Income Inequality and Mortality: A Norwegian Perspective*

Aline Bütikofer   René Karadakic   Kjell G. Salvanes

February 6, 2021

Abstract

While Norway has experienced income growth accompanied by a large decline in mortality during the past several decades, little is known about the distribution of these improvements in longevity across the income distribution. Using municipality-level income and mortality data, we show that the stark income gradient in infant mortality across municipalities in the 1950s mostly closed in the late 1960s. However, the income gradient in mortality for older age categories across municipalities persisted until 2010 and only flattened thereafter. Further, the infant mortality gap between rich and poor Norwegian families based on individual-level data persisted several decades longer than the gap between rich and poor municipalities and only finally closed in the early 21st century.

Keywords— Income Inequality, Mortality, Health Behaviour   ***JEL***— D63, I12, J10, I14

1 Introduction

During the twentieth century, high-income countries experienced growth in real incomes accompanied by a historically unique decline in mortality. This negative association between income and mortality has been well documented across countries and the income gradient in mortality—the fact that relatively richer people live longer—is observed throughout the income distribution within

*The authors gratefully acknowledge comments by Janet Currie, Sonya Krutikova, Sarah Cattan, Hannes Schwandt, James Banks, and seminar participants at the Institute for Fiscal Studies and the Norwegian School of Economics. This work was partially supported by the Research Council of Norway through project No. 275800 and through its Centres of Excellence Scheme, FAIR project No. 262675 and by NORFACE DIAL grant No. 462-16-050. Bütikofer: aline.buetikofer@nhh.no; Karadakic: rene.karadakic@nhh.no; Salvanes: kjell.salvanes@nhh.no. Address for all authors: Department of Economics, Norwegian School of Economics, Helleveien 30, 5045 Bergen, Norway.

countries (Cutler, Deaton and Lleras-Muney, 2006; Case, Lubotsky and Paxson, 2002). Various reasons exist for the gradient in mortality, including that compared to the rich, the poor have higher exposure to economic and social stress, lower use of health care services, different health behaviours and settle in different neighbourhoods. Recently, the differences in life expectancy by income even increased in many high-income countries and there is evidence that life expectancy among the most disadvantaged groups in the US is on a downward trend (see, e.g., Chetty et al., 2016). Parallel to the decrease in life expectancy, inequality in mortality at older ages has increased in the US since the 1990s, while inequality in mortality among young people has decreased (Currie and Schwandt, 2016*b*).

Nevertheless, several aspects of the relationship between income and mortality remain not well understood. For instance, a question remains whether the recent increase in inequality in mortality is also evident in the context of a comprehensive welfare state like Norway, where a social safety net guarantees a living wage and access to a public health care system that is paid for from general taxation and that guarantees free medical care to all residents.[1] Moreover, we know little about the role of a social safety net, public health measures targeted at the poorest localities, and medical innovations in the decline in the mortality gradient among the young. Lastly, we still do not understand well whether closing the mortality gap at the local level also closes the within-location differences between the rich and poor.

In this paper, we first take a closer look at the inequality in age-group and gender-specific mortality rates in Norway over the past 30 years. To date, (Case and Deaton, 2015; Currie and Schwandt, 2016*a*,*b*; Currie, Schwandt and Thuilliez, 2020) document the trends in socioeconomic inequality in mortality in the US, France and Canada. While income inequality in Norway (as proxied by the Gini coefficient) is substantially lower than in the US, Canada or France (World Inequality Database, 2020), it has been on an increasing trend over the past 30 years, similar to other Western countries (Aaberge, Atkinson and Modalsli, 2016).[2] To analyse whether similar trends in the inequality in mortality rates also exist in more equal societies such as Norway, we followed Currie and Schwandt (2016*b*) and compared inequality in mortality across different municipalities ranked by income.

Changes in social conditions and medical progress are often first visible in infant mortality because mortality in younger ages typically reacts quicker to transformations influencing the whole of society. Moreover, inequality in adult health is documented to have its roots in childhood (Case, Lubotsky and Paxson, 2002). Hence, changes in infant mortality may be important determinants of the developments in longevity and inequality in mortality. As we usually measure life expectancy at mid-life, the measure necessarily omits the health and well-being of children. Therefore, in a second step we examined how inequality in infant mortality changed over a period of 70 years. Our analysis period started after the invention of antibiotics and the resulting dramatic decrease in deaths

[1] Kinge et al. (2019) documents that socioeconomic status is positively correlated with life expectancy in Norway.

[2] Note that inequality in Norway is still among the lowest of the countries analysed in this volume.

from infectious disease (Easterlin, 1995). Nevertheless, we investigated a period defined by major technological, medical and pharmaceutical innovations including the innovation of respirators, the introduction of many vaccines for widespread childhood illnesses and the finding that maternal smoking and environmental toxins negatively affect unborn children.

However, such innovations do not necessarily affect individuals equally across socioeconomic groups. While disease campaigns and new pharmaceuticals lowering mortality from poverty-related diseases decrease health inequality (Bhalotra and Venkataramani, 2015; Bütikofer and Salvanes, 2020), medical improvements in recent decades, for example in cancer treatment, are shown to increase the take-up of affluent groups first, and thereby serve to reinforce health inequalities (Glied and Lleras-Muney, 2008). Moreover, public health interventions, in particular information campaigns, may have a differential effect across socioeconomic groups if richer people are responding faster to advice (de Walque, 2010; Aizer and Stroud, 2010; Kjellsson, Gerdtham and Lyttkens, 2011). Hence, studying whether and how inequalities in mortality are changing over time is central to understanding the reasons behind the current mortality gradient and its future development.

Although the neighbourhood can have large effects on children's long-term outcomes (see, e.g., Chetty and Hendren, 2018), mortality—particularly infant mortality—may not only depend on the local area with its health care offerings, but also on the family and its health behaviour. Therefore, we leveraged the Norwegian register data and focused on both municipality- and individual-level income and thereby considered the infant mortality gradient across both municipalities (1951–2018) and households (1967–2018). This allowed us to distinguish between innovations improving and levelling out health care access or public health measures both across and within municipalities.

We present four key findings. First, we find that when using an internationally comparable framework, mortality decreased in Norway across all age categories between 1990 and 2018. While there were small income gradients in mortality in 1990 for some older age categories at the local level, mortality decreased more in disadvantaged municipalities and there was no difference in age-specific mortality rates across high- and low-poverty areas in Norway in 2018. Second, we show that infant mortality decreased in Norway between 1951 and 2018. While there were large disparities in infant mortality rates across rich and poor municipalities in 1951, these effectively closed by the end of the 1960s. This period of convergence in the mortality rate between rich and poor areas coincided with the rollout of better health care access for all and the expansion of the Norwegian welfare state. Third, we show that closing the infant mortality gap between the rich and the poor at the individual level took about 40 years longer than at the municipality level. That is, infants from the 10% richest families had a substantially lower mortality rate than those from the 10% poorest families until about 2010. Subsequently, the Norwegian infant mortality gap has closed at both the local and individual level.

There are several reasons why these inequalities in infant mortality across municipalities closed much earlier than across individuals. For example, the decrease in inequality across local areas in Norway coincided with the introduction of comprehensive social welfare institutions, universal access to infant health care, and extensive disease control and vaccination campaigns (Pekkarinen, Salvanes and Sarvimäki, 2017; Bütikofer, Løken and Salvanes, 2019; Bütikofer and Salvanes, 2020). Finally, we show that absolute mortality in the first few days of life and the mortality gap between the richest and the poorest Norwegian families changed prior to the 1980s, whereas mortality at 2–12 months post-birth changed dramatically in the 1990s and the income gradient for this age category completely vanished after 2010. Importantly, high-income families always led the sharp decreases in infant mortality. This suggests that advantaged groups can leverage the various health innovations more rapidly and adapt their behaviour more quickly to new knowledge.

This paper complements the growing literature on the relationships between income and mortality in high-income countries (Currie and Schwandt, 2016*b*; Chetty et al., 2016). First, we document—in an internationally comparable framework—that mortality has been decreasing in all Norwegian municipalities over the past 30 years and that inequality in mortality among older people has fallen. Second, we study trends in the mortality gradient over 70 years to shed light on whether the advent of the Norwegian welfare state was able to close the existing mortality gaps between the rich and poor. Moreover, we expand the literature by analysing local- and individual-level inequality in infant mortality to better understand whether future policies should target disadvantaged areas or disadvantaged families more directly.

The remainder of the paper is structured as follows. Section 2 describes the data. Section 3 provides the results for the internationally comparable framework. Section 4 presents the empirical findings on infant mortality. Section 5 concludes.

2 Data

To analyse the relationship between income inequality and mortality, we used various Norwegian register data. These population-wide panel data are primarily provided by Statistics Norway (SSB) and the Norwegian Public Health Institute (FHI). The SSB data include several registries for population, education, earnings and residency. We could link these data sets using individual identifiers and include information on residence, educational attainment and earnings. Parental identifiers enabled us to link parents and their children. The FHI maintains the medical birth registry and the death registry, which can be linked to other registry data. The medical birth registry provides information about the timing of infant deaths, birth weight, gestational age, and some indicators of the risky health behaviour of mothers (e.g. smoking). This enabled us, for example, to connect a child's birth outcomes to its parents' socioeconomic status. In addition, we made use of the detailed information on year of death and the municipality of residence at death, both of which are available after 1951.

Our income inequality measures were based on earnings data from 1967 to 2018. This earnings measure included discounted labour earnings, taxable sickness benefits, parental leave benefits, pensions, and unemployment benefits. For the death counts, we combined information from the death and medical birth registries.[3]

In Section 3, where we provide internationally comparable results on the mortality gradient in Norway, we aggregated the individual-level data to the municipality level to measure the link between poverty and mortality across local areas. We consider municipalities to be a relevant unit of analysis as they constitute the administrative level responsible for the delivery of health care services, such as general practitioners, emergency rooms and infant health check-ups, in Norway. We used earnings to create poverty shares for all municipalities in each year.[4] We defined the poverty share as the proportion of working age individuals (20 to 60 years of age) within a municipality earning less than 50% of national median earnings in the relevant year (OECD, 2020). Using annual population data for one-year age groups together with death counts, we then computed the age- and gender-specific mortality rate at the municipality level for each year.

In Section 4, we focus on the relationship between income inequality and infant mortality at the individual level. Infant deaths are all deaths of children that occur between delivery until the end of the first year of life of the child. We calculated cohort-specific infant death rates per 1,000 live births for different deciles of the parental lifetime earnings distribution. To compute the parental income distribution, we ranked children by parental lifetime earnings. The lifetime earnings of mothers and fathers were calculated by taking the average incomes of individuals between ages 34 and 40 years. Income in mid-life has been shown to provide a good approximation for the lifetime earnings of individuals and reflects socioeconomic status much better than the earnings of parents at the birth of the child (Nybom and Stuhler, 2016; Bhuller, Mogstad and Salvanes, 2017; Attanasio and Nielsen, 2020). This analysis allows us to shed some light on the relationship between children's socioeconomic status and infant mortality.

Table 1 provides some descriptive statistics for the sample used in Section 4. A birth cohort consisted of approximately 55,000 individuals. Overall, our sample included approximately 2.9 million live births between 1967 and 2018. Mothers were on average about three years younger than fathers and their average age at childbirth increased over the observational period. Education for parents also increased considerably, with 57% of women in 2015 obtaining some type of post-secondary degree. Likewise, earnings at birth increased substantially between 1970 and 2015. Note that we measured parental lifetime earnings between ages 34 and 40 years. For children of the youngest cohorts in our sample, this earnings measure was progressively based on earnings observations at younger parental ages and therefore did not increase in the same way as earnings at birth. As this measurement issue could influence our findings, we applied a sensitivity analysis whereby we grouped parents based on education instead, and employed three different education groups as an alternative to the lifetime earnings deciles. We classified parents into three broad

[3]Not all infant deaths that occur in the first few hours are included in the death registry. Therefore, we added additional information from the medical birth registry.

[4]Municipalities in Norway are subject to continuous aggregation and de-aggregation. Therefore, we harmonised municipalities in each year to match the municipality structure prevailing in 2019, consisting of 422 municipalities in mainland Norway. We excluded the Norwegian archipelagos in the Arctic Ocean (Svalbard and Jan Mayen) from the analysis.

educational groups based on their highest educational degree: individuals who had finished any post-secondary education (including short and long tertiary education), individuals who had only finished high school (secondary schooling), and those who had never finished high school (primary schooling).[5] For most of the analysis, the education of the mother was the primary measure, and only in cases where maternal education was not applicable did we use paternal education as our measure.

Table 1: Summary Statistics: Infant Mortality Sample

	1970	**1985**	**1995**	**2005**	**2015**
Number of Live Births	62,226	49,050	57,941	55,275	56,340
Share Male	0.48	0.48	0.48	0.49	0.49
Share Low Birth Weight ($\leq$ 2500 gram)	0.044	0.043	0.045	0.048	0.044
Share Preterm Birth ($\leq$ 37 gram)	0.054	0.057	0.067	0.069	0.061
Deaths per 1000 Live Births (1st year)	12.28	8.14	3.90	2.46	2.08
Mother's Age at Birth	26.19	27.35	28.84	30.25	30.68
Father's Age at Birth	29.26	30.24	31.71	33.26	33.63
Mother Post-Secondary Education	0.15	0.32	0.39	0.53	0.57
Mother Secondary Education	0.10	0.25	0.33	0.29	0.25
Parental Life Time Earnings	438.70	554.90	694.40	869.90	538.10
Parental Earnings at Birth	235.40	297.60	319.40	414.90	498.60

Note: Income in 1,000 Norwegian Kroner adjusted to 2015 level using CPI provided by SSB

3 Trends in Mortality Inequality Across Age Groups — Part A

This section aims to provide an internationally comparable overview of the development of mortality rates at the geographic level for different age, gender and income groups in Norway following Currie and Schwandt (2016*b*). We first ranked the municipalities using their poverty shares from richest to poorest, and grouped them into bins (ventiles), each representing approximately 5% of the Norwegian population in 1991, 2000, 2010 and 2017.[6] In addition, we aggregated the age- and gender-specific mortality rates for six distinct age categories, namely 0–4, 5–19, 20–49, 50–64, 65–79 and 80 or more years. Combining the mortality measures and the poverty ventiles allowed us to compute the one-year death rates for each year, gender, age and ventile cell. We age-adjusted the age groups to the year 2017.

[5] This classification follows SSB using NUS-2000 codes and categories as follows: post-secondary (6,7,8), secondary (4,5), and primary (0,1,2,3)

[6] Owing to the large population size of the Oslo municipality, we divided Oslo into six sub-areas based on basic statistical units (SSB, 2020).

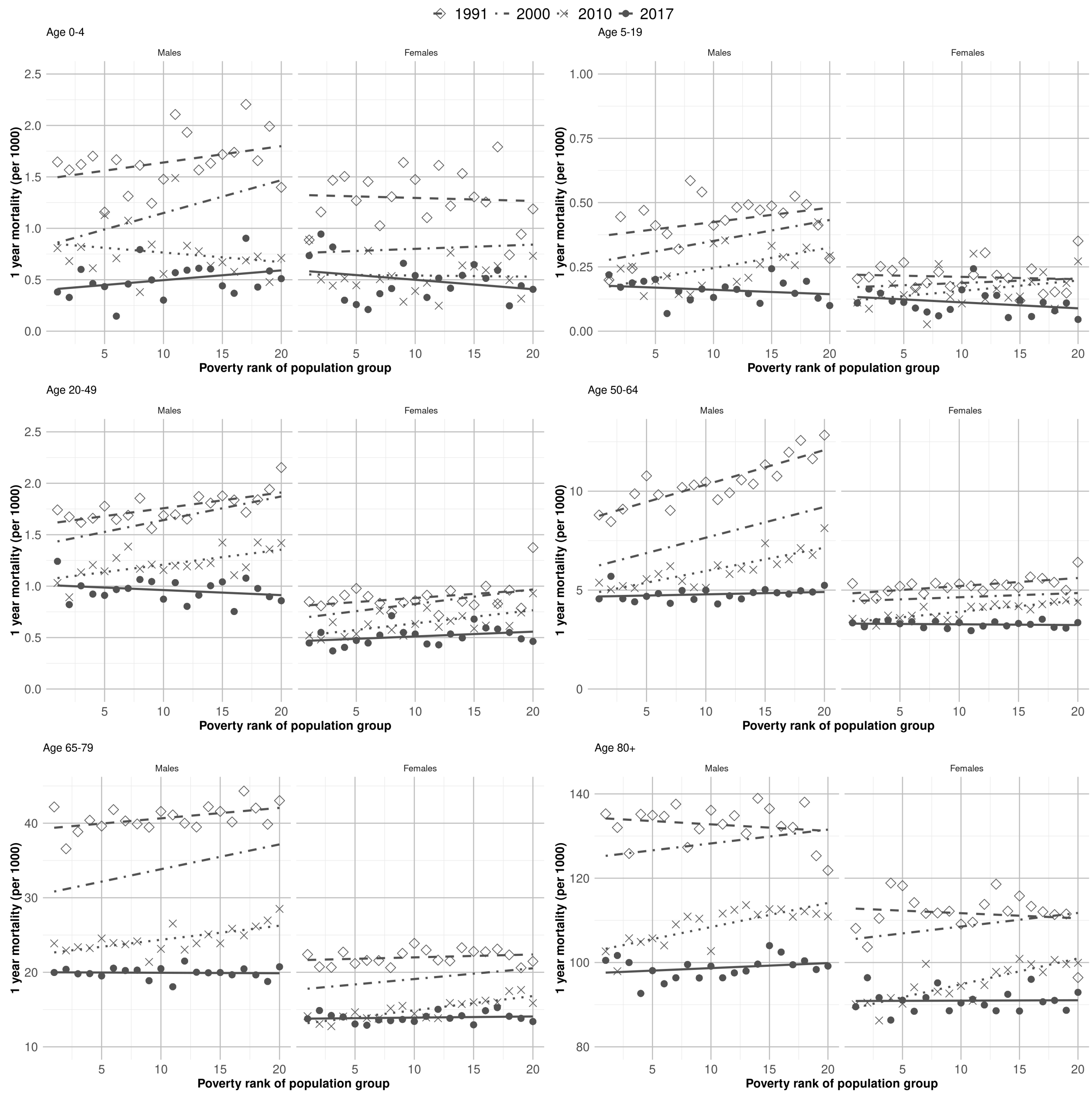

Figure 1: One-Year Mortality Rates by Municipality-Level Poverty Rates

Notes: Average one-year mortality rates are plotted across poverty rate percentiles. Each bin represents a group of municipalities with about 5% of the overall population in the respective year. Straight lines provide linear fits.

Figure 1 depicts the results for the internationally comparable analysis separately for each age group and gender in 1991, 2000, 2010 and 2017. The municipality-level poverty rank is on the x-axis, where municipalities with the lowest poverty share have the lowest poverty rank and vice versa, and the one-year age-adjusted mortality rates per 1,000 individuals is on the y-axis.[7] In Table 2, we report the age-specific mortality in the least and most deprived areas and the change in inequality for each group and time period. Moreover, we test whether the changes in slopes over time for each group are statistically significant.

Several patterns apply to all age groups. First, over the whole observation period, absolute mortality decreased in all age groups. Second, men of every age were more likely to die compared to women in the same age group. Even though the gap between female and male mortality narrowed over time, the gender disparities did not disappear for all age groups by 2017. Third, the income gradients in mortality were a predominantly male phenomenon at the municipality level. For women, there were no significant poverty gradients in morality. For men, however, several age categories initially depicted substantial differences in mortality between the more and less deprived areas. The fourth universal trend concerns the reductions in absolute mortality: even though the relative declines in mortality for men and women were similar in some age groups, the absolute declines in mortality were mostly driven by the large decrease in the mortality rates of men in the oldest age groups. Last, the poverty gradients in mortality declined over time, such that by the end of 2017 we did not observe any income gradients at the geographic level in any of the six age groups.

For men and women in the youngest age group (0 to 4 years), Figure 1 illustrates that their mortality decreased from approximately 1.7 to 0.5 per 1,000 and from 1.4 to 0.5 per 1,000, respectively. While there was no income–mortality gradient for girls in any of the years, the small gradient in mortality for boys disappeared between 2000 and 2010. The mortality in the age group 5 to 19 years was lower than for younger children. Nevertheless, the trends appear similar: a small decline in both gradient and mortality from 1991 to 2017 together with a very small mortality decline for men and no mortality inequality in any of these years for women. For the age group 20–49 years, we observed only small declines in mortality for both men and women and a very small decrease in the poverty gradient for men.

The largest gradient and decrease in gradient in mortality among men was in the age group 50 to 64 years. In 1991, men of the most advantaged ventile had a 50% lower mortality rate compared to men in the most disadvantaged ventile. By 2017, the differences across areas in mortality had evened out for both men and women in this age group. Both men and women in the age category 65 to 79 years experienced marked declines in absolute mortality of approximately 50% and 35%, respectively. For the age group 80 years and older, we observed the largest absolute declines in mortality. For men, deaths dropped by 37 per 1,000 and for women by approximately 35 per 1,000. Although there were weak gradients in mortality in the oldest age group before 2017, there was no longer inequality in mortality across municipalities in 2017.[8]

[7]Note that the results do not change substantially if we use municipality-level median and mean earnings for the ranking of municipalities instead of the poverty share.

[8]Note that we compared all our results to national averages of the Human Mortality Database and they matched in all age categories except for the 80 years and older category, where we missed approximately

Table 2: Age-Specific Mortality in Least and Most Deprived Areas and Change in Inequality

	Lowest Poverty Rate				Highest Poverty Rate				Slope Coefficient				P-Value		
	1991	2000	2010	2017	1991	2000	2010	2017	1991	2000	2010	2017	Δ^{1991}_{2000}	Δ^{2000}_{2010}	Δ^{2010}_{2017}
Men															
0-4	1.645	0.933	0.807	0.381	1.398	0.299	0.712	0.511	0.016	0.032	-0.009	0.009	0.422	0.042	0.112
									(0.010)	(0.017)	(0.010)	(0.006)			
5-19	0.199	0.361	0.209	0.219	0.283	0.500	0.293	0.100	0.006	0.008	0.008	-0.002	0.606	0.967	0.003
									(0.004)	(0.003)	(0.003)	(0.002)			
20-49	1.741	1.389	1.031	1.241	2.153	1.664	1.419	0.858	0.015	0.023	0.015	-0.005	0.280	0.238	0.003
									(0.004)	(0.006)	(0.004)	(0.004)			
50-64	8.795	5.728	5.376	4.559	12.840	9.482	8.133	5.239	0.175	0.156	0.118	0.012	0.560	0.214	0.000
									(0.024)	(0.023)	(0.019)	(0.013)			
65-79	42.180	32.520	23.870	19.970	43.030	38.880	28.510	20.740	0.140	0.333	0.188	-0.007	0.032	0.078	0.002
									(0.059)	(0.063)	(0.049)	(0.030)			
80+	135.300	127.100	102.600	100.500	121.900	115.500	110.900	99.170	-0.155	0.327	0.572	0.119	0.099	0.330	0.005
									(0.179)	(0.222)	(0.111)	(0.101)			
Women															
0-4	0.887	0.740	0.888	0.734	1.188	0.560	0.732	0.407	-0.003	0.004	-0.001	-0.009	0.616	0.643	0.430
									(0.011)	(0.009)	(0.007)	(0.008)			
5-19	0.204	0.100	0.111	0.109	0.351	0.336	0.272	0.046	-0.001	0.002	0.004	-0.002	0.467	0.553	0.049
									(0.002)	(0.003)	(0.003)	(0.002)			
20-49	0.849	0.769	0.520	0.447	1.375	1.117	0.930	0.463	0.008	0.014	0.013	0.005	0.341	0.805	0.106
									(0.005)	(0.004)	(0.004)	(0.003)			
50-64	5.335	4.541	3.553	3.343	6.410	4.299	4.406	3.358	0.041	0.021	0.057	-0.004	0.294	0.025	0.000
									(0.013)	(0.013)	(0.008)	(0.006)			
65-79	22.390	20.010	14.120	13.770	21.470	22.160	15.870	13.390	0.039	0.144	0.191	0.015	0.057	0.336	0.000
									(0.038)	(0.038)	(0.030)	(0.027)			
80+	108.100	102.300	90.100	89.510	96.430	106.000	99.930	92.930	-0.120	0.323	0.614	0.009	0.079	0.095	0.000
									(0.201)	(0.140)	(0.097)	(0.106)			

Columns (1)-(8) report the means of (smoothed) 1-year mortality rates for each gender and age group in 1991, 2000, 2010 and 2017, in the bin of municipalities with lowest and highest poverty rate, respectively. Columns (9)-(12) report the coefficient of the fitted regression line in each year. Column (13)-(15) report p-values for the null hypothesis that the slopes in the respective years (see column header) are equal. Standard errors for regression coefficients are reported in parentheses.

Note that the finding that mortality is equally distributed across municipality-level poverty rates does not mean that mortality in Norway is no longer income dependent. It is important to point out that the analysis presented in Figure 1 shows that the aggregate mortality difference between poor and rich areas evened out in 2017. In Section 4, we therefore focus on a municipality- and individual-level approach to describe how the gradients in infant mortality changed over time in terms of local and individual inequality.

4 Mortality Inequality Among Infants 1951–2018 — Part B

The great decline in infant mortality during the 20th century and its causes and consequences has been of great interest to researchers and policy makers alike. Like other developed countries, Norway experienced a marked decline in infant mortality between 1900 and 1955 from 80 deaths per 1,000 live births in 1900 to 23 deaths per 1,000 live births in 1955 (Backer, 1963). This period is often referred to as the 'Mortality Revolution' (Easterlin, 1995) and is characterised by a decrease in deaths from infectious disease. In particular, advances in public health such as water purification (Cutler and Miller, 2005; Beach et al., 2016; Alsan and Goldin, 2019) and infant health care services (Moehling and Thomasson, 2014; Hjort, Sølvsten and Wüst, 2017; Bhalotra, Karlsson and Nilsson, 2017; Bütikofer, Løken and Salvanes, 2019) and medical developments such as the introduction of antibiotics (Bhalotra and Venkataramani, 2015) contributed to the large decline. Although the decline slowed after 1955, further advances in medical technology, pharmaceutical innovations, and public health measures led to substantial decreases in infant mortality from 15 deaths per 1,000 live births in 1967 to 2.5 deaths per 1,000 live births in 2018 (see, e.g., Daltveit et al., 1997; Bharadwaj, Løken and Neilson, 2013). In this section, we investigate the development of the mortality inequality among infants at the municipality and individual levels to discuss, for example, how the expansion of the Norwegian welfare state and new medical technologies altered the gradient between income and infant mortality.

4.1 Methodology

Our main analysis concerns the comparison of infant mortality rates—deaths during the postnatal period until the end of the first year of life—from 1967 to 2018. We computed gender-specific mortality rates (deaths per 1,000 live births) for all infants as well as for four distinct age groups: 0–24 hours after birth, 2–7 days after birth, 8–28 days after birth and 29–365 days after birth.

20% of deaths using our data. The difference likely arose for two main reasons. First, we used different data sources than the Human Mortality Database. Second, we only included individuals that were residents in a municipality at the time of death and therefore excluded Norwegian citizens with a place of residence outside Norway. Nonetheless, the discrepancy should not pose a problem in interpreting the gradients and trends in our mortality data for this age group.

To compare income gradients in infant mortality rates in Norway over time, we ranked infants according to their parental lifetime income and calculated the three-year mortality rates by decile of parental income. Note that we used three-year mortality rates as the annual rates of deaths per thousand live births for specific gender, age, decile and year groups can be volatile in a small population such as Norway. For consistent scaling, we adjusted the definition of the mortality rate in the following way:

$$\mathrm{MR}_{d,g,t} = \frac{\sum_{t=t-1}^{1} \mathrm{deaths}_{d,g,t}}{\mathrm{births}_{d,g,t} \cdot 3},$$

where $\mathrm{MR}_{d,g,t}$ is the three-year mortality rate divided by three for a specific decile d, gender of the child g, and year t. Specifically, we scaled the three-year infant mortality rate to an annual rate that enabled us to interpret it in a similar fashion as the definition of deaths per 1,000 live births.

For the years 1951 and 1954 where we studied infant mortality by municipality income level, we used one-year mortality rates.

4.2 Infant Mortality by Gender and Age 1968–2018

As discussed, infant mortality in Norway has declined from approximately 15 deaths per 1,000 live births in 1967 to 2.5 deaths per 1,000 live births in 2018. Figure 2 depicts the development of infant death rates separately for boys and girls. The figure illustrates two distinct features. First, male infants were subject to an infant mortality rate that was about 40 percent higher than that of female infants in 1967. This gender mortality gap continuously declined and had almost disappeared by the beginning of the 21st century. Second, as also shown in Figure 2, the decrease in infant mortality for both men and women was steeper before the mid-1990s than afterwards.

Figure 2: Infant Mortality 1967–2018 by Gender

Notes: Cohort-specific infant mortality by gender between 1967 and 2018. Each dot represents the cohort-specific deaths in the first year after birth per 1,000 live births.

Different medical innovations could affect infant death rates at different times after delivery. To investigate these differences, we plot the deaths per 1,000 live births in Figure 3 for four distinct age categories by gender. The first category captures infant deaths within the first 24 hours after delivery, the second category deaths occurring between 2 and 7 days after birth, the third deaths between 7 and 28 days after birth, and the last category shows all infant deaths that occurred 28 days or more after birth.

Figure 3 displays several distinct trends. While the decrease in the mortality rate from 1967 to 2018 was about 90% among the first two categories and about 80% among the second two categories, the decrease was more modest for the category containing deaths between 8 and 28 days after birth. Importantly, the sharpest declines in mortality occurred during different decades for each of these age categories. Deaths 0–24 hours after birth and deaths 2–7 days after birth fell most strongly between 1967 and 1980, likely because of technological advancements in neonatal medicine implemented during the 1970s and 1980s. In particular, treatments for infants with respiratory disorders became increasingly effective (see, e.g., Bharadwaj, Løken and Neilson, 2013). Jorgensen (2010), for example, suggests that the use of a surfactant as a treatment for respiratory distress syndrome reduced mortality from respiratory distress among infants by 40 percent in the US. In addition, the increasing availability of incubators, better respiratory management, ventilators, and overall improvements in neonatal care improved the chances of survival for low birth weights and preterm births in the critical post-delivery period (Lee et al., 1999).

Although there is a steady decrease in infant mortality among the ages 8 to 28 days, the reduction does not display a clear pattern and is thus more difficult to link to a specific technological progress or public health campaign. Nevertheless, the decrease in mortality likely reflects general improvements in health care, health care access and the health behaviour of mothers.

The gender gap in the mortality rate for infants between 29 and 365 days is much smaller than for the other categories. The most visible decline in infant mortality for this category started in the late 1980s and early 1990s, where we see a drop in male infant mortality of almost 70% within just five years. This phenomenon coincides with an influential article published in one of Norway's largest newspapers discussing the association between the sleeping position of the infant and occurrences of sudden infant death syndrome (SIDS). In turn, the article was based on the results from a larger Norwegian surveillance system introduced to limit SIDS and marks the starting point of a major public health campaign encouraging parents to have their infants sleep on their backs (Daltveit et al., 1997). Later research corroborated that sleeping in a prone position influences infant respiration and their ability to move their body in life-threatening situations, both of which can have lethal consequences.

Overall, different technological developments and new medical insights reduced infant death rates at different ages. The remainder of the paper discusses whether the reductions in infant mortality observed for different age groups had differential consequences along the parental income distribution.

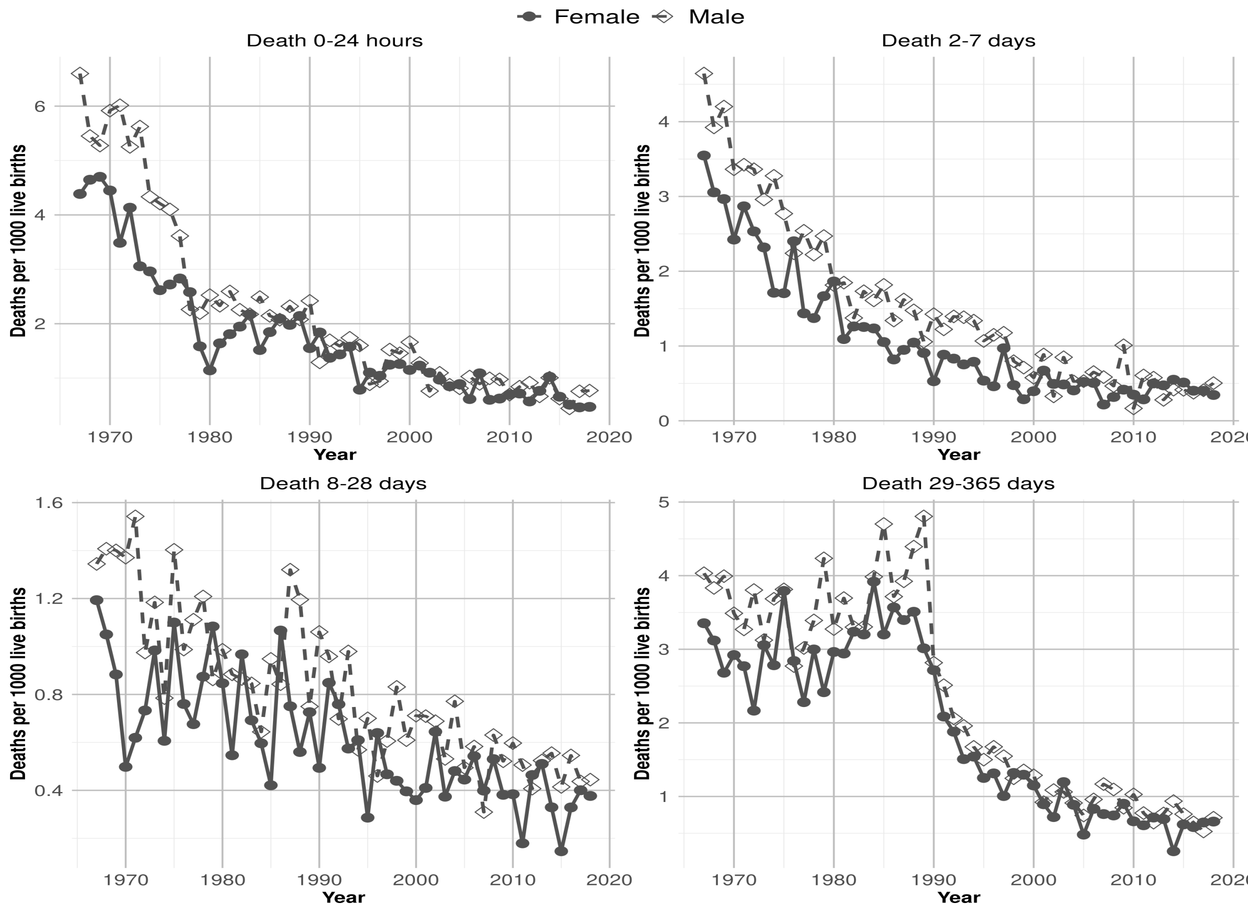

Figure 3: Infant Deaths 1967–2018 by Gender and Age Category

Notes: Cohort-specific infant mortality by gender and age category between 1967 and 2018. Each dot represents cohort-specific deaths in one of the four age categories (0–24 hours, 2–7 days, 7–28 days, and 29–365 days after birth) per 1,000 live births.

4.3 Inequality and Infant Mortality 1951–2018

Infant mortality decreased over many decades. However, the question remains of whether public health investment and widespread availability of medical technology can close the mortality gap between rich and poor children. In a first step, we extended the inequality analysis in Section 3 to include all years between 1967 and 2018. Although there was little gradient in mortality among the youngest group (ages 0–4 years) at the municipality level between 1990 and 2017 (see Figure 1), the expansion of the Norwegian welfare state and the advent of new industries in Norway such as oil and gas production in the 1960s and 1970s could have evened out the income disparities across municipalities and thereby lowered the inequality in infant mortality between 1967 and today. The results for this extension are shown in Figure 4; the left panel presents the results for males and the right panel for females. Both panels plot infant deaths per 1,000 live births on the y-axis and birth year on the x-axis. Municipalities are ranked by the municipality-level poverty rate. The triangles and dots identify the infant mortality for the poorest and richest 10 percent of municipalities, respectively.

Figure 4 displays the strong decline in infant mortality from 1967 to 2018 discussed earlier (see Figure 2). Although mortality is a little higher in 1967 and the decline in mortality for the poorest municipalities is slightly steeper than that for the richest municipalities, the differences between rich and poor municipalities are not significant. This indicates that geographical differences in infant mortality were already small in Norway in the late 1960s.[9] As a variety of factors affect infant deaths, including health care access, environmental influences, genetic endowment and health behaviour of the parents, particularly mothers' behaviour, there are several reasons that can explain these small geographic differences.

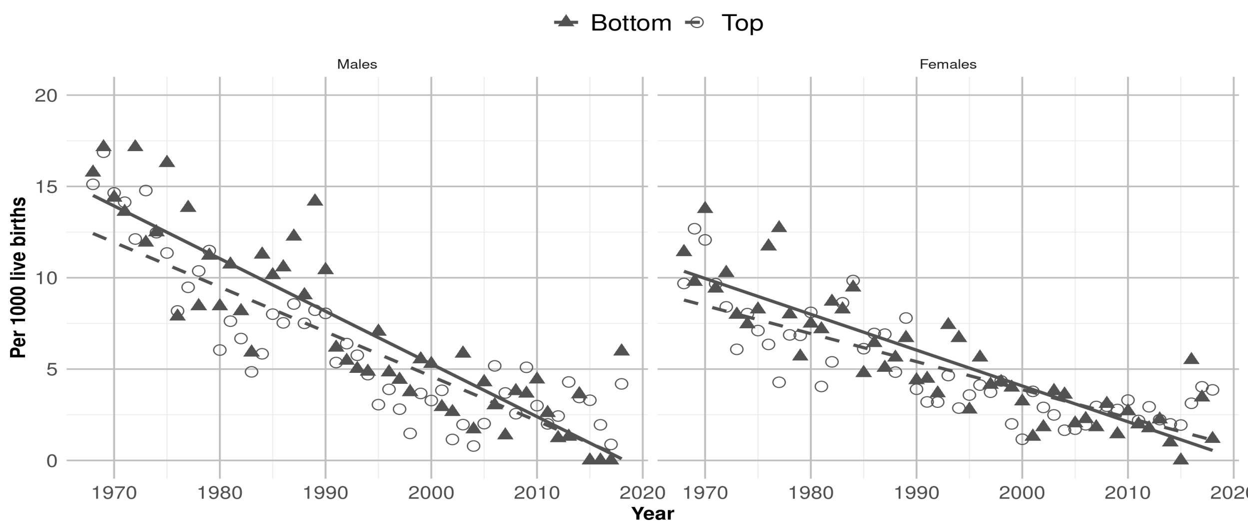

Figure 4: Municipality-Level Inequality of Infant Deaths 1967–2018

Notes: Cohort-specific infant mortality by gender in municipalities with the 10% highest and 10% lowest poverty rates from 1967 to 2018. Each triangle/dot represents infant deaths per 1,000 live births. Straight lines provide linear fits.

Access to infant health care was rolled out in Norway in the first half of the 20th century with the goal to reach out to everyone and to establish a unified and free primary health care system for infants (Bütikofer, Løken and Salvanes, 2019). Almost all municipalities had a centre providing infant health care in the late 1960s and in 1972, it became mandatory for all municipalities to operate state-funded health care centres for infants and mothers. The Health Directorate, through official guidelines and handbooks, regulated the services provided by the centres, with the centres being responsible for the national vaccines programme and information campaigns targeting new parents. This suggests that universal health care investments before the late 1960s may have evened

[9]Note that infant mortality is an extreme health outcome and our findings do not necessarily suggest that newborns are equally healthy across all municipalities.

out any health inequalities by geography to a large degree.

To investigate the importance of public health policies and the diffusion of medical innovations such as antibiotics before 1967, we documented inequality in mortality in the 1950s by combining infant mortality data from the Death Register in 1951 and 1954 with aggregate data on municipal-level average taxable income in the same years.[10] Figure 5 depicts the differences in infant deaths per 1,000 live births in 1951, 1954 and 1968 in the 10% richest and 10% poorest municipalities. The figure shows that even though geographical differences in infant mortality across municipalities were small in the late 1960s, there was a clear gradient in the early 1950s. In particular, the infant mortality rate in municipalities in the bottom decile in 1951 and 1954 was twice as high as the infant mortality rate in the top decile of the municipality-level income distribution. While the mortality rate only decreased to a small degree between 1951 and 1968 in the richest municipalities, infant deaths were decreasing dramatically between 1954 and 1968 in the poorest areas.

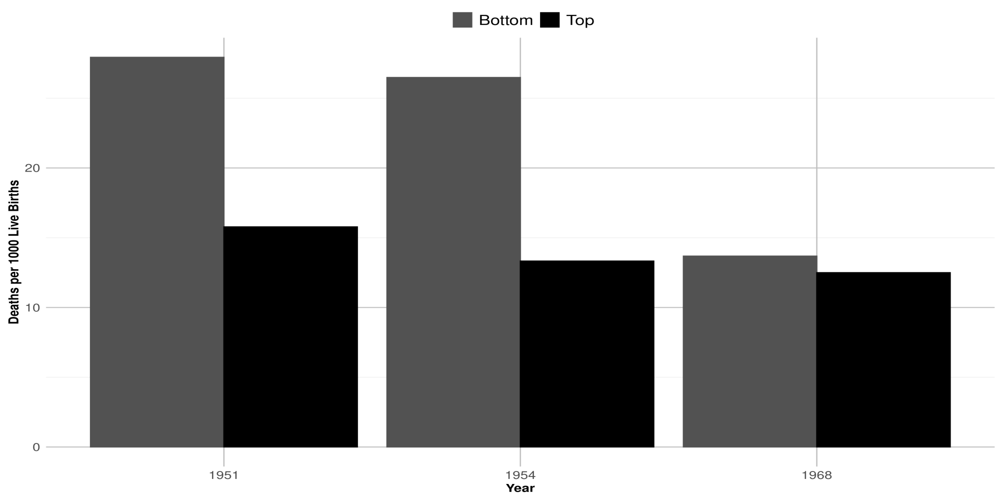

Figure 5: Municipality-Level Inequality of Infant Deaths 1951, 1954 and 1968

Notes: Cohort-specific infant mortality in the municipalities with the 10% highest and 10% lowest average tax incomes in 1951, 1954 and 1968. Each bar represents infant deaths per 1,000 live births.

In addition to infant health care, there are several other reasons why the inequalities in infant mortality fell sharply in the 1950s and 1960s. Similar to the other Nordic countries, Norway introduced comprehensive social welfare institutions, which enhanced access to public services and social insurance with important implications for inequality and social mobility during the 1950s and 1960s (Pekkarinen, Salvanes and Sarvimäki, 2017). Moreover, economic recovery programmes in the aftermath of World War II brought changes to the pre-war economic structure and income distribution. In addition, the availability of effective antibiotics and advancements in disease detection techniques led to extensive disease control campaigns, for example against tuberculosis,

[10]The aggregate income data was compiled from the Norwegian municipality database (Kommune-database) provided by the Norwegian Centre for Research Data (NSD).

which lowered the disease burden in poor Norwegian municipalities (Bütikofer and Salvanes, 2020). Moreover, 1953 saw a new law for child immunisation against diphtheria introduced, followed by a vaccine against polio in 1956 (FHI, 2017). Overall, these interventions lowered poverty or at least the consequences of being poor and had important equalising effects on the infant mortality rate across municipalities.

Even though the differences between rich and poor municipalities in infant mortality were small in the late 1960s in Norway, there may still have been large income disparities in infant mortality within municipalities. Because family socioeconomic status could affect parental behaviour or the possibilities of families shielding themselves from negative environmental influences, we additionally studied inequality at a less aggregated level. In particular, we analysed the differences in infant deaths between children born into the top and bottom deciles of the parental income distribution between 1967 and 2018. Moreover, we documented mortality inequality for different age groups to further our understanding of what policies are most central in closing the socioeconomic mortality gap.

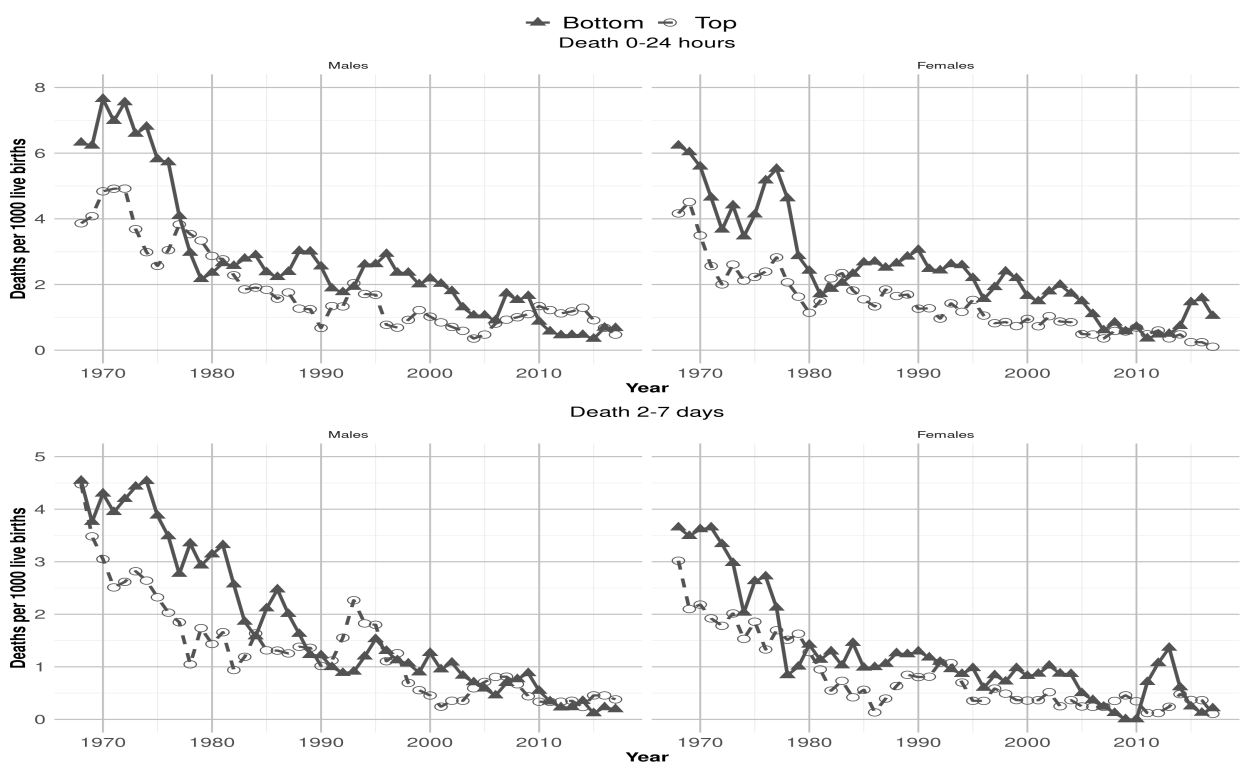

Figure 6: Individual-Level Inequality of Infant Deaths 0–24 Hours and 2–7 Days after Birth

Notes: Infant mortality in the top and bottom deciles of the parental income distribution by gender from 1968 to 2017. Each dot/triangle represents cohort-specific infant deaths per 1,000 live births 0–24 hours or 2–7 days after birth. Parental lifetime income is calculated by taking the average income of individuals between age 34 and 40.

Figures 6 and 7 depict the male and female infant death rates for the different age categories of infant death. For all age categories, male mortality rates are higher. The time patterns, however, are similar for both genders, indicating that men and women both benefited from improvements in health technologies and information at a similar point in time.

The mortality gap between the poorest and richest families was quite substantial in the 1960s and 1970s among males and females in the first two categories (see Figure 6). As discussed in Section 4.2, deaths within the first 24 hours after birth declined sharply in the 1970s. Interestingly, this became evident about five years earlier for the richest individuals compared to the poorest individuals, suggesting that affluent families were faster adaptors of medical technology or acted more quickly to public awareness campaigns about the negative consequences of maternal smoking during pregnancy (see, e.g., Aizer and Stroud, 2010). Overall, the decline in infant mortality was larger for the bottom decile than the top decile. In particular, the mid-1970s brought tremendous improvements regarding infant mortality for the poorest income groups. This suggests that the medical advances in neonatal care in the 1970s were likely to have reduced inequality and thereby benefited the more vulnerable disproportionately to higher socioeconomic status families.[11] The income gradient in infant mortality in the first 24 hours only disappeared between 2005 and 2010, while the mortality gap between children born into the poorest and the richest families closed in 2018. The pattern for deaths between 2–7 days after birth resembled that for the earliest timing category. The gap between rich and poor after the mid-1980s was, however, much smaller than for deaths within the first 24 hours.

The pattern for deaths between 8–28 days and 28 days after birth differed from those for the younger age categories. Deaths between 8–28 days after birth were slightly higher for infants from a lower socioeconomic background than those from a higher socioeconomic background during most of the analysis period. Due to the small number of deaths occurring for this timing category, the year-to-year variation in infant mortality in this category was very high. Nevertheless, Figure 7 reveals that both the mortality rate and the income differences declined over time and the rates for infants from less and more deprived backgrounds converge around 2010. Infant deaths between 29 and 365 days after birth did not decline significantly until 1990, and the gradient between the top and bottom deciles was substantial and persistent until the end of the 1980s. In 1987, the average infant mortality rate was approximately 50% higher in the bottom decile of the parental income distribution compared to the top decile. However, a substantial decrease in the mortality rate for this age category in the 1990s closed the income gap substantially. By the mid-1990s, the average infant mortality rate was 20% higher among the poorest than the richest families. As discussed, information campaigns encouraging parents to have their infants sleep on their backs in the 1990s coincide with this sharp decrease in death rates among this age category. The mortality inequality

[11]Note that there is a negative correlation between socioeconomic status and the likelihood of low birth weight and preterm births. Hence, improvements in neonatal care might be more beneficial to newborns from poor families. In Section 4.4, we discuss this relationship in detail.

further decreased for death between 29 and 365 days after birth and disappeared around 2015.[12]

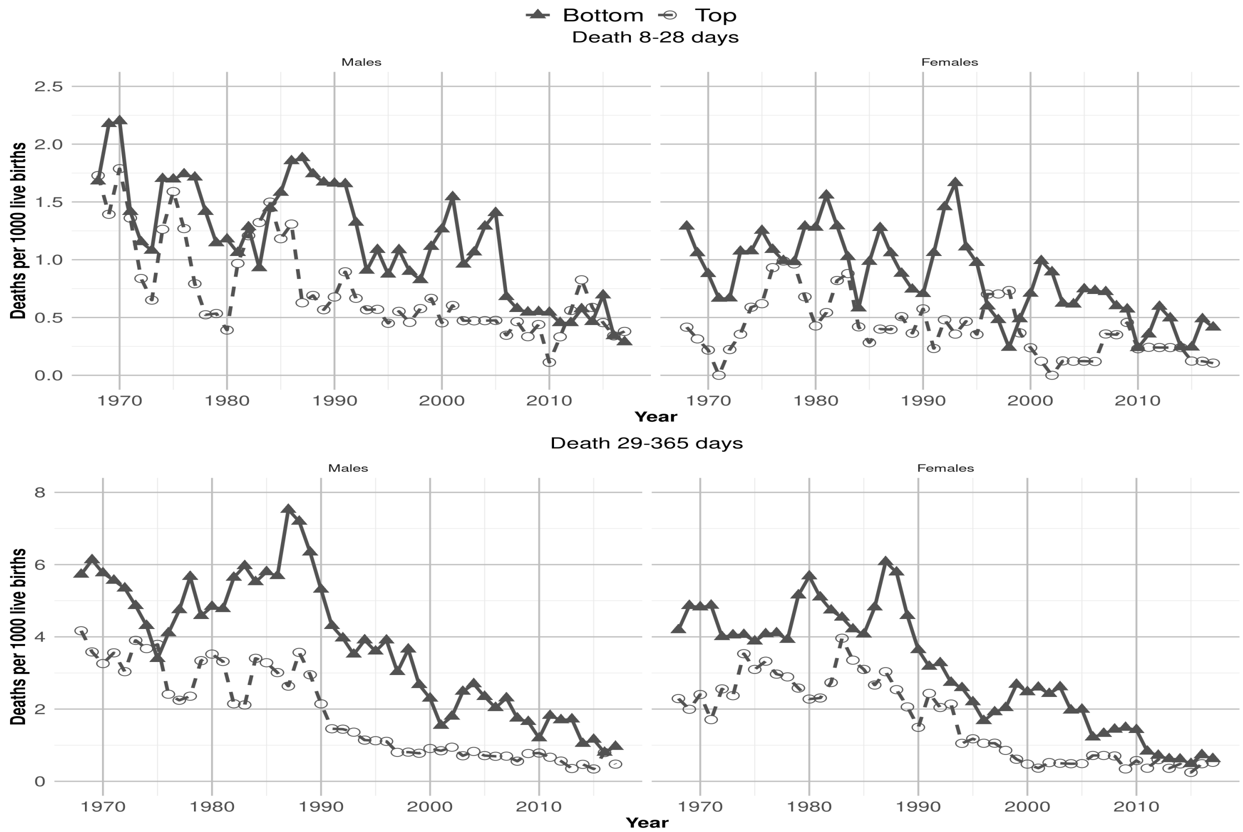

Figure 7: Individual-Level Inequality of Infant Deaths 8–28 and 29–365 Days after Birth

Notes: Infant mortality in the top and bottom decile of the parental income distribution by gender from 1968 to 2017. Each dot/triangle represents cohort-specific infant deaths per 1,000 live births 8–28 or 29–365 days after birth. Parental lifetime income is calculated by taking the average income of individuals between ages 34 and 40 years.

Overall, children born into both the top and the bottom part of the parental income distribution benefited from large declines in infant mortality between 1967 and 2018. The periods of decline in mortality rates mostly started among the most advantaged families first. However, the decrease was disproportionately larger among children from the lowest socioeconomic background and the income gap in infant mortality for all age groups closed by 2015. These differences in the timing of the closing of the infant mortality gap at the local and individual level are striking. Moreover, they may well explain why our results presented in Section 3 differ from the findings of Kinge et al. (2019), which concludes that the differences in life expectancy at 40 years of age by individual income increased from 2005 to 2015 in Norway.

[12]Note that a sensitivity analysis studying mortality differences based on parental education instead of parental lifetime income confirms that the infant mortality gap between high and low socioeconomic status at the individual level closed by 2018 for all four age categories. The results are in Appendix Figure A1.

4.4 Low Birth Weight and Preterm Deliveries

Children born with low birth weight (birth weights less than 2,500 grams) and preterm deliveries (born before the end of the 37th week of gestation) account for a large share of infant deaths. A question remains whether socioeconomic differences in low birth weight and preterm births could explain part of the link between income inequality and infant mortality and the disappearance of the income–mortality gradient in the 2000s. Low birth weight is frequently associated with higher rates of subnormal growth, illness and neuro-developmental problems (Hack, Klein and Taylor, 1995). Birth weight is determined by a variety of factors during the in utero period such as nutritional intake, stress, illness, pollution and maternal health behaviour (e.g. smoking) (see, e.g., Almond, Hoynes and Schanzenbach, 2011; Aizer, Stroud and Buka, 2016; Almond, 2006; Currie and Walker, 2011; Lien and Evans, 2005) and birth weight is shown to affect later-in-life outcomes (Black, Devereux and Salvanes, 2007). Similarly, preterm births are related to poorer lung development, which also affects cognitive ability and labour market outcomes (Bharadwaj, Løken and Neilson, 2013). We leveraged detailed information in the medical birth registry to investigate how low birth weight and preterm birth relate to the decline in infant mortality and the potential underlying mechanisms.

Figure 8 illustrates the male and female rates of children born with low birth weight and preterm births over time. These rates are the average number of low birth weight or preterm births per 1,000 live births by decile of parental lifetime income. The figure shows a substantial socioeconomic gap in the frequency of low birth weight and preterm births prior to 2010, and the fact that between 1967 and 2010, both low birth weight and preterm births increased for the top and the bottom income deciles. There are two potential reasons for the latter. First, low birth weights and preterm birth are positively correlated with the mother's age at birth. As the average age of mothers at birth increased by four years from 1967 to 2018, these age differences might have resulted in a slight increase in low birth weight and preterm births over the analysis period. Second, the definitions of infant mortality near the threshold of viability differ between countries, and reporting standards can change over time (Chen, Oster and Williams, 2016).

Most importantly, Figure 8 shows that socioeconomic differences in low birth weight and preterm births decreased after about 2005. After 2010, the gap in birth outcomes between the 10% richest and 10% poorest families closed. This convergence coincides with the convergence in infant mortality presented in Figures 6 and 7.[13]

As maternal smoking constrains foetal growth and increases the likelihood of preterm birth or low birth weight (see, e.g., Kramer, 1987, for an overview), socioeconomic differences in mothers' smoking behaviour could be a driver of the patterns observed above. In particular, Aizer and Stroud (2010) suggest that the information on the negative effects of smoking on health had an immediate impact on educated mothers and the health of their newborns. Less-educated mothers changed their

[13] Note that a sensitivity analysis studying differences based on parental education instead of parental lifetime income confirmed these findings. The results are presented in Appendix Figure A2.

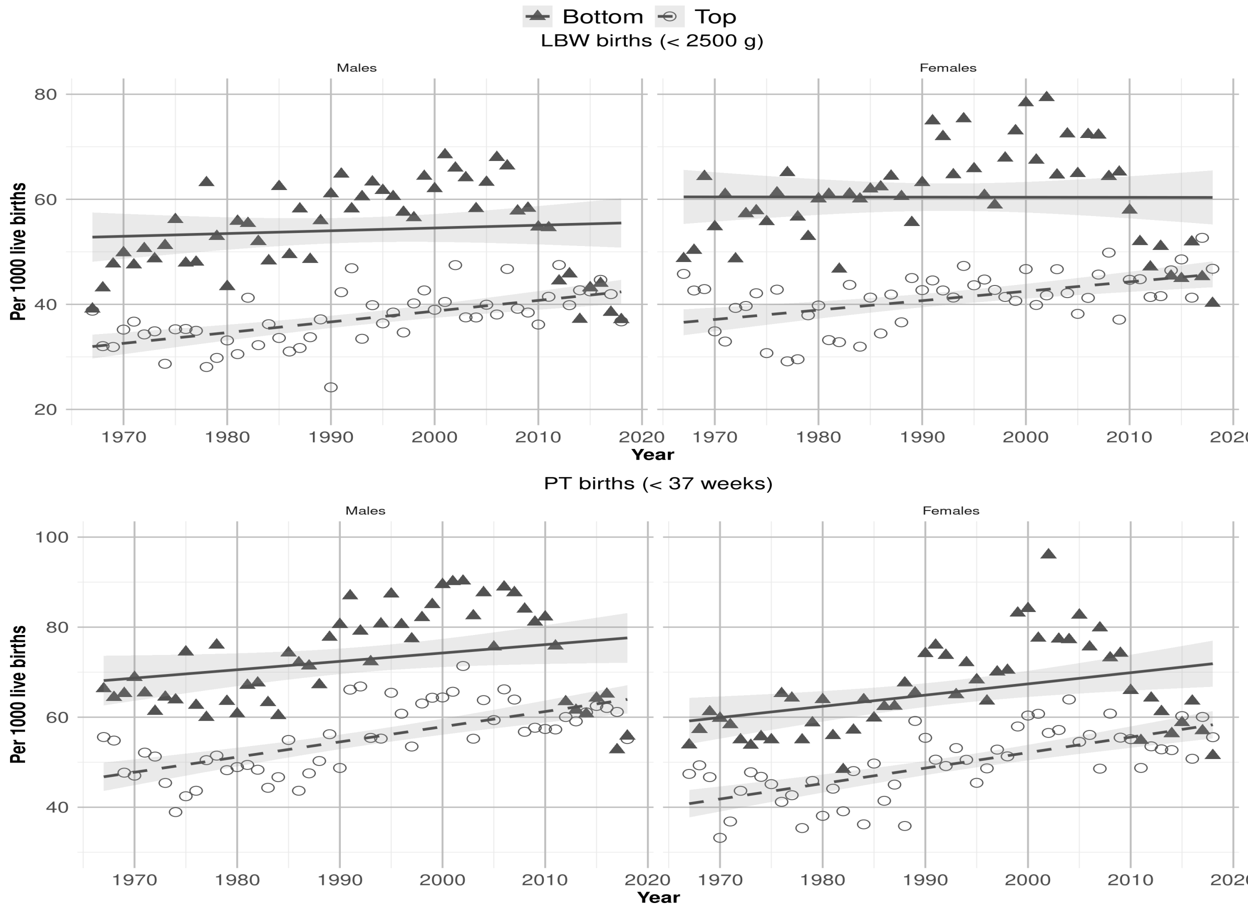

Figure 8: Individual-Level Inequality in Low Birth Weight and Preterm Births 1968–2018

Notes: Cohort-specific numbers of children born with low birth weight (<2500 gram) and preterm deliveries (before the end of the 37th week of gestation) per 1,000 live births in the top and bottom deciles of the parental income distribution by gender from 1967 to 2018. Parental lifetime income was calculated by taking the average income of individuals between ages 34 and 40 years.

smoking behaviour much later. Convergence in the smoking behaviour of rich and poor mothers could therefore be a driver of the closing of the socioeconomic gap in low birth weight, preterm births and the infant mortality rate. Since 2000, the Medical Birth Register has included several questions on maternal smoking behaviour. We plot the likelihood of smoking at the end of the pregnancy by children's birth cohort in Figure 9. While more than 20% of the most disadvantaged mothers reported smoking at the end of the pregnancy, only 5% of the most advantaged mothers smoked during pregnancy in 2000. The figure shows a rapid decline in the percentage of mothers smoking at the end of the pregnancy in the bottom decile of the income distribution. This decline is present for both male and female infants and is almost identical in magnitude. By 2018, almost no mothers in the top decile of the income distribution reported smoking while pregnant and only 1% of the mothers in the bottom decile still smoked during pregnancy.[14]

[14]Note that a sensitivity analysis studying differences based on parental education instead of parental

Changes in smoking policies and tobacco tax hikes are shown to influence maternal smoking behaviour and the exposure of infants to second-hand smoke (Lien and Evans, 2005; Adda and Cornaglia, 2010). Although Norway's Tobacco Act of 1988 forbids smoking in public premises and vehicles, a 2004 change in the law extended the smoking ban to bars and restaurants. This policy decreased maternal smoking among mothers working in bars and restaurants (Bharadwaj, Johnsen and Løken, 2014), accompanied by major smoking prevention campaigns. Hence, the decrease in the socioeconomic gap in smoking could have accelerated with the reform in 2004. While smaller in utero exposure to maternal smoking mostly affects low birth weight and preterm incidents and thereby infant mortality during the first week of life, less exposure to second-hand smoke during the first year of life strongly relates to lower rates of SIDS (Carpenter et al., 2013; CDC, 2020) and thus the decline in infant deaths 29–365 days after birth. Hence, the changes in the smoking behaviour of mothers are likely to have constituted a contributing factor to the closing of the socioeconomic gap in infant mortality after 2000.

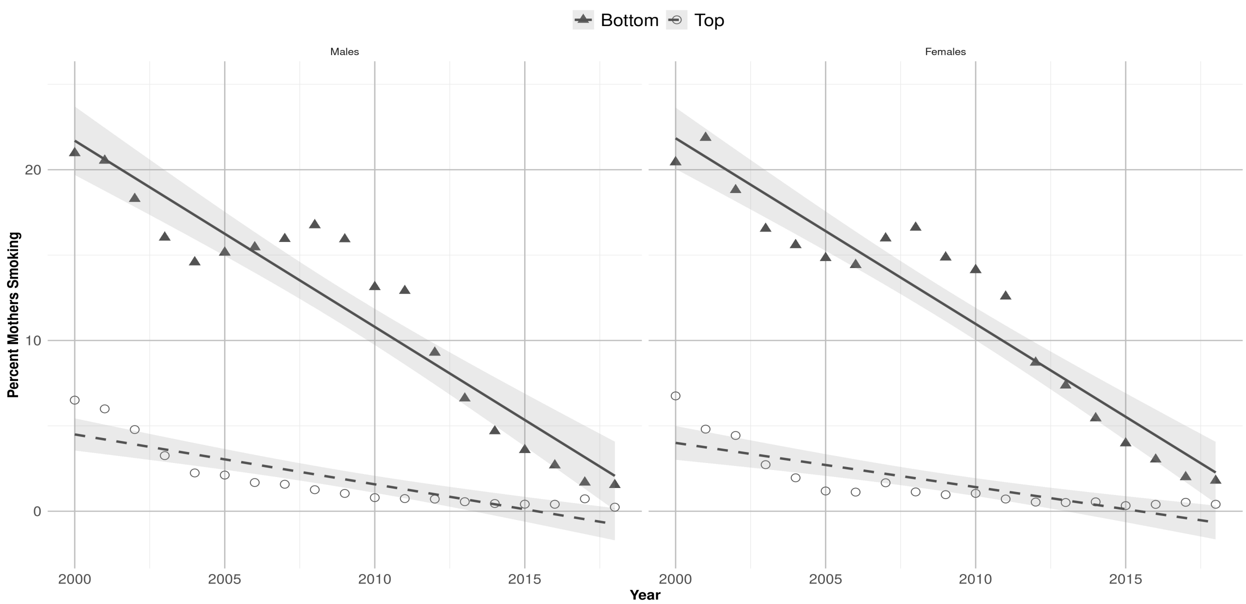

Figure 9: Individual-Level Inequality in Maternal Smoking 2000–2018

Notes: percent of mothers smoking at the end of pregnancy in the top and bottom deciles of the parental income distribution by gender from 2000 to 2018. Parental lifetime income was calculated by taking the average income of individuals between ages 34 and 40 years.

5 Conclusion

Technological and medical advancements have prolonged human life during the past several decades. Whether the decrease in mortality is evenly distributed, or whether it compensates or reinforces

lifetime income confirmed these findings. The results are presented in Appendix Figure A3.

mortality inequality is less clear and context dependent. In this regard, we used both municipality- and individual-level income and mortality data to analyse mortality gradients over the past 70 years in Norway.

We find that mortality, and in particular infant mortality in Norway, has greatly declined for individuals of all ages. Focusing on mortality at a geographic level (municipalities) for the years 1991 to 2017 revealed that mortality in absolute terms has fallen for all age groups. While there are income gradients at older ages in the early 1990s, a municipality's poverty level seems to have played a very small role in determining the risk of death at any given age in 2018. Nevertheless, while these findings document equality in mortality across Norwegian municipalities by 2018, they do not imply that there are no income gradients in mortality within Norwegian society. In particular, there may still exist a strong association between income and mortality at the individual level.

For infants, the decline of the income gap in mortality at the geographic level had already closed by the late 1960s. At the individual level, however, the inequalities in mortality persisted much longer and the risk of dying within the first year of life only converged in 2010 for children born into the richest and poorest Norwegian families. Our results suggest that the decline in infant mortality since 1951, as well as the income gradient in infant mortality, were strongly tied to advances in medical technology, the scientific discovery of the link between SIDS and sleeping positions, and the dangers of maternal smoking.

Overall, the results suggest that improvements in infant mortality over the past 70 years in Norway are an important example of how access to health care, the transmission of scientific knowledge, as well as societal level changes in health behaviour can affect children's lives—particularly among disadvantaged groups. Although the levelling out of the playing field among the rich and the poor in terms of infant mortality is an important achievement for a comprehensive welfare state such as Norway, it is important to note that this does not suggest that mortality equality at older ages holds for children born today. Occupational hazards and different health behaviours as teenagers by various socioeconomic groups could still contribute to mortality inequality at later ages for these individuals. This leaves room for further research to investigate how the closing of the early-life mortality gap between the rich and the poor translates into individual-level mortality differences by socioeconomic background later in life.

References

Aaberge, Rolf, Anthony B Atkinson, and Jørgen Modalsli. 2016. "On the measurement of long-run income inequality. Empirical evidence from Norway, 1875-2013." Statistics Norway, Research Department Discussion Papers 847.

Adda, Jérôme, and Francesca Cornaglia. 2010. "The Effect of Bans and Taxes on Passive Smoking." *American Economic Journal: Applied Economics*, 2(1): 1–32.

Aizer, Anna, and Laura Stroud. 2010. "Education, Knowledge and the Evolution of Disparities in Health." National Bureau of Economic Research Working Paper 15840.

Aizer, Anna, Laura Stroud, and Stephen Buka. 2016. "Maternal Stress and Child Outcomes: Evidence from Siblings." *Journal of Human Resources*, 51(3): 523–555.

Almond, Douglas. 2006. "Is the 1918 influenza pandemic over? Long-term effects of in utero influenza exposure in the post-1940 US population." *Journal of political Economy*, 114(4): 672–712.

Almond, Douglas, Hilary W. Hoynes, and Diane Whitmore Schanzenbach. 2011. "Inside the War on Poverty: The Impact of Food Stamps on Birth Outcomes." *The Review of Economics and Statistics*, 93(2): 387–403.

Alsan, Marcella, and Claudia Goldin. 2019. "Watersheds in Child Mortality: The Role of Effective Water and Sewerage Infrastructure, 1880–1920, mortality." *Journal of Political Economy*, 127(2): 586–638.

Attanasio, Orazio, and Torben Heien Nielsen. 2020. "Economic Resources, Mortality and Inequality."

Backer, J.E. 1963. *Dødeligheten og dens Årsaker i Norge 1856 til 1955.* Oslo:Central Bureau of Statistics of Norway.

Beach, Brian, Joseph Ferrie, Martin Saavedra, and Werner Troesken. 2016. "Typhoid fever, water quality, and human capital formation, mortality." *The Journal of Economic History*, 76(1): 41–75.

Bhalotra, Sonia R, and Atheendar Venkataramani. 2015. "Shadows of the captain of the men of death: Early life health interventions, human capital investments, and institutions, mortality." *Human Capital Investments, and Institutions (August 8, 2015).*

Bhalotra, Sonia R., Martin Karlsson, and Therese Nilsson. 2017. "Infant Health and Longevity: Evidence from a Historical Trial in Sweden." *Journal of European Economic Association*, 15(5): 1101–1157.

Bharadwaj, Prashant, Julian V Johnsen, and Katrine V Løken. 2014. "Smoking bans, maternal smoking and birth outcomes, mortality." *Journal of Public economics*, 115: 72–93.

Bharadwaj, Prashant, Katrine Vellesen Løken, and Christopher Neilson. 2013. "Early life health interventions and academic achievement, mortality." *American Economic Review*, 103(5): 1862–91.

Bhuller, Manudeep, Magne Mogstad, and Kjell G. Salvanes. 2017. "Life-Cycle Earnings, Education Premiums, and Internal Rates of Return." *Journal of Labor Economics*, 35(4): 993–1030.

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes. 2007. "From the Cradle to the Labor Market? The Effect of Birth Weight on Adult Outcomes." *The Quarterly Journal of Economics*, 122(1): 409–439.

Bütikofer, Aline, Katrine V Løken, and Kjell G Salvanes. 2019. "Infant health care and long-term outcomes, mortality." *Review of Economics and Statistics*, 101(2): 341–354.

Bütikofer, Aline, and Kjell G Salvanes. 2020. "Disease control and inequality reduction: Evidence from a tuberculosis testing and vaccination campaign." *Review of Economic Studies*.

Carpenter, Robert, Cliona McGarvey, Edwin A Mitchell, David M Tappin, Mechtild M Vennemann, Melanie Smuk, and James R Carpenter. 2013. "Bed sharing when parents do not smoke: is there a risk of SIDS? An individual level analysis of five major case–control studies." *BMJ open*, 3(5).

Case, Anne, and Angus Deaton. 2015. "Rising Morbidity and Mortality in Midlife Among White non-Hispanic Americans in the 21s Century." *Proceedings of the National Academy of Sciences of the United States of America*, 112(49): 15078—-15083.

Case, Anne, Darren Lubotsky, and Christina Paxson. 2002. "Economic Status and Health in Childhood: The Origins of the Gradient." *American Economic Review*, 92(5): 1308–1334.

CDC. 2020. "Health Effects of Secondhand Smoke." *https://www.cdc.gov/tobacco/data_statistics/fact_sheets/secondhand_smoke/health_effects/index.htm#:~:text=There%20is%20no%20risk%2Dfree,infant%20death%20syndrome%20(SIDS).*, Accessed: 2020-10-30.

Chen, Alice, Emily Oster, and Heidi Williams. 2016. "Why is infant mortality higher in the United States than in Europe?" *American Economic Journal: Economic Policy*, 8(2): 89–124.

Chetty, Raj, and Nathaniel Hendren. 2018. "The Impacts of Neighborhoods on Intergenerational Mobility I: Childhood Exposure Effects*." *The Quarterly Journal of Economics*, 133(3): 1107–1162.

Chetty, Raj, Michael Stepner, Sarah Abraham, Shelby Lin, Benjamin Scuderi, Nicholas Turner, Augustin Bergeron, and David Cutler. 2016. "The Association Between Income and Life Expectancy in the United States, 2001-2014." *JAMA*, 315(16): 1750–1766.

Currie, Janet, and Hannes Schwandt. 2016*a*. "Inequality in mortality decreased among the young while increasing for older adults, 1990–2010." *Science*, 352(6286): 708–712.

Currie, Janet, and Hannes Schwandt. 2016*b*. "Mortality inequality: the good news from a county-level approach." *Journal of Economic Perspectives*, 30(2): 29–52.

Currie, Janet, and Reed Walker. 2011. "Traffic Congestion and Infant Health: Evidence from E-ZPass." *American Economic Journal: Applied Economics*, 3(1): 65–90.

Currie, Janet, Hannes Schwandt, and Josselin Thuilliez. 2020. "Pauvreté, Egalité, Mortalité: mortality (in) equality in France and the United States." *Journal of Population Economics*, 33(1): 197–231.

Cutler, David, and Grant Miller. 2005. "The role of public health improvements in health advances: The twentieth-century United States." *Demography*, 42: 1–22.

Cutler, David, Angus Deaton, and Adriana Lleras-Muney. 2006. "The determinants of mortality." *Journal of economic perspectives*, 20(3): 97–120.

Daltveit, Anne Kjersti, Nina Øyen, Rolv Skjærven, and Lorentz M Irgens. 1997. "The epidemic of SIDS in Norway 1967-93: changing effects of risk factors, infant, mortality." *Archives of disease in childhood*, 77(1): 23–27.

de Walque, Damien. 2010. "Education, Information and Smoking Decisions: Evidence from Smoking Histories in the United States, 1940–2000." *Journal of Human Resources*, 45(3): 682–717.

Easterlin, Richard A. 1995. "Industrial revolution and mortality revolution: Two of a kind?" *Journal of Evolutionary Economics*, 5(4): 393–408.

FHI. 2017. "History of the Norwegian Public Health Institue." *https://www.fhi.no/en/about/this-is-the-norwegian-institute-of-public-health/history-of-the-norwegian-institute-/*, Accessed: 2020-10-12.

Glied, Sally, and Adriana Lleras-Muney. 2008. "Technological innovation and inequality in health." *Demography*, 45: 741–761.

Hack, Maureen, Nancy K Klein, and H Gerry Taylor. 1995. "Long-term developmental outcomes of low birth weight infants, mortality." *The future of children*, 176–196.

Hjort, Jonas, Mikkel Sølvsten, and Miriam Wüst. 2017. "Universal Investment in Infants and Long-Run Health: Evidence from Denmark's 1937 Home Visiting Program." *American Economic Journal: Applied Economics*, 9(4): 78–104.

Jorgensen, Anne M. 2010. "Born in the USA–the history of neonatology in the United States: a century of caring, mortality." *NICU Currents*, 1(1): 8–11.

Kinge, Jonas Minet, Jørgen Heibø Modalsli, Simon Øverland, Håkon Kristian Gjessing, Mette Christophersen Tollånes, Ann Kristin Knudsen, Vegard Skirbekk, Bjørn Heine Strand, Siri Eldevik Håberg, and Stein Emil Vollset. 2019. "Association of household income with life expectancy and cause-specific mortality in Norway, 2005-2015." *Jama*, 321(19): 1916–1925.

Kjellsson, Gustav, Ulf-G Gerdtham, and Carl Hampus Lyttkens. 2011. "Breaking bad habits by education – smoking dynamics among Swedish women." *Health Economics*, 20(7): 876–881.

Kramer, M. 1987. "Determinants of low birth weight: methodological assessment and meta-analysis." *Bulletin of the World Health Organization*, 65(5): 663–737.

Lee, Kwang-sun, Babak Khoshnood, Stephen N Wall, Young-pyo Chang, Hui-Lung Hsieh, and Jaideep K Singh. 1999. "Trend in mortality from respiratory distress syndrome in the United States, 1970-1995." *The Journal of pediatrics*, 134(4): 434–440.

Lien, Diana S., and William Evans. 2005. "Estimating the Impact of Large Cigarette Tax Hikes: The Case of Maternal Smoking and Infant Birth Weight." *Journal of Human Resources*, 40(2).

Moehling, Carolyn, and Melissa Thomasson. 2014. "Saving Babies: The Impact of Public Health Education Programs on Infant Mortality." *Demography*, 51(2): 367–386.

Nybom, Martin, and Jan Stuhler. 2016. "Heterogeneous income profiles and lifecycle bias in intergenerational mobility estimation, mortality." *Journal of Human Resources*, 51(1): 239–268.

OECD. 2020. "Poverty Rate Definition." *hhttps://data.oecd.org/inequality/poverty-rate.htm*, Accessed: 2020-10-16.

Pekkarinen, Tuomas, Kjell G Salvanes, and Matti Sarvimäki. 2017. "The evolution of social mobility: Norway during the twentieth century." *The Scandinavian Journal of Economics*, 119(1): 5–33.

SSB. 2020. "Metadata: Basic Statistical Units." *https://www.ssb.no/a/metadata/conceptvariable/vardok/135/en*, Accessed: 2020-10-16.

World Inequality Database. 2020. "Pre-Tax Disposable Income Gini Index." data retrieved from World Inequality database on 2020-01-11, `https://wid.world/`.

A Appendix

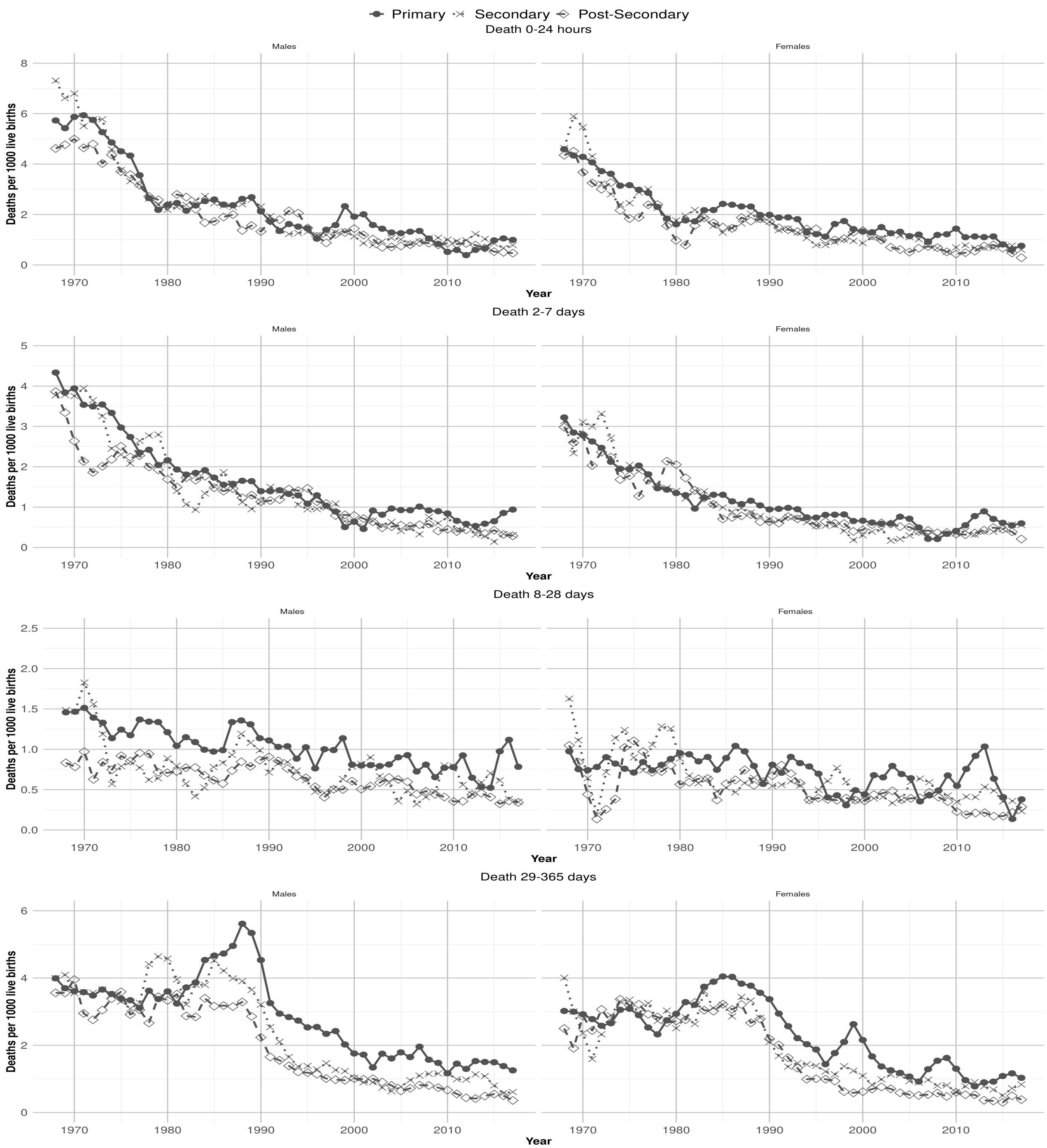

Figure A1: Individual-Level Inequality by Education and Age of Death

Notes: Infant mortality in three different education groups by gender from 1968 to 2017. Each dot/rectangle/triangle represents cohort-specific infant deaths per 1,000 live births (smoothed over three years) for the four different age categories. Education is classified based on NUS-2000 codes.

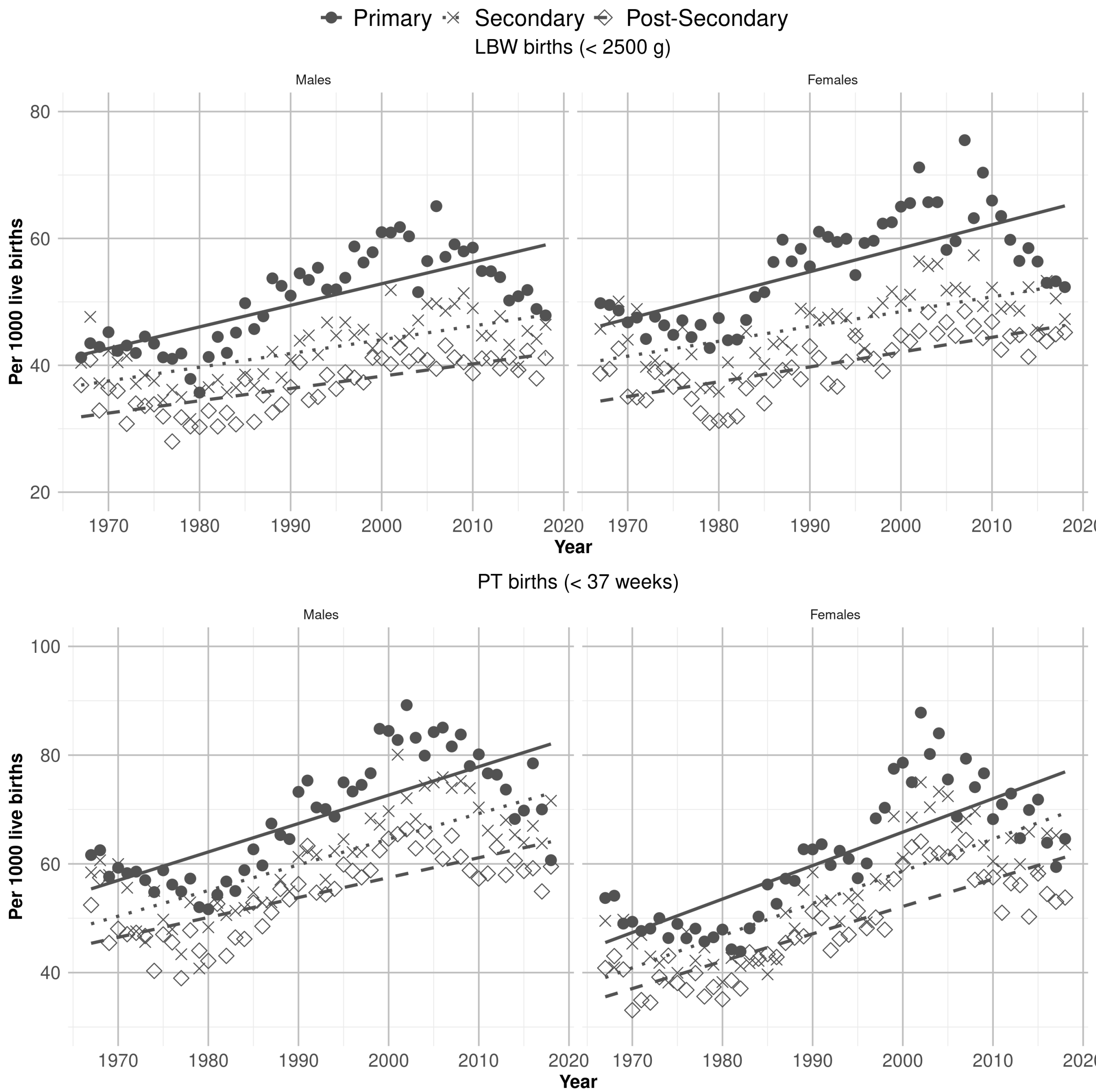

Figure A2: Individual-Level Inequality in Low Birth Weight and Preterm Births 1967-2018

Notes: Cohort-specific numbers of children born with low birth weight (<2,500 grams) and preterm deliveries (before the end of the 37th week of gestation) per 1,000 live births in the three educational groups by gender from 1967 to 2018. Education is classified based on NUS-2000 codes.

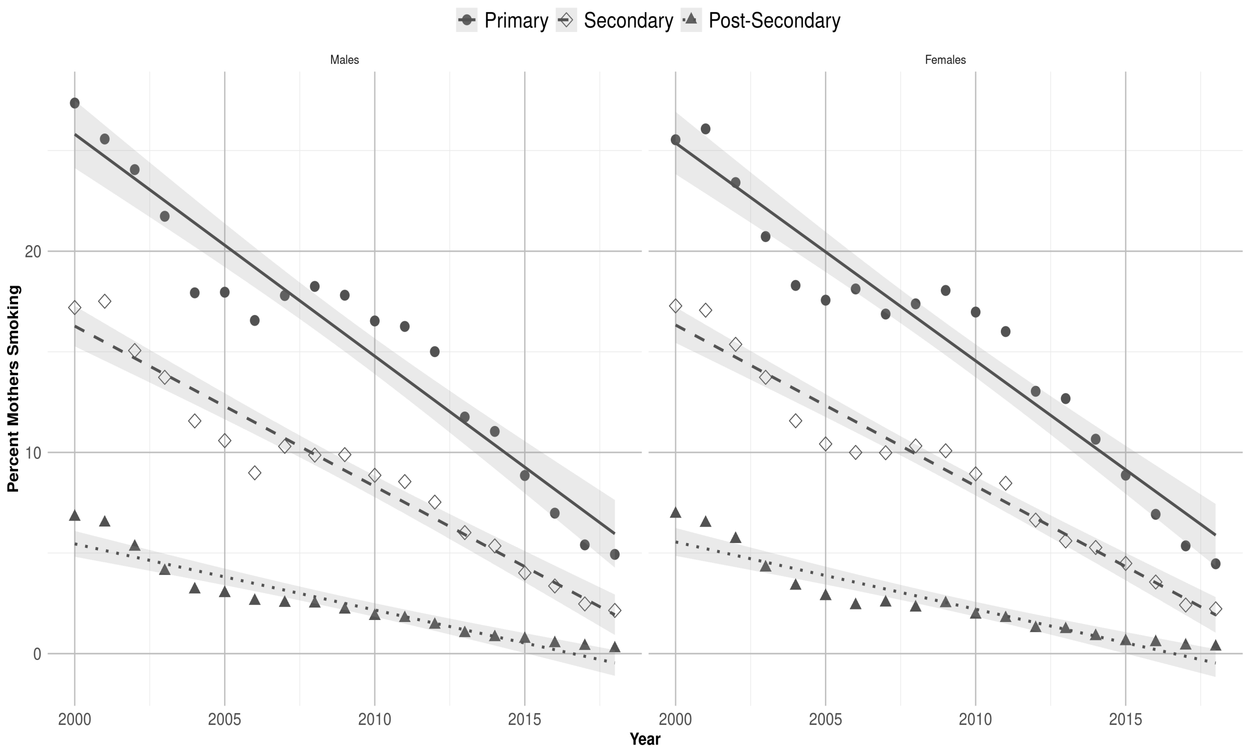

Figure A3: Individual-Level Inequality in Maternal Smoking by Education 2000-2018

Notes: Percentage of mothers smoking at the end of pregnancy in the three educational groups by gender from 2000 to 2018. Education is classified based on NUS-2000 codes.