Trends in Death License: Analyzing the Distribution of Death Licenses in Great Toronto Area in the Past Decade and Potentional Realation to the Extreme Weather and Covid-19*

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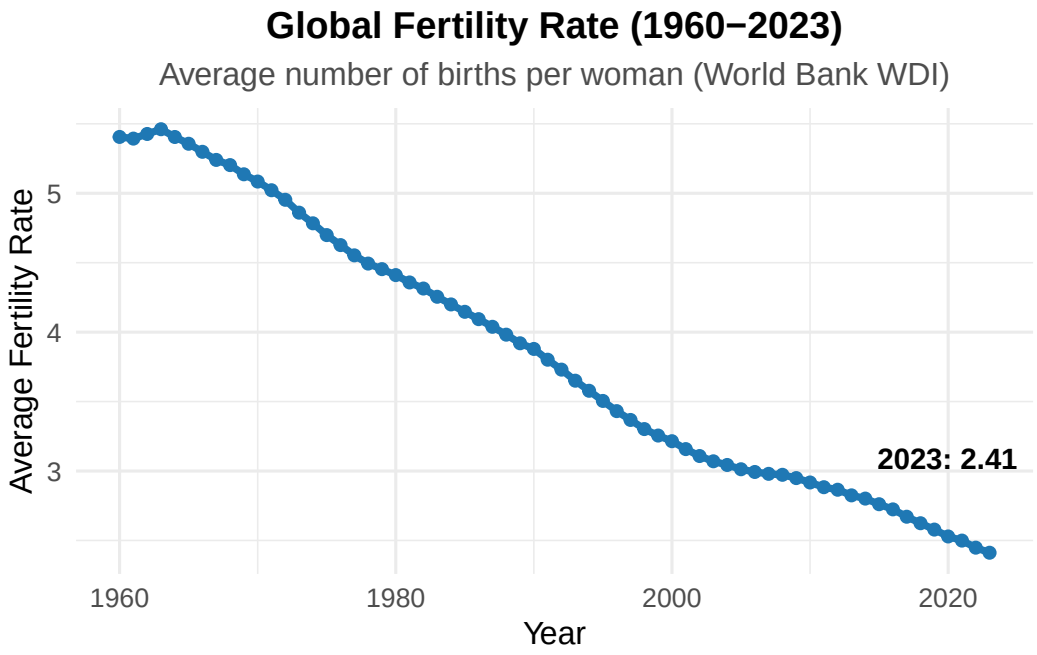


Figure 1: Global Trend

*Code and data are available at: https://github.com/Jie-jiao05/Paper-1.git

Undoubtedly, the world is facing a profound challenge in fertility. As shown in Figure 1, the average number of births per woman fell from more than 5.4 in 1960 to just 2.41 in 2023, a reduction of more than half. Although this global average is somewhat influenced by higher fertility rates in less developed regions, the downward trend remains evident across the world, with significant declines in both advanced and emerging economies. As shown in Figure 2, all major economies experienced clear reductions in fertility between 1960 and 2023, and almost all are now below the global replacement level of about two births per woman. Emerging nations such as India and Brazil are also moving toward similar demographic patterns. While the decline has been relatively moderate in Europe and most pronounced in China, partly due to earlier population control policies, the overall pattern reflects a transformation that reaches far beyond population size. Persistently low fertility and population aging have raised concerns about shrinking labor forces and increasing dependency ratios, leading many countries to rely more heavily on immigration as a demographic buffer.

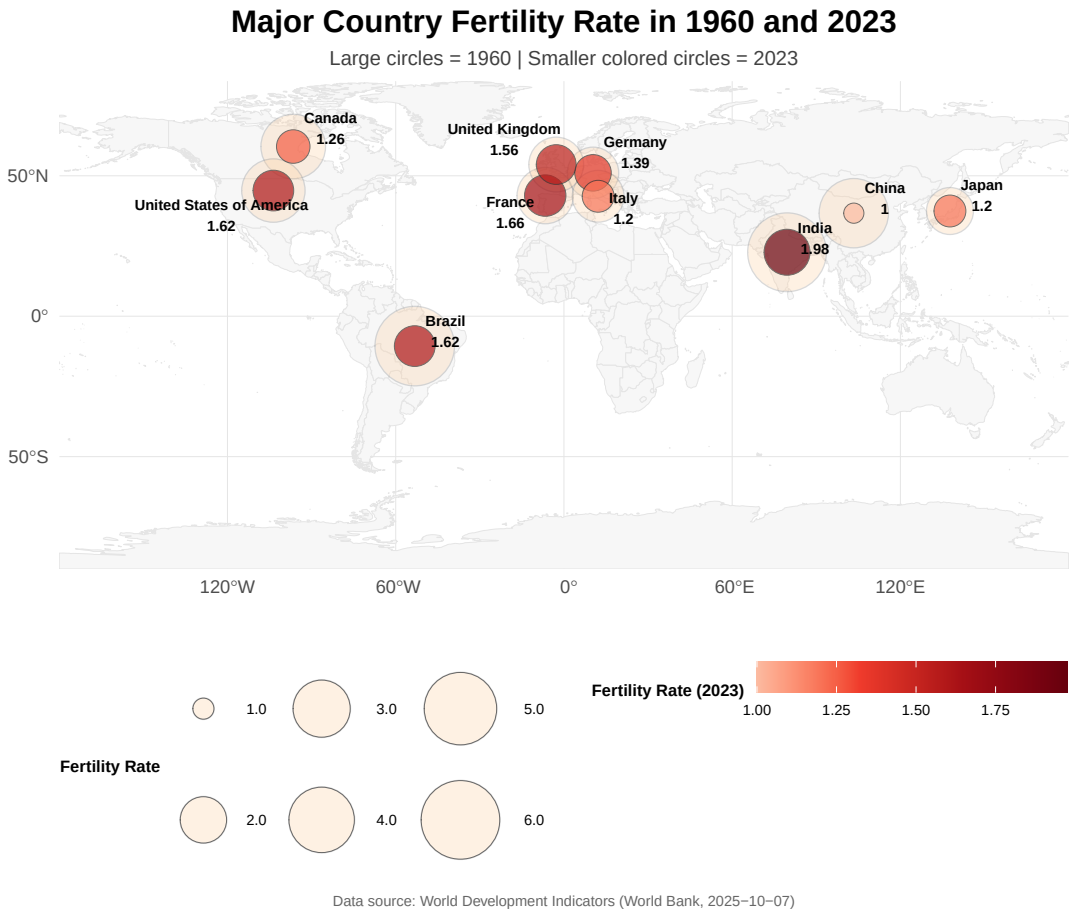
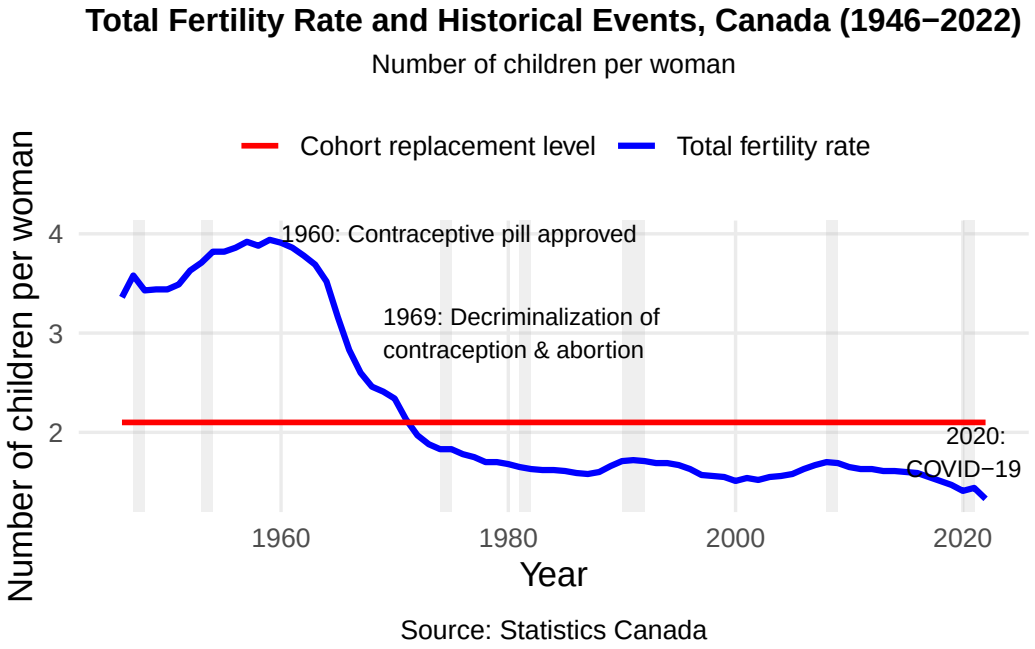


Figure 2: G7 and China, India, and Brazil

The roots of this transformation can be understood through both social and biological per-

spectives. On the social side, higher education levels, expanding female participation in the workforce, and rapid urbanization have redefined family structures and reduced the economic incentives for having children. Growing personal autonomy, delayed marriage, and shifting social expectations from traditional motherhood toward independent professional identity have further reshaped reproductive intentions. Psychological factors also contribute like fear of infant mortality, maternal self-doubt, and anxiety about the physical and emotional costs of childbirth have encouraged some individuals or couples to postpone or reconsider parenthood, with an increasing number choosing to remain child-free. Even more influential are rising economic pressures. High housing costs, unstable employment, and the growing expense of education have made parenting increasingly burdensome, reinforcing decisions to limit family size.

These social, biological, and psychological transformations carry important implications for maternal and infant health. While fertility decline often occurs alongside broader demographic and socioeconomic change, it is not a direct cause of shifts in disease patterns. Instead, both reflect underlying improvements in living conditions, healthcare access, and women's social status. As populations age and family sizes shrink, maternal and infant health indicators become key reflections of overall public health progress. In the Canadian context, understanding how provincial fertility decline corresponds with infant mortality and cause-specific disease burdens offers valuable insight into whether advancements in healthcare have successfully reduced preventable deaths and improved early-life outcomes over time.



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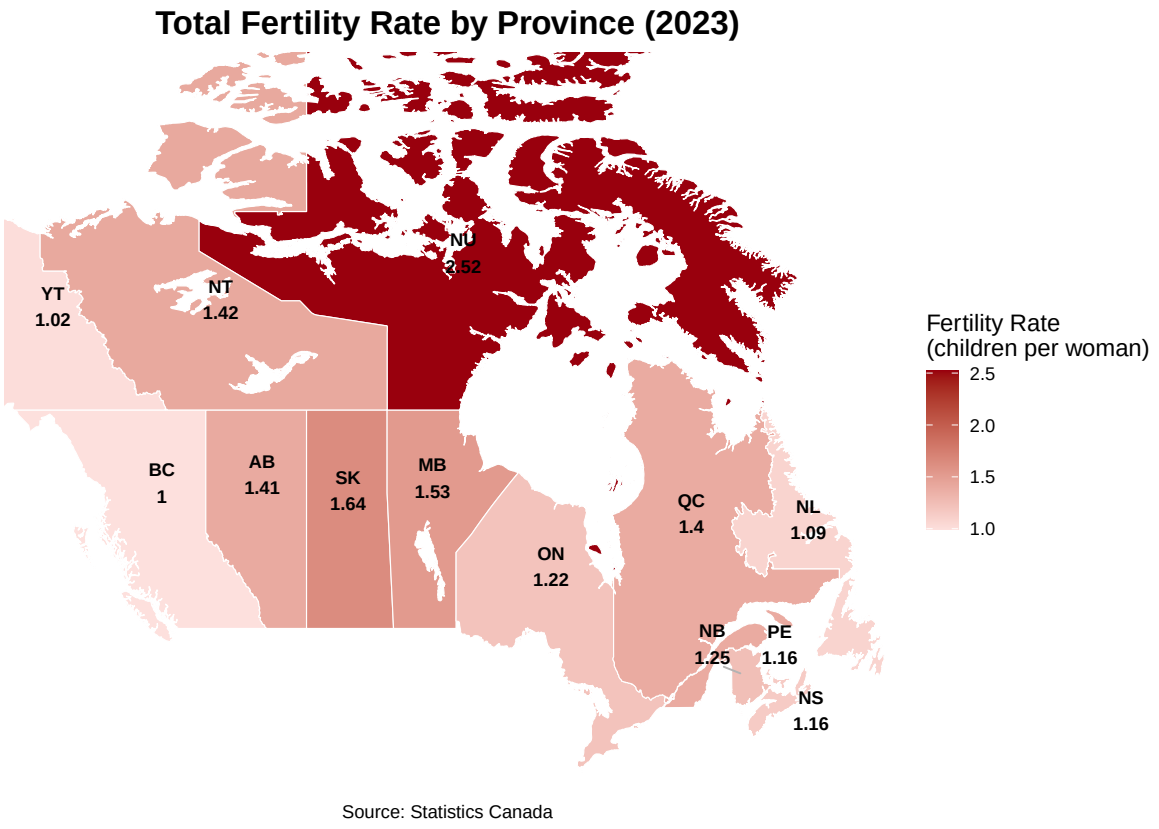

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Figure 5 highlights the leading causes of infant deaths (age 0) in Canada in 2022, showing that fatalities are highly concentrated within a few medical categories. The most prominent cause is certain conditions originating in the perinatal period (I050), followed by congenital malformations, deformations, and chromosomal abnormalities (I051). Together, these two categories account for the majority of infant deaths. Other notable causes, such as ill-defined or unspecified conditions (I058) and diseases of the nervous system (I030), occur at much lower frequencies. In contrast, infectious causes such as septicaemia (I003) and pneumonia (I039) contribute minimally, indicating that communicable diseases no longer play a major role in infant mortality in Canada.

Infant deaths are now increasingly concentrated in biological and developmental risks surrounding the perinatal stage, such as genetic defects, chromosomal abnormalities, preterm birth, and placental dysfunction. These conditions are difficult to eliminate through conventional public

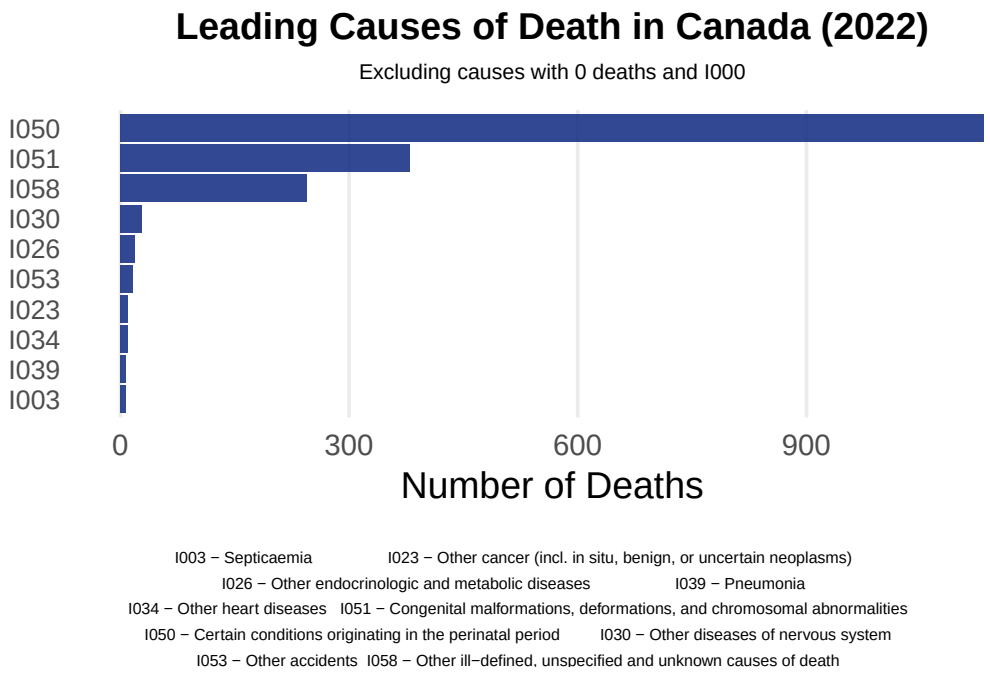

Figure 5: Disease Histogram by Descent

health measures and require more advanced approaches, including prenatal screening, genetic counseling, and neonatal intensive care. In other words, while medical progress has significantly reduced preventable deaths, it also calls for greater attention to genetic and developmental disorders, which have become central challenges for improving infant health in the twenty-first century.

As shown in Figure 6, the three major causes of infant mortality in Canada—I050 (conditions originating in the perinatal period), I051 (congenital malformations, deformations, and chromosomal abnormalities), and I058 (unspecified causes of disease)—display distinct patterns between 2000 and 2022. Among them, I050 consistently remains the leading cause of infant deaths, with relatively stable numbers but a slight increase in recent years. I051 shows comparatively little change over time, exhibiting minor fluctuations and a modest overall decline. In contrast, I058 demonstrates the greatest variability, particularly after 2015, indicating a rising proportion of deaths classified under diagnostic uncertainty or cases lacking clear medical attribution.

In Figure 7, it shows that for I050 (conditions originating in the perinatal period), male deaths consistently exceed those of females. Although both sexes follow similar long-term patterns, a gradual decline is observed after 2010, followed by a slight rebound in recent years. In contrast, for I051 (congenital malformations, deformations, and chromosomal abnormalities) and I058 (unspecified causes of disease), sex differences are relatively small and remain stable over time, indicating that male and female infants have broadly comparable levels of exposure

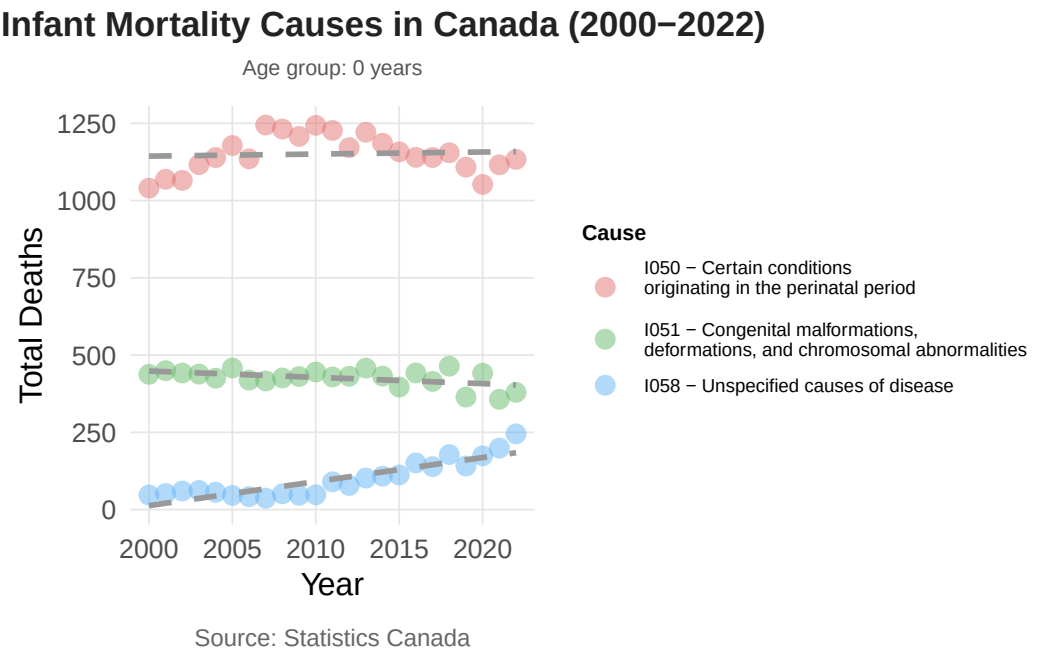

Figure 6: Major Diseases Scatter Plot

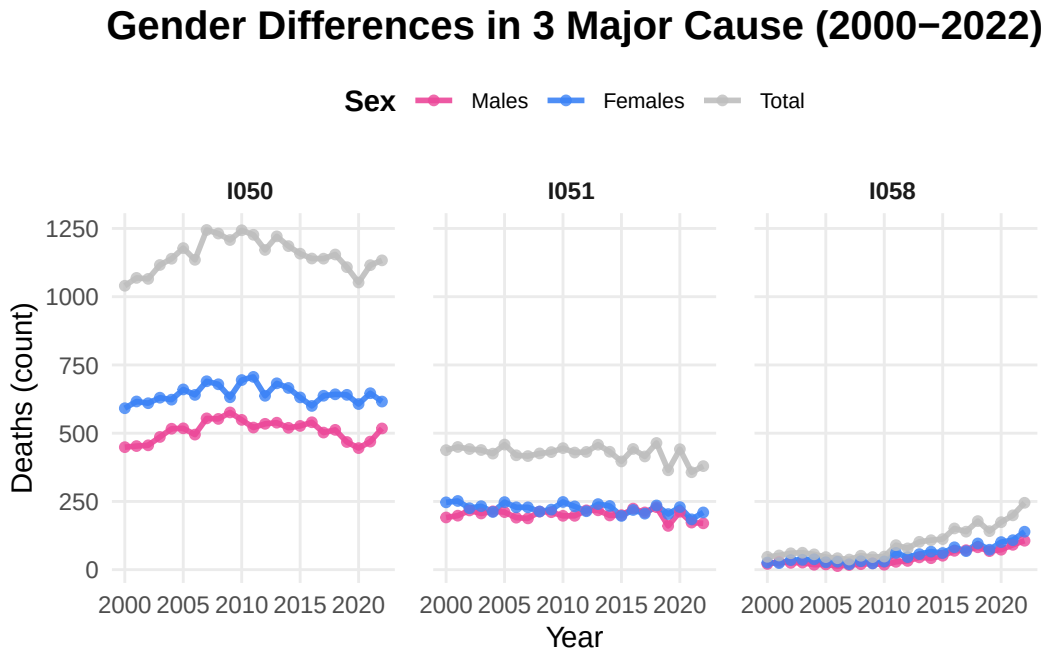

Figure 7: Gender-Specific Death

and recovery capacity. In general, and perhaps surprisingly, male infants are biologically more vulnerable during the perinatal stage, which suggests a greater susceptibility to preterm birth, respiratory distress, and other early developmental complications. However, beyond this stage, no profound gender differences are observed in disease patterns, and health risks become largely comparable between male and female infants after birth.