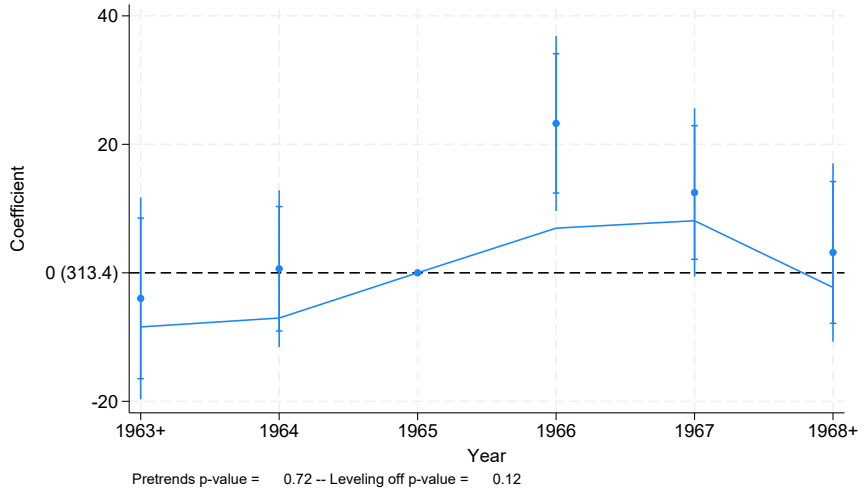


(a) Average Violation in Parallel Trends

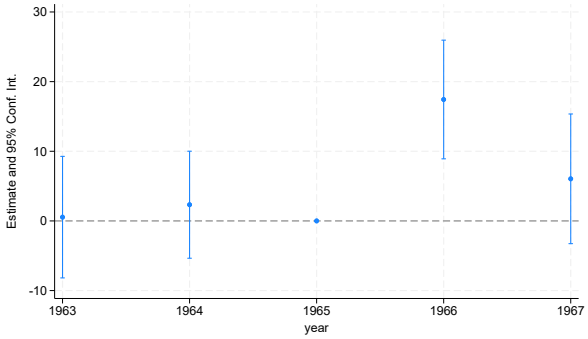


(b) Upper Confidence Bound Violation in Parallel Trends

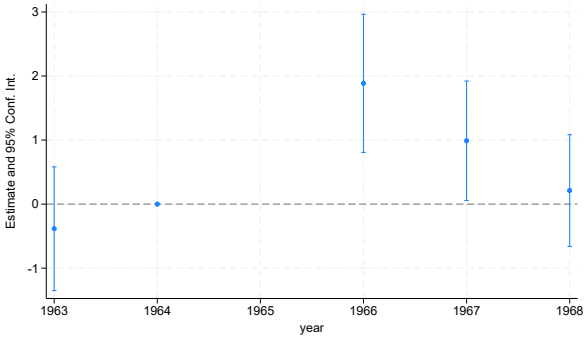
Appendix B Figure 6: Least "wiggly" Path of Confound



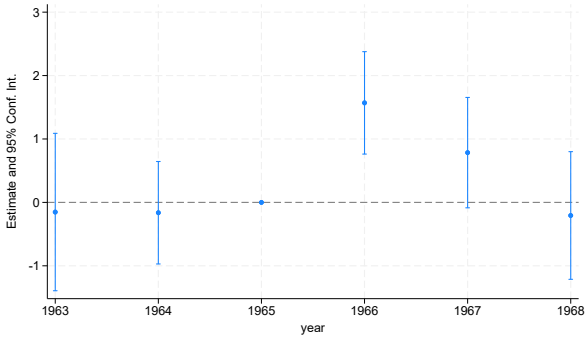
Appendix B Figure 7: Effects on Gendered Infant Mortality - Robustness



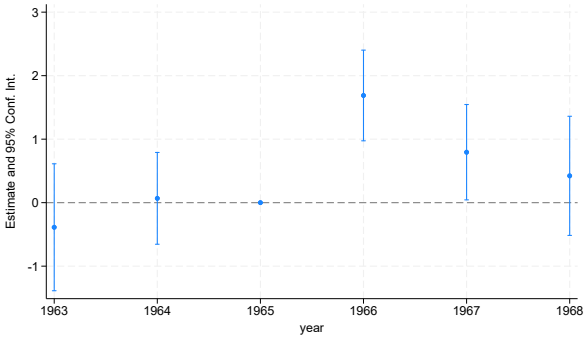
(a) Neonatal Gendered Infant Mortality



(b) Using 1964 as Base Period



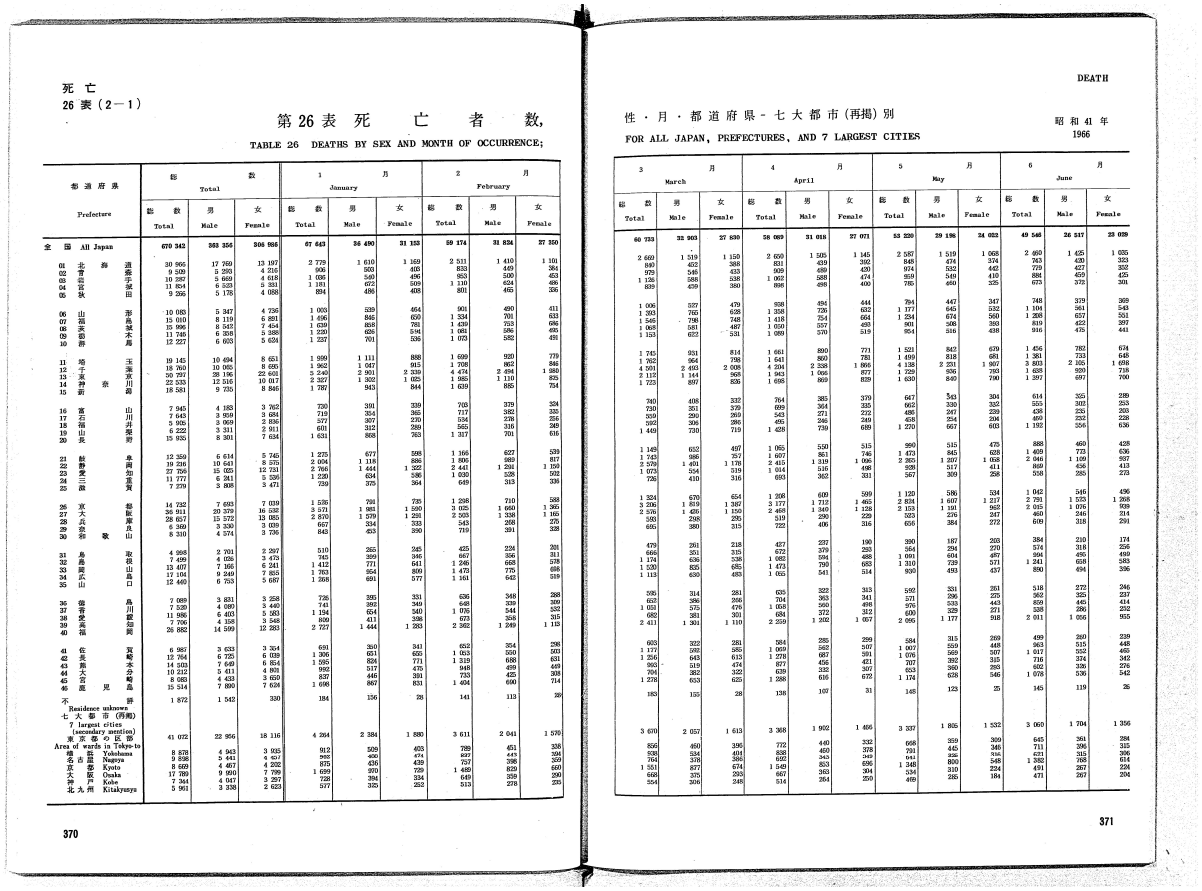
(c) Excluding December and January



(d) Excluding Major Cities

C Data Sources

Appendix C Figure 1: Japan Vitality Statistics Example Table



死 亡
26 表（2－1）

第 26 表　死　亡　者　数，

TABLE 26　DEATHS BY SEX AND MONTH OF OCCURRENCE;

都道府県 Prefecture	総数 Total			1月 January			2月 February		
	総数 Total	男 Male	女 Female	総数 Total	男 Male	女 Female	総数 Total	男 Male	女 Female
全国 All Japan	670 342	363 356	306 986	67 643	36 490	31 153	59 174	31 824	27 350
01 北海道	30 966	17 769	13 197	2 729	1 610	1 119	2 511	1 410	1 101
02 青森	9 539	5 295	4 244	906	503	403	833	449	384
03 岩手	10 287	5 669	4 618	1 035	540	495	953	500	453
04 宮城	11 804	6 533	5 271	1 181	672	509	1 110	624	486
05 秋田	9 266	5 178	4 088	894	486	408	801	465	336
06 山形	10 083	5 347	4 736	1 003	539	464	901	490	411
07 福島	15 010	8 119	6 891	1 496	846	650	1 334	701	633
08 茨城	15 996	8 542	7 454	1 639	858	781	1 439	723	716
09 栃木	11 746	6 358	5 388	1 220	626	594	1 061	586	475
10 群馬	12 227	6 693	5 534	1 237	701	536	1 109	582	527
11 埼玉	19 145	10 494	8 651	1 999	1 111	888	1 699	920	779
12 千葉	18 760	10 085	8 675	1 962	1 047	915	1 708	862	846
13 東京	50 797	28 196	22 601	5 240	2 901	2 339	4 474	2 494	1 980
14 神奈川	22 535	12 518	10 017	2 327	1 302	1 025	1 985	1 110	875
15 新潟	18 581	9 735	8 846	1 787	943	844	1 639	885	754
16 富山	7 945	4 183	3 762	720	391	329	703	379	324
17 石川	7 643	3 959	3 684	718	354	365	717	382	335
18 福井	5 905	3 069	2 836	577	307	270	534	298	236
19 山梨	6 222	3 311	2 911	601	312	289	565	316	249
20 長野	15 935	8 301	7 634	1 631	868	763	1 317	701	616
21 岐阜	12 359	6 614	5 745	1 275	677	598	1 166	627	539
22 静岡	19 216	10 643	8 573	2 004	1 118	886	1 806	983	817
23 愛知	27 756	15 025	12 731	2 766	1 444	1 322	2 441	1 291	1 150
24 三重	11 777	6 241	5 536	1 230	634	596	1 030	528	502
25 滋賀	7 279	3 808	3 471	739	375	364	649	313	336
26 京都	14 732	7 693	7 039	1 536	791	745	1 298	710	588
27 大阪	36 914	20 379	16 535	3 571	1 981	1 590	3 025	1 660	1 365
28 兵庫	28 617	15 572	13 045	2 870	1 579	1 291	2 503	1 338	1 165
29 奈良	6 369	3 330	3 039	667	354	313	543	268	275
30 和歌山	8 310	4 574	3 736	843	453	390	719	391	328
31 鳥取	4 998	2 701	2 297	510	265	245	425	224	201
32 島根	7 499	4 025	3 474	745	399	346	667	356	311
33 岡山	13 407	7 166	6 241	1 412	771	641	1 246	668	578
34 広島	17 104	9 249	7 855	1 763	954	809	1 473	775	698
35 山口	12 449	6 753	5 697	1 268	691	577	1 161	645	516
36 徳島	7 089	3 831	3 258	726	395	331	636	348	288
37 香川	7 539	4 099	3 440	741	393	348	648	339	309
38 愛媛	11 986	6 403	5 583	1 194	654	540	1 076	544	532
39 高知	7 706	4 158	3 548	809	411	398	673	358	315
40 福岡	26 882	14 599	12 283	2 727	1 444	1 283	2 362	1 249	1 113
41 佐賀	6 987	3 633	3 354	691	350	341	652	354	298
42 長崎	12 764	6 725	6 039	1 306	651	655	1 153	550	603
43 熊本	14 503	7 649	6 854	1 595	824	771	1 315	688	627
44 大分	10 212	5 411	4 801	992	517	475	948	499	449
45 宮崎	8 685	4 433	3 952	837	446	391	733	425	308
46 鹿児島	15 514	7 890	7 624	1 698	867	831	1 404	690	714
不詳 Residence unknown	1 872	1 542	330	184	156	28	141	113	28
七大都市（再掲） 7 largest cities (secondary section)	41 072	22 956	18 116	4 284	2 384	1 880	3 611	2 041	1 570
東京都の区部 Area of wards in Tokyo-to	41 072	22 956	18 116	4 284	2 384	1 880	3 611	2 041	1 570
横浜 Yokohama	8 878	4 943	3 935	912	509	403	788	451	338
名古屋 Nagoya	9 336	5 441	4 457	952	490	462	774	425	349
京都 Kyoto	8 669	4 467	4 202	875	436	439	757	398	359
大阪 Osaka	17 789	9 993	7 796	1 699	970	729	1 482	829	653
神戸 Kobe	7 344	4 047	3 297	726	394	332	649	339	310
北九州 Kitakyusyu	5 961	3 338	2 623	577	325	252	513	278	235

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DEATH

性・月・都道府県－七大都市（再掲）別

昭和 41 年
1966

FOR ALL JAPAN, PREFECTURES, AND 7 LARGEST CITIES

3月 March			4月 April			5月 May			6月 June		
総数 Total	男 Male	女 Female	総数 Total	男 Male	女 Female	総数 Total	男 Male	女 Female	総数 Total	男 Male	女 Female
60 723	32 903	27 820	58 069	31 018	27 071	53 220	29 198	24 022	49 546	26 517	23 029
2 669	1 519	1 150	2 600	1 505	1 145	2 587	1 519	1 068	2 468	1 435	1 033
840	452	388	831	439	392	848	474	374	763	430	333
979	546	433	939	489	450	974	532	442	779	427	352
1 126	588	538	1 062	588	474	959	549	410	886	459	427
839	439	380	896	488	408	785	460	325	673	372	301
1 006	527	479	938	494	444	894	447	447	748	379	369
1 393	765	628	1 358	720	638	1 377	645	732	1 104	561	543
1 546	798	748	1 418	754	664	1 234	674	560	1 208	657	551
1 068	581	487	1 059	577	482	891	508	383	819	422	397
1 153	622	531	1 089	570	519	954	516	438	916	475	441
1 745	931	814	1 661	890	771	1 521	842	679	1 456	782	674
1 762	964	798	1 641	860	781	1 499	818	681	1 384	733	651
4 591	2 493	2 098	4 394	2 338	2 056	4 138	2 231	1 907	3 803	2 105	1 698
2 112	1 144	968	1 943	1 066	877	1 728	926	802	1 628	909	719
1 723	897	826	1 698	869	829	1 530	840	690	1 397	697	700
740	408	332	764	385	379	647	343	304	614	325	289
720	351	369	699	364	335	662	330	332	555	302	253
559	290	269	543	271	272	486	247	239	436	231	205
593	306	287	493	246	247	428	224	204	460	232	228
1 449	730	719	1 428	739	689	1 270	667	603	1 192	556	636
1 149	652	497	1 065	550	515	990	515	475	888	460	428
1 743	986	757	1 627	861	766	1 473	845	628	1 469	773	696
2 579	1 401	1 178	2 415	1 319	1 096	2 265	1 207	1 058	2 046	1 109	937
1 073	554	519	1 014	516	498	938	517	421	869	456	413
726	410	316	693	362	331	567	309	258	538	265	273
1 324	670	654	1 208	609	599	1 120	586	534	1 042	546	496
3 206	1 819	1 387	3 177	1 712	1 465	2 824	1 607	1 217	2 791	1 553	1 238
2 176	1 431	1 155	2 468	1 349	1 138	2 153	1 191	962	2 015	1 076	939
583	298	285	519	290	229	533	276	257	460	246	214
695	380	315	722	406	316	656	384	272	649	318	291
479	291	218	427	237	190	390	197	193	384	210	174
666	351	315	672	379	293	564	294	270	574	318	256
1 174	636	538	1 082	594	488	1 091	604	487	994	485	509
1 320	825	495	1 473	790	683	1 310	739	571	1 241	658	583
1 113	630	483	1 055	541	514	930	493	437	880	494	386
595	314	281	625	322	303	592	331	261	518	272	246
652	386	266	704	363	341	571	296	275	462	225	237
1 031	575	456	1 058	560	498	976	533	443	859	445	414
682	381	301	684	372	312	600	329	271	528	296	232
2 411	1 301	1 110	2 239	1 202	1 037	2 095	1 177	918	2 021	1 066	955
603	322	281	564	283	299	584	315	269	499	260	239
1 177	595	582	1 069	562	507	1 007	569	438	963	515	448
1 256	643	613	1 278	687	591	1 076	569	507	1 017	552	465
993	519	474	977	456	421	707	392	315	716	374	342
704	382	322	639	332	307	653	360	293	602	326	276
1 278	653	625	1 288	616	672	1 174	628	546	1 078	536	542
183	155	28	138	107	31	148	123	25	145	119	26
3 670	2 057	1 613	3 368	1 902	1 466	3 337	1 805	1 532	3 060	1 704	1 356
856	460	396	772	440	332	668	359	309	645	361	284
938	534	404	838	460	378	791	445	346	711	396	315
764	376	388	692	343	349	644	330	314	631	315	316
1 551	877	674	1 549	853	696	1 345	800	545	1 382	768	614
668	375	293	667	363	304	534	310	224	491	267	224
554	306	248	514	264	250	469	285	184	471	267	204

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