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The Demographic Impacts of the Sieges of Paris, 1870–1871

Foreword

What Victor Hugo memorably called 'l'Année terrible' [The Terrible Year or The Year of Horrors], from August 1870 to July 1871, was marked above all in the imagination of the Western world by the two dramatic sieges of Paris. The first was by the German army, from September 1870 to January 1871, to force the surrender of the French Government of National Defence, and then by the French army during April and May 1871, to crush the popular insurrection known as the Paris Commune.

Recent history had witnessed other sieges, a feature of conventional war throughout the ages. Only a few years before, there had been the siege of Vicksburg (1863), during the American Civil War; the siege of Delhi (1857), during the Indian Mutiny; and the siege of Sebastopol (1854–1855), during the Crimean War. Some of Europe's historic cities had suffered sieges; for example, Venice and Rome in the aftermath of the 1848 revolutions, and Warsaw in 1831. The 'Année terrible' also saw major sieges of Strasbourg and Belfort.

Nevertheless, the two sieges of Paris were traumatic and sensational as no others had been. First, because it was Paris: one of Europe's most populous cities, its leading cultural centre, the main focus of international tourism, and the historic capital of one of its most powerful states. To many observers, it was scandalous that such a city should be the target of military attack, which threatened cultural treasures of world significance as well as the lives of a large civilian population. Yet Paris was also the world's largest fortress, with ramparts, outlying forts, a flotilla of gunboats, and armoured trains. From a military point of view, these two sieges were on the grandest scale.

Second, because of what many contemporary observers thought was the incongruity between a city seen as the epitome of fashion, luxury, and pleasure, and the stark violence of war and starvation. The whole city was fortified and barricaded. Elegant ladies were recruited as nurses. Artists and intellectuals served on the ramparts and in the trenches. World famous restaurants served horsemeat and rats. And then, in May 1871, the city's most famous sites saw a pitched battle between two armies.

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Third, because of the extreme extent, by 19th-century standards, of civilian suffering, death, and destruction that was caused. During the German siege, the population went hungry, caught epidemic diseases, suffered from cold, and faced severe artillery bombardment. During the siege of the Commune, and especially during its final ‘bloody week’, the city again suffered artillery fire, brutal combats in its streets, widespread destruction of some of its greatest monuments, summary executions, and mass arrests.

An immediate consequence of these violent events was the disruption of the Parisian economy, the core of France’s manufacturing and export trades, and a major loss of population.

If these events have been chronicled, often in a very dramatic way, little attempt has been made to look at the long-term socio-economic consequences, which is why this demographic study is original and welcome. In the 1870s, there were attempts to calculate rates of death and disease, and to quantify population loss. But few researchers over the last 150 years have looked further, and none has used sophisticated research methods such as in this article.

This approach, while interesting for specialist demographers as an exploration of methods applicable to historic cases, is also valuable to all those interested in this subject. For example, it gives the possibility of assessing the broad effects of the much-criticized food policy of the Government of National Defence and the municipal authorities in the 20 arrondissements during the German siege. The government decided not to impose general food rationing, which meant that rationing by price created severe inequalities. But the arrondissements did set up *cantines municipales*, which provided a subsistence diet to increasing numbers of people, especially in the poorer districts. Basic foodstuffs—most importantly, bread and horsemeat—did mean that starvation was kept at bay, but as this study finds, there was a measurable impact on the youngest children’s survival, growth, and life expectancy.

The Commune, on the other hand, suffered no food shortages, and the distribution of money and food to families of the National Guard seems to have meant that there was no general effect on health and growth, even though families and the economy were severely disrupted by the effects of the civil war, increased deaths, and mass arrests, which easily explains the sharp fall in fertility.

Yet the Parisian economy was resilient enough to recover quite quickly, it seems from the demographic evidence; and this confirms the impression of many contemporaries that despite the trauma of the civil war and the suffering it caused, the city soon seemed fairly normal again.

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The Demographic Impacts of the Sieges of Paris, 1870–1871

Following the Age of Revolution (Osterhammel, 2014), Paris witnessed two wars at the end of the 19th century. First, in September 1870, the Prussian army besieged the French capital, and then, beginning in March 1871, so did the French government. Both sieges were waged on people perceived to be socially and politically dangerous. As Tombs (1997) wrote:

> Their common target was regarded by many, and especially by its inhabitants, as unique: the centre and symbol of modern civilization in some of its most admirable, but also in some of its most dangerous, forms. Both attacks were ultimately political, intending not merely to reduce a fortress but to chastise its inhabitants. (p. 541)

While the political significance of these events has been well researched, their demographic consequences have been less investigated due in part to their relatively limited scale. The 1870–1871 wars claimed fewer than 150,000 French military casualties, unlike the Great War that would kill almost 10 times that number less than half a century later. The damage in 1870–1871, however, was concentrated in Paris itself and specifically on its working class. Using individual-level data to measure the short- and long-term consequences of both sieges, this paper focuses on Paris's working-class population, particularly in the 19th arrondissement (north-eastern district).

Sieges usually provoke harsh famines, and Paris was especially beset during the Prussian event. We first assess the famine's impact on mortality during and immediately after the siege, and then explore its long-term effects on survivors by focusing not only on adult mortality but also on adult height. Adult height is often used as an intermediate variable that, on the one hand, captures life conditions (nutrition, diseases, and work) during childhood or adolescence and, on

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the other, correlates with chances of survival later in life (Fogel, 1994). We also explore the relationship between nutrition, stature, and adult mortality, which is not straightforward due to the timing of variations in diet across the two sieges and the age at exposure to the famine; to selection effects from mortality, migration, or fertility; and to the concomitant changes in health conditions.

Short-lived nutritional shocks might not have long-lasting effects on physiological growth if children can later recover in height (see experimental evidence in Barham et al., 2013). Many studies suggest that very early ages are the most critical, which is in line with the so-called foetal origins hypothesis (Barker, 1990; Almond and Currie, 2011; Almond et al., 2017). However, the context and nature of the shock may matter, as well as any intrahousehold distributions of resources. Shortfalls in agricultural income due to droughts in late 20th-century Indonesia (Maccini and Yang, 2008) and to the *phylloxera* pest in late 19th-century France (Banerjee et al., 2010) seem to have resulted in acute growth retardation among children *in utero* during the shock, although Cogneau and Jedwab (2012) find that it was mostly 2- to 5-year-old girls who were affected by the large drop in cocoa producer prices in late 20th-century Côte d'Ivoire. Van den Berg et al. (2011) observed effects on migrants to Sweden at even later ages (5, 6, and 9 years old).

Child mortality itself might confound malnutrition's effect on stature or on survival into adulthood , namely by selecting out the shortest or weakest (Bozzoli et al., 2009). Cases of famine in which both child mortality and undernutrition reached high levels are found in the 1944 Dutch Hunger Winter (Scholte et al., 2015), in the aftermath of the Chinese Great Leap Forward (Almond et al., 2010), and during the siege of Leningrad (Sparen et al., 2004). Sieges and famines can also result in reduced fertility and possible outmigration from stricken areas, thus requiring great effort to isolate nutritional causes from the selection effects potentially confounding them (for the Chinese case, see Gørgens et al., 2012).

Finally, the negative correlation between height and adult mortality found in many epidemiological studies (e.g. Waaler, 1984) may be coincidental. Part of it might correspond to early 'shrinkage' resulting from previous illnesses (Leon et al., 1995). Short stature also correlates with lower socio-economic status and adverse living or working conditions (e.g. Jousilahti et al., 2000). Furthermore, rather than the improved diet explanation favoured by Fogel (1994), the reduced burden of infections may account for why cohorts born in late 19th-century Northern Europe both ended up taller after childhood and experienced lower risk of cardiovascular disease at old age, compared to cohorts born earlier (Crimmins and Finch, 2006). Aside from these impacts on height, it seems that the delayed impact of famines on the adult mortality of survivors may vary depending on the context,[1] and even the same context can generate

(1) Compare, for instance, Lindeboom et al. (2010) on the sharp decrease in life expectancy after age 50 for those *in utero* or under 1 during the Dutch potato famine, and Song (2009) on the Great Chinese Famine having had no effect on later age mortality.

two different conclusions, depending on the method used and whether heterogeneity is taken into account.(2)

We take a threefold approach to exploring these questions. First, we combine vital records and population census data to estimate mortality and fertility during the sieges. Secondly, we use first-hand individual data from military conscription files to analyse height developments in cohorts born between 1850 and 1880. Thirdly, military files allow us to track individual conscripts from ages 20 to 45 and to analyse differential adult mortality according to their age during the sieges.

I. Two sieges and a famine

In a context of general tension in Europe due to the growing power of Prussia and the German states, the French declared war on Prussia on 19 July 1870. After brief preparations, the Prussian troops and their German allies invaded France at the beginning of August, and from that moment on, the French would experience a succession of defeats. A month after the invasion began, the French emperor, Napoléon III, surrendered in Sedan (Howard, 2001; Wawro, 2003). This swift defeat was unexpected by many in France, especially in Paris, where a new government had formed and was preparing for defence against the Prussian army, which had quickly advanced towards the city. Ten days after news of the surrender had reached the capital, the Prussian armies cut off all the railway lines to and from the city. Two days later, Paris was surrounded. Few people had time to flee the city, and of that minority, most came from the wealthiest segments of the population. Contemporary reports estimated that, out of Paris's 1.9 million inhabitants, at most 300,000 inhabitants had escaped (Sueur, 1872).

This marked the beginning of a long and agonizing crisis. With only little time to prepare, Parisians would soon begin to face food shortages and a particularly cold winter. Contemporary sources detail the exceptionally harsh living conditions throughout the period, and as suitable meat ran in short supply by early November, butchers began selling dog, cat, crow, and sparrow. An open-air rat market was even set up in front of the Hôtel de Ville (city hall). What is perhaps more telling is that the cost of basic food skyrocketed, which both contemporary accounts and historical works have documented. In just 3 months, from the end of September to the end of December, the price for a dozen eggs increased by a factor of 13, while that of a ration of potatoes increased tenfold. Henryot (1871) recounted people queuing day and night for food that became less and less nutritious, to the point it did not seem like food

(2) For the 1866–1868 Finnish famine, Kannisto et al. (1997) found no difference in adult mortality for the affected cohorts, whereas Doblhammer et al. (2013) found a small but significant reduction in life expectancy after 60 years old for the most affected.

at all. He also provided accounts of high mortality from smallpox and other epidemics, unheated hospitals, and young children lacking milk.

By the end of January, the city became overwhelmed and was forced to surrender, thus leading to an armistice that recognized France's defeat in early March 1871. However, the raising of this first siege did not bring an end to the city's hardships, as the radical *Commune de Paris* soon incited a revolution as a direct result of the defeat (Tombs, 1999). Thus, the Paris Commune instigated yet another onslaught on the city, which was led by French government forces who prosecuted this siege even more fiercely due to the deep class divisions fomenting the conflict (Rougerie, 2004). This much shorter siege culminated in the infamous bloodbath of *La Semaine sanglante* (The Bloody Week) of 21–28 May. Food scarcity during the uprising was less critical than during the Prussian siege, as neither contemporary accounts (Lissagaray, 2004) nor historians mention any famine or additional deaths linked to a lack of food, probably because mobility was less severely constrained.

Thus plagued by a two-part war lasting nearly 9 months, the city was fully blockaded from mid-September 1870 to the end of January 1871 and besieged again from mid-March to the end of May 1871. Several issues here matter to our study. First, the little time people had to flee the city before the Prussian blockade curbs the migration selection effect among those in the population who bore the burden of the siege. Secondly, because both sieges were limited in both space and time, the population under study is also quite limited but easily identifiable. Lastly, the widespread famine resulting from the first 4-month siege quickly became the main cause of death—if not directly, then indirectly, through diseases caused by hunger. Only few war-related casualties occurred at this time, but during the Commune's brief and besieged regime, mortality increased due to fighting and massacres.

II. Mortality during the sieges

Paris was a deadly environment even in normal times, with significantly higher mortality than in the rest of the country. Typically for historical populations, this mortality was concentrated among the young. Various contemporary accounts cite the total number of deaths during the sieges, sometimes breaking these figures down by week, sex, or age (Alméras, 1925; Sueur, 1872; Sheppard, 1877; Du Camp, 1881). Sueur (1872) counted around 32,000 deaths between September and December, thus bringing to 72,000 the estimated death total for 1870. The mortality count for 1871 is more uncertain, particularly during the Commune. Although Sueur calculated around 42,000 deaths from the beginning of the year to 14 March, no mortality figures were reported for the Commune period (mid-March to late May), and it therefore remains unclear whether mortality remained high or quickly returned to standard levels. Our study provides some evidence for the latter possibility, indicating that around

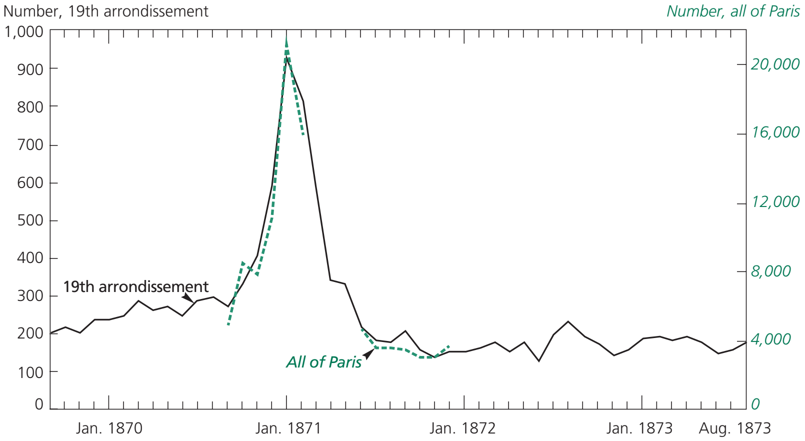
12,000 deaths occurred from mid-March to the end of May, excluding The Bloody Week. The mortality counts for that week are greatly debated, with contemporary observers—especially those on the insurgents' side—providing high estimates of between 17,000 (Lissagaray, 2004) and 30,000 deaths (Pelletan, 1880), while historians settle on much lower numbers, such as Tombs's (1994) mention of 10,000 deaths. Ultimately, as Tombs (2012) emphasized, the import and legends surrounding these events explain how such high figures became widely accepted, even if never substantiated. After reviewing the evidence, he estimated a much lower—but still massive—death toll for The Bloody Week of approximately 5,700 to 7,400 deaths, although the exact figure will probably never be known. Finally, published yearbooks point to around 30,000 deaths between 1 June and the end of the year. All told, the figure of 90,000 deaths sets a lower bound for the year 1871, with The Bloody Week included.

Taken all together, these figures reveal an astonishing toll. Considering that an average year before the sieges saw around 45,000 deaths, we estimate 72,000 additional deaths over the 2-year period of 1870 and 1871, representing an average annual increase of 80%. Sueur counted over 37,000 deaths for the first 2 months of 1871, 5 times the usual levels, which we have thus weighted at around 50% of the increase.

To improve upon these aggregate figures, we collected data first-hand from vital records for Paris's 19th arrondissement, covering the period of September 1869 to August 1873. We also gathered all individual death records for the year preceding the crisis (September 1869 to August 1870), for the crisis itself (September 1870 to May 1871, excluding The Bloody Week), and for the following months (June 1871 to August 1871). During the Commune, deaths were still recorded by the administration using the same forms and methods as before, although these might not be as reliable as earlier records due to public services in disarray. After the Commune uprising was quelled, these records were treated as illegitimate and their information was crossed out (*bâtonnés*). Nevertheless, they remained legible and could be digitized. In addition, we inputted the deaths from every other page of the registers for the subsequent 2 years, thus creating a 50% sample of the deaths occurring between September 1871 and August 1873. The 1866 population census counted 88,930 inhabitants living in the 19th arrondissement, or 5% of the Paris population. Figure 1 shows that the district's monthly variation in recorded deaths is similar to that of Paris as a whole. Furthermore, the effect of the crisis was short-lived, with mortality higher than normal between October 1870 and May 1871 but returning to standard levels as early as June 1871. The 19th arrondissement's number of deaths for 1870 (1,937) is 61% above that of 1869 (1,203), and it reaches 89% for 1871 (2,273); hence our calculation of a 75% average increase in mortality.

During the Commune, mortality fell for all age groups when compared to the Prussian siege, especially among neonatal and infant deaths, which returned to pre-crisis levels. The highest relative mortality is observed for

Figure 1. Deaths per month, July 1869 – August 1873, 19th arrondissement and all of Paris



Coverage: Deaths in the 19th arrondissement (except for The Bloody Week) and all Paris (September 1870 to December 1871, excluding the Commune period of March–May 1871).

Source: Vital records of the 19th arrondissement; *Bulletin de Statistique Municipale*.

men ages 20–39. Post-crisis deaths fell by more than 25%, although some people who had died earlier would have instead died in this period under standard conditions.

To get a better sense of excess mortality, especially at early ages, we used the abovementioned individual death records to estimate boys' mortality rates for those birth cohorts most exposed to the crisis. We also estimated a pre-crisis benchmark for under-5 mortality (see Box). Our pre-crisis estimates are already high (infant mortality reaches 25%) but consistent with what Van de Walle and Preston (1974) found for girls' mortality in the Seine *département* among the 1866 to 1870 cohorts (see Appendix Table A.1).

Table 1 reports probabilities of dying (${}_nq_x$) for the 1866 to 1872 birth cohorts (Appendix Table A.2 provides a full Lexis table). Let us first note that estimated infant mortality (${}_1q_0$) in 1872 is very close to the pre-crisis benchmark level, meaning that children born in 1872 were already enjoying post-crisis living conditions. Children born in 1866 and 1867 seem to have suffered from a slight increase in mortality between ages 3 and 5, but the first cohort to be truly impacted by the famine is that of 1868: 1- to 5-year-old mortality climbs to 24% compared to the pre-crisis estimate of 16%. Few children in the 1869 birth cohort were actually exposed to the crisis before age 1, while mortality subsequently peaks between 1 and 2 years old (${}_1q_1$ = 22%) and remains high between 2 and 3 (8%). This results in a mortality estimate that reaches as high as 31% between 1 and 5 years of age—twice the benchmark level.

For the 1870 birth cohort, infant mortality is the highest. However, and perhaps surprisingly, mortality at later ages falls to standard levels, such that

Box. Method for estimating mortality rates

We use mortality data collected from the 19th arrondissement to compute mortality rates before age 20 by cohort.

First, we compute a pre-crisis benchmark. For under-5 mortality, we rely on the death records of the 1865–1869 cohorts: for the probability of death at each age (${}_1q_0$, ${}_1q_1$, ${}_1q_2$, etc.), we use deaths recorded between September 1869 and August 1870 for the corresponding 4-month cohort born between September and December. We collected monthly births only for the years 1868 to 1873. For the years before 1868, we estimate the 4-month cohort sizes by applying the average of the shares for 1868 and 1869 to the total number of births. While our mortality data distinguish males from females, birth data do not; therefore, we estimate male births at 51.2% of total births. Of the children who died between 0 and 48 months of age in the 19th arrondissement and who were recorded as having been born in Paris, we assume that most of them had also been born in that district. Van de Walle and Preston (1974) estimate that 11% of children born in Paris and under age 5 were with wet nurses in the countryside. Yet out-of-home wet nursing was more a middle-class practice and certainly rare in the 19th arrondissement; we make no correction for it.

For infant mortality (${}_1q_0$), we use recorded deaths occurring before age 1 and between September 1869 and August 1870 for the 4-month cohort born in Paris between September and December 1869. We do not include deaths between September and December 1870 because this period corresponds to the beginning of the first siege. In doing so, we miss a few deaths for babies aged between 8 and 12 months. To compensate for this, we complement our estimate with recorded deaths before age 1 in the same months of 1869 (September to December), which occurred among the cohort born between September and December 1868 (see Appendix Figure A.1).

For ${}_1q_1$, we similarly use the 4-month cohort born between September and December 1868 to calculate recorded deaths between ages 1 and 2 from September 1869 to August 1870. We assume that the benchmark estimate for ${}_1q_0$ can be applied to compute the number of survivors at age 1. Again, we use the preceding cohort (September to December 1867) to complete our estimate. For ${}_1q_2$ and ${}_1q_3$ we repeat this procedure. According to our computations using the 1869 yearbook and the 1866 population census, the mortality rate between 5 and 20 years of age was around 1.35% for the whole of Paris in 1869. For ${}_1q_4$ to ${}_1q_{19}$, we thus adopt a fixed value of 1.35%. This assumption results in a 6.6% probability of death between ages 5 and 10, a slightly higher figure than the 4.9% obtained by Van de Walle and Preston for girls in the 1866–1870 cohorts born in the Seine département (see Appendix Table A.1).

Second, we compute mortality during the crisis itself. For the 1866 to 1871 birth cohorts, we extract the number of Parisian-born children's deaths according to the age window that can be fully observed in our database from September 1869 to August 1873: 4 to 6 years old for the 1866 cohort; 3 to 5 years old for 1867; and so on. We also extract the number of deaths for 8-month cohorts (January to August) to obtain one additional age interval for each cohort. For instance, we observe the deaths of 6- to 7-year-old children born in Paris between January and August 1866, and so forth; this allows us in particular to estimate infant mortality for the birth year 1872, using deaths before age 1 recorded between January and August 1873. We then estimate the number of survivors at the beginning of each age window by applying the benchmark probabilities of dying to the total number of births in the 19th arrondissement for each cohort. This amounts to making one of two assumptions: either most children born in Paris who died between 0 and 7 years old in the 19th arrondissement were also born in that district; or there were few differences in mortality between out-migrants and in-migrants, with zero net migration occurring at early ages between the 19th arrondissement and the rest of Paris.

Table 1. Probabilities of dying for the 1866–1872 cohorts (%)

	Pre-crisis	1866	1867	1868	1869	1870		1871		1872
						S1	S2	S1	S2	
n births	—	**3,183**	**3,548**	**3,318**	**3,405**	**1,824**	**1,824**	**1,533**	**868**	**3,303**
$_1q_0$	**24.6**	24.6	24.6	24.6	24.6	**29.4**	**41.9**	**32.2**	**30.1**	**23.5**
$_1q_1$	**10.4**	10.4	10.4	10.4	**21.6**	**14.0**	**7.9**	**7.9**	**8.9**	10.4
$_1q_2$	**3.0**	3.0	3.0	**9.6**	**8.0**	**3.2**	**2.7**	3.0	3.0	3.0
$_1q_3$	**2.0**	2.0	**5.4**	**4.6**	**3.1**	2.0	2.0	2.0	2.0	2.0
$_1q_4$	**1.4**	2.0	**1.7**	**2.1**	1.4	1.4	1.4	1.4	1.4	1.4
$_1q_5$	**1.4**	**1.7**	**1.7**	1.4	1.4	1.4	1.4	1.4	1.4	1.4
$_1q_6$	**1.4**	**0.6**	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
$_4q_1$	16.0	16.5	19.1	24.3	31.0	19.5	13.4	13.7	14.6	16.0
$_5q_0$	36.7	37.1	39.1	43.0	48.0	43.2	49.6	41.5	40.3	35.8
$_{20}q_0$	48.4	48.5	50.5	53.5	57.6	53.7	58.9	52.3	51.3	47.6
Ratio $_{20}q_0$ to pre-crisis	1.00	1.00	1.04	1.11	1.19	1.11	1.22	1.08	1.06	0.98

Note: Number of births represents total boys and girls, while probabilities of dying are only for boys. The bold numbers in the top row are based on observed mortality, while baseline mortality applies in the other cases. The $_4q_1$, $_5q_0$, and $_{20}q_0$ rows at the bottom all combine observed and baseline mortality. See text and Appendix for estimated mortality rates. Columns 1870-S1 through 1871-S2 are cohorts of individuals born in the first (S1: January to June) and second (S2: July to December) semesters of the years 1870 and 1871.
Coverage: Deaths of males in the 19th arrondissement, excluding The Bloody Week.
Source: Vital records of the 19th arrondissement.

under-5 mortality ends up slightly lower than for the 1869 cohort. This suggests that the famine was sufficiently short-lived that the effects were not quite so lethal for those who survived the sieges. Table 1 breaks down the birth years 1870 and 1871 into two semesters. The children born between July and December 1870 faced the highest infant mortality by far—up to 42% and only 41% reached age 20. As for many of those born in the first semester of 1871, their first months of life coincided with the second siege, during which infant mortality appears to be more benign (32%). Lastly, only half as many children were born in the second semester of 1871 compared to their 1870 counterparts, due to the large drop in fertility and probably also to miscarriages. Their infant mortality remains high and almost equals that of the first semester birth cohort. Yet, the three cohorts born after July 1870 experience the standard mortality after 1 year old, as living conditions in 1872 had returned to normal.

Two salient facts emerge from this analysis. First, most of the excess mortality concentrates on the very young. Even though the numbers of deaths increase by almost the same rate at all ages, the proportional decrease in survival chances is necessarily greater for age cohorts with the highest pre-crisis mortality. Second, the sieges had no lasting effect on mortality, as both the famine and harsh winter ended at the same time, while living conditions quickly returned to normal after June 1871. Overall, the effect of the crisis on mortality was considerable but briefer than other historical experiences such as Finland in 1867, Leningrad during the Second World War, or China's Great Leap Forward.

III. Height of male cohorts exposed to famine

We explore the consequences of the sieges on height at 20 years old. We rely on individual data from the military registers, as all 20-year-old men had to report to the army in the residential district of their parents, where the military authorities both tested their fitness for service and recorded their height. A lottery was then held to select conscripts from among those deemed fit, who formed the bulk of the French army, while the rest constituted a reserve army that could be mobilized in case of war. Medical examinations were held in February $t + 1$ for the cohort born in year $t - 20$, and conscripts were called to duty in August. Because of the war, the 1850 birth cohort was called earlier, in September 1870, whereas the 1851 birth cohort was called later, in 1872.

1. Data collection: methodological choices

It was not possible to collect data for all Paris due to the 10,000 conscripts enlisting there every year.(3) Therefore, we collected individual data on all cohorts (whatever their place of birth) who enlisted in the 19th arrondissement and were born between 1850 (aged 20 during the sieges) and 1880 (born 10 years after the sieges). Among those recruits, 63% were born in Paris or in the bordering municipalities. This share is lower in the early years, with large inflows of refugees from Alsace-Lorraine after 1871.(4) Furthermore, in 1860, the Paris city limits were extended to encompass neighbouring municipalities, with the 19th arrondissement itself forming a merger of La Villette and the northern part of Belleville. In our analysis, the recruits born in the municipalities absorbed after 1860 are recoded as Paris natives.(5) To explore the effects of the crisis on height, we restricted the study sample to natives of 'Greater Paris', comprising all bordering municipalities, even those only partially

(3) For comparison, we collected the same data from military registers in two poor districts: the 3rd arrondissement of Paris and the 4th arrondissement of Lyon (online Supplementary Material C). https://www.cairn.info/loadextraweb.php?ID_ARTICLE=E_POPU_2101_0007

(4) The peace treaty signed in Frankfurt on 10 May 1871 ended the war. However, in addition to a war indemnity of 5 billion francs, it also forced France to cede part of its eastern region (Alsace-Lorraine). Residents were given the option to keep their French nationality and emigrate, or to become German citizens. Many who chose the former moved to Paris in 1871 and 1872, including children that we observe later when they reach 20 years old.

(5) These municipalities were completely absorbed by Paris in 1860 and disappeared: Auteuil, Batignolles, Belleville, Bercy, Chaillot, Charonne, Grenelle, La Chapelle, La Villette, Ménilmontant, Montmartre, Passy, Plaisance, Varennes, and Vaugirard.

absorbed or left intact.[6] In all cases, these municipalities were also subjected to the Prussian siege, and they experienced the same dreadful living conditions as Paris had. This area is thus larger than Paris proper yet smaller than the Seine *département*.

Thus, we observe only conscripts whose parents were living in the 19th arrondissement when they were 20 years old. We can reasonably assume that almost all Parisian recruits born in this working-class district were exposed to the sieges and that those who left Paris just before each siege were mainly from the upper social classes. Post-war outmigration poses a more difficult problem. Due to practical constraints, we could not search for all under-20 Greater Paris natives born between 1850 and 1870 who were living in Paris during the sieges but migrated afterwards—for which they would have been registered elsewhere in France. For cohorts born after 1860 who enlisted in the 19th arrondissement, 31% were born there, while another 21% were born in adjacent districts or municipalities, which indicates intense short-distance migration. Using the probabilities in Table 1 together with our birth data, we estimate that between 30% and 40% of 19th-arrondissement natives surviving until age 20 are listed at this age in this district. These figures point to high outmigration between 0 and 20 years old, most often to other Paris districts or to surrounding suburban areas. However, we do not find that outmigration rates display any specific variation across birth years, thus leading us to believe that selection linked to migration should not be of great concern.

To summarize, then, we analyse height in a sample of 20-year-old males enlisted in the 19th arrondissement and born in Paris or its immediate surroundings (Greater Paris). Pearson's correlation coefficient between the mean height of 19th-arrondissement natives and the mean height of Greater Paris natives is 0.86.

2. Height developments of natives from the 19th arrondissement

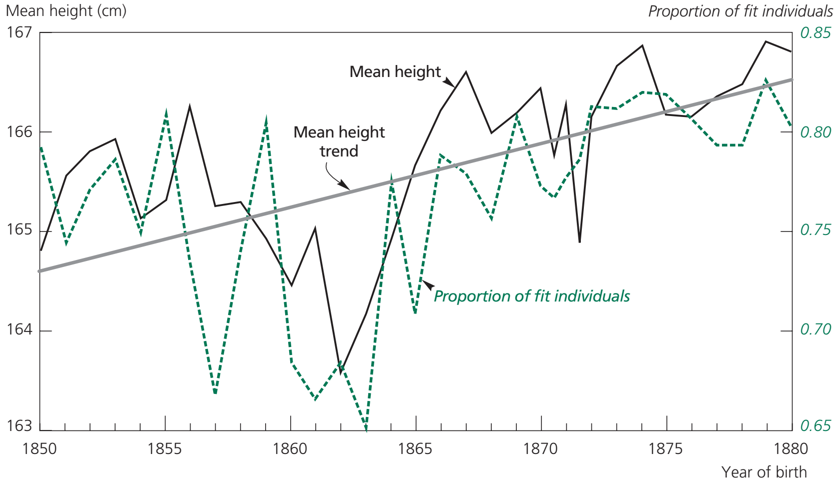
Figure 2 illustrates the variation in the average height of conscripts across birth years, once again breaking down the years 1870 and 1871 into two semesters. Mean height exhibits a large range of variation, reaching a minimum of 163.6 cm for the 1862 birth cohort and a maximum of 166.9 cm for the 1874 birth cohort.[7]

Among the 1850 to 1880 cohorts, the shortest conscripts were born between 1860 and 1864, i.e. those between 6 and 10 years old in 1870. In contrast, the

(6) Clockwise, what we call 'Greater Paris' included Aubervilliers, Pantin, Le Pré Saint-Gervais, Les Lilas, Bagnolet, Montreuil, Saint-Mandé, Charenton-le-Pont, Ivry-sur-Seine, Gentilly, Montrouge, Vanves, Issy-les-Moulineaux, Boulogne, Neuilly, Levallois-Perret, Clichy, Saint-Ouen, Saint-Denis, and Montrouge. This is a subgroup of the larger Seine *département*, used for instance in Van de Walle and Preston (1974).

(7) The height developments in Paris's 19th arrondissement are uncorrelated with those of Lyon's 4th, suggesting that they do not reflect nationwide shocks that affected other comparable urban areas (see Supplementary Material, Figure C.2 and the related discussion).

Figure 2. Mean height of 19th-arrondissement conscripts born in Greater Paris and proportion of fit individuals



Note: One estimate per birth year, except for 1870 and 1871, which are each divided into two semesters.
Coverage: 19th arrondissement military draft; conscripts born in Greater Paris.
Source: Conscription records of the 19th arrondissement of Paris.

1868 to 1871-S1 cohorts, who were the most afflicted by famine-driven mortality at a young age (see Table 1), are taller on average than earlier cohorts and only slightly shorter than those born after the crisis, i.e. from 1872 to 1880. One exception is the peculiar cohort of the few children born in 1871-S2, who are significantly shorter. Given that living conditions subsequently improved, the change observed for the remaining cohorts is what would be expected, regardless of epidemiological or nutritional shocks. Indeed, observed mean heights for the 1865 to 1871-S1 cohorts do not significantly deviate from a linear time trend. In contrast, the 1860–1864 cohorts lie significantly below the trend.

Fitness for military service was assessed by a medical examination that measured height, among other metrics. Unfit individuals were either deferred, allocated to auxiliary services that did not require good physical health, or simply exempted. Fitness assessments exhibit the same time patterns as those of height: less than 70% of potential recruits are declared fit in the 1860–1863 cohorts, whereas the proportion of fit individuals always lies above 75% after birth year 1865, and even above 80% after 1872. As seen in Figure 2, the proportion of fit individuals each year correlates rather well with height (correlation coefficient of 0.66).

For fitness and several characteristics of the height distribution (see below), we then test the statistical significance of the deviations from time trends of each of cohorts between 1860 and 1871. Because we believe it is safe to assume that older cohorts were little affected by the sieges,(8) our target cohorts are

(8) We checked that the birth years 1858 and 1859 presented small and insignificant coefficients.

indeed those aged between 0 and 10 years old or those even *in utero* during the events. We use ordinary least squares regressions weighted by the square root of the number of individuals in each birth year. More specifically, we calculate this equation:

$$\overline{Y}_t = \sum_{\tau=1860}^{1871} \alpha_\tau \cdot 1\{t = \tau\} + v(t) + \varepsilon_t \quad (1)$$

For the cohort born in year t, $\overline{Y}_t$ is either the proportion of fit individuals, the overall mean height, the mean height of the shortest 25% (1st quartile), or that of the tallest 25% (4th quartile). $v(t)$ is a function of t. Table 2 reports the estimates obtained with a linear time trend, i.e. $v(t) = y_0 + y_1 t$.[9] Only non-target cohorts (1850 to 1859 and 1872 to 1880) contribute to the time trend estimate, which here is assumed to provide a counterfactual proportion of fitness or

Table 2. Mean height of 1860 to 1871 birth cohorts, deviations from time trend

Year	Proportion of fit individuals (%)		Mean height		Mean height 1st quartile		Mean height 4th quartile		*p* value K–S test[(a)] compared to	
									1872	1872–1875
	(1)		(2)		(3)		(4)		(5)	(6)
1860	−8.8**	(3.2)	−1.20***	(0.39)	−1.30**	(0.56)	−1.50**	(0.62)	.000	.000
1861	−10.9***	(3.1)	−0.71*	(0.39)	−1.60**	(0.56)	−0.22	(0.66)	.006	.000
1862	−9.2**	(3.2)	−2.20***	(0.39)	−2.00***	(0.53)	−2.00***	(0.67)	.000	.000
1863	−12.8***	(3.2)	−1.60***	(0.39)	−1.30**	(0.54)	−2.20***	(0.62)	.000	.000
1864	−0.6	(3.3)	−0.95**	(0.41)	−0.77	(0.56)	−1.20*	(0.66)	.010	.000
1865	−7.4**	(3.1)	−0.27	(0.39)	−1.20*	(0.56)	−0.56	(0.68)	.180	.056
1866	+0.3	(3.1)	+0.24	(0.38)	+0.67	(0.54)	−0.09	(0.63)	.977	.434
1867	−0.8	(3.1)	+0.57	(0.38)	+1.20**	(0.51)	+0.82	(0.66)	.582	.992
1868	−3.3	(3.3)	−0.09	(0.41)	−0.06	(0.57)	−0.51	(0.66)	.933	.751
1869	+1.6	(3.2)	+0.06	(0.39)	+0.15	(0.54)	+0.22	(0.63)	1.000	.571
1870-S1	−2.1	(4.3)	+0.25	(0.53)	−0.17	(0.77)	+0.08	(0.88)	.170	.282
1870-S2	−2.9	(4.6)	−0.45	(0.58)	−0.21	(0.77)	−0.71	(0.95)	.552	.182
1871-S1	−2.0	(4.5)	0.05	(0.56)	−0.47	(0.80)	+1.20	(0.93)	.938	.301
1871-S2	−1.2	(4.9)	−1.40**	(0.61)	−0.60	(0.80)	−1.00	(1.1)	.092	.011
Time trend	+0.22***	(0.07)	+0.05***	(0.01)	+0.05***	(0.01)	+0.02*	(0.01)	—	—
N	33								7,241[(b)]	9,296[(b)]

(a) Columns 5 and 6 show the results of the Kolmogorov–Smirnov test for the height distribution of each birth year being equal to, respectively, the height distribution of the 1872 cohort and of the 1872–1875 cohorts pooled together. The *p* value is the risk of mistakenly rejecting equality.
(b) Total number of observations for birth cohorts 1860–1872 (Column 5) and 1860–1875 (Column 6).
Note: Observations in Columns 1–4 are weighted by the square root of the number of individuals in each birth year (and in the corresponding quartile for quartile means). For Columns 5 and 6, each test relies on observations for a given birth year and for the comparison group, either birth year 1872 (n = 670) or 1872–1875 pooled (n = 2,725). Standard errors in parentheses. $*p < .10$ $**p < .05$ $***p < .01$. Because our data originate from exhaustive samples of 20-year-old conscripts, standard errors are not based on a sampling model but instead on stochastic processes such as nature and historical events that provoke deviations from deterministic trends.
Coverage: 19th arrondissement military draft; conscripts born in Greater Paris.
Source: Conscription records of the 19th arrondissement of Paris.

(9) We also tried using a cubic polynomial trend, but this made little difference.

mean height (absent the sieges) for comparing the observed values. The estimates of the α_τ coefficients then measure deviations from this counterfactual to find potentially affected cohorts (1860 to 1871).

Estimates suggest that the 1860 to 1864 birth cohorts lie significantly below the time trend for both fitness (Column 1) and height (Columns 2 to 4), with the former showing an increase of 8 to 12 percentage points in unfit individuals (except 1864) and the latter indicating a mean height deficit of more than 1 cm. The height of the 1862 and 1863 cohorts seems especially affected.

Regarding the proportion of fit individuals, the birth years 1866 to 1871 do not significantly deviate from the time trend. Likewise, no significant anomaly is found for the adult height of conscripts under 5 years old at the time of the sieges. For individuals born in 1871-S2 and *in utero* during the sieges, estimates point to an average height deficit of around 14 mm. This occurs mainly at the middle of the distribution, as the 1st and 4th quartiles display rather smaller height deficits of, respectively, 6 mm and 10 mm. Yet, no specific drop in fitness is identified.

Column 5 of Table 2 reports the Kolmogorov–Smirnov tests, which indicate the equality of each birth-year height distribution relative to 1872. Column 6 runs the same comparison using the 1872 to 1875 cohorts all together as reference. Again, the height distribution for the years 1865 to 1871-S1 cannot be distinguished from that of the post-crisis birth years, and it is only the 1871-S2 cohort's cumulative distribution of height that lies significantly above those of 1872 to 1875. Combined with the change in mortality, the change in height suggests that the sieges seem to have affected two different age cohorts: the youngest, i.e. those under 2 years old at the time of the crisis, including those *in utero*; and 6- to 10-year-olds. These observations give rise to two questions. Could the apparent absence of a height deficit for the youngest cohorts be due to selective mortality or selective fertility? Should we attribute the oldest cohorts' height losses to the impact of siege-induced famine? In the following, we will address those two questions.

3. Selection linked to excess mortality and reduced fertility

If famine disproportionately kills children whose physical growth potential is lowest, survivors will appear to be taller than they would have in the absence of excess mortality. Hence, selective mortality may hide indications that even the survivors' height was impacted (e.g. Alter, 2004; Bozzoli et al., 2009).

At the same time, famine could affect fertility choices, given such terrible conditions in which to have a child. Both sieges resulted in lower fertility, with recorded births dropping to 37,000 in all of Paris for 1871 compared to 55,000 in a typical pre-crisis year. Looking at more precise data collected directly from the 19th-arrondissement birth registers, we find a decline occurring between March 1871 and February 1872. A typical month in that district would see 270 registered births, which begins to fall to 240 in March 1871 and drops to the low points of 86 and 85 births for, respectively, September and October of that year (a 70% decline). These correspond to children conceived during the worst months of the first siege, December to February (Cogneau and Kesztenbaum, 2016: Figure 2). Surprisingly, fertility recovers but does not bounce back in compensation in the months afterwards, not even in 1872 or 1873. Some families may have been more able than others to postpone having a child, resulting in a selection effect on fertility, although the direction of the selection is uncertain. On the one hand, fertility patterns for the 1871-S2 cohort may be disproportionately biased against children with the lowest growth potential, as the poorest families might have refrained from having babies (see Hart, 1993, on the Dutch Hunger Winter), or they could have suffered more miscarriages. If this is the case, then individuals born in these circumstances will appear to be taller than they would have in a standard year, as do survivors in the case of excess mortality. On the other hand, the relatively rich could conceivably control their fertility, such that part of the drop in the 1871-S2 cohort's adult height could be explained by an over-representation of short individuals from poor social backgrounds.

Selective mortality should skew height distributions to the left by decreasing the statistical weight of the shortest individuals. Along these lines, Meng and Qian (2009) proposed examining the quantiles of height distribution in order to detect selection. In the presence of negative selection based on height potential (i.e. if individuals with shorter height potential are more likely to die), the bottom quantiles of the adult height distribution will shift upwards while the top quantiles will also increase, although to a lesser extent. Then, if the nutritional shock is uniform across the distribution of the height potential, it should reveal itself more in the top quantiles, as the height loss of survivors will be less attenuated by selective mortality. However, this is not what happened (see Table 2, Columns 3 and 4), as deviations from the trend are not significantly different among any of the cohorts when looking at the 1st or 4th quartiles.[10] Likewise, the Kolmogorov–Smirnov tests (Table 2, Column 5) show that the height distributions in the 1868 to 1871-S1 cohorts—which have the highest child mortality—are not more skewed than in the 1872 cohort. The 1871-S2 cohort is the case in which selection by mortality and by fertility both apply, and the drop in height is more pronounced at the centre of the distribution than at the bottom or top.

We performed a complementary analysis to check which assumptions regarding mortality selection could generate the observed variations in height.[11] On top of the absence of any significant impact on quantiles, these checks indicate the unlikelihood of mortality selection having a very significant impact on the

(10) See also Figure 6 in Cogneau and Kesztenbaum (2016).

(11) Our assumptions ranged from extreme, regarding non-parametric bounds for treatment variables (Lee, 2009) to milder ones, such as a linear mortality gradient based on expected height (see Supplementary Material A).

height of children born before 1870. We believe instead that most children were able to catch up in physical growth in the aftermath of the sieges. However, selection effects could have blurred the famine's impact on survivors' height in the 1870 and 1871-S1 birth cohorts, especially if that impact was sufficiently limited in magnitude. Neither can we exclude that the average short height in the 1871-S2 cohort can be at least partially attributed to fertility selection.[12]

4. The 1860–1864 height deficit

The drop in height for the 1860–1864 cohorts, who were between ages 6 and 10 during the events, merits further inquiry. Were these cohorts young enough to be affected by famine but too old to catch up? Can their large height deficit be attributed to other events—whether nationwide or local? Or could this deficit be due merely to measurement errors?

To check for measurement errors, we looked at the height of individuals born in Alsace-Lorraine but who enlisted in the 19th arrondissement (Supplementary Material B). We know for sure that most of these conscripts migrated to Paris after the 1871 German annexation of this region. Consequently, they were not exposed to the same shocks as Paris natives. The 1860–1864 cohorts show no height anomaly for this specific group of soldiers, who were measured at the same time and in the same place as the others. Thus, we conclude that measurement errors are of no concern here.

Other explanations may be advanced at a broader level. For instance, 1859 and 1861 were years of crop failure in France, although the following years nevertheless saw agricultural output return to high levels (Lévy-Leboyer, 1968). Along the same lines, 1865 and 1866 witnessed outbreaks of cholera that resulted in a general increase in mortality, although to a much lesser extent than the previous episodes of 1832, 1849, and 1854 (Bourdelais et al., 1978). Some of the children born in 1865 and 1866 could have been protected by breastfeeding, while their older counterparts born between 1860 and 1864 would not have, thus resulting in the older children ending up shorter. However, statistics broken down by age for the city of Berlin reveal 55% higher cholera mortality among children under 12 months than among those aged 1–5 (Vacher, 1868). If breastfeeding could have protected a minority, then the tall height of the 1865–1866 cohorts may well be a result of selection by mortality at early ages. In contrast, the 1860–1864 cohorts were old enough to survive but young enough to have their height impacted by cholera.

After 1866, living conditions in Paris quickly improved, which could have contributed to Paris natives catching up in height with migrants who arrived

(12) Nor do the data for Paris's 3rd arrondissement reveal any significant deviation from the trend for the 1868 to 1870 cohorts. Yet, both the 1871-S1 and 1871-S2 cohorts in this district exhibit a height loss that is very close in magnitude to the loss observed for the 19th arrondissement's 1871-S2 cohort (when compared, for instance, to the post-crisis birth year of 1873). See Supplementary Material C.

later.[13] According to Lévy-Leboyer (1968), French industry experienced rapid growth between 1865 and 1869 and reached an annual average rate of 3%—twice that of 1860–1865. Meanwhile, cholera did not return, and new aqueducts provided Paris with clean water.

Ultimately, the following narrative could plausibly explain the events affecting the 1860–1864 birth cohorts. All cohorts born before 1865 were exposed to unfavourable health conditions at early ages, notably cholera, after which living conditions substantially improved, thus making these cohorts much shorter than those born afterwards. Children born between 1860 and 1864 were young and frail enough to be affected by famine at ages 6–10, especially as residents of a low-income urban neighbourhood like the 19th arrondissement. Unlike younger cohorts, they were too old to either benefit from post-1866 improvements or catch up in height after 1872. This story is consistent with an attenuated height deficit for cohorts born outside Paris but living in the 19th arrondissement at age 20, among whom around half had already migrated to Paris between ages 6 and 10 at the time of the sieges (see Supplementary Material B). This scenario also coheres with the absence of any 1860–1864 effect on migrants from Alsace-Lorraine who arrived in Paris after 1871.[14] The next section will look at whether the scar of relatively short height translated into higher adult mortality for both these early-born cohorts and those younger or even *in utero* during the sieges.

IV. Male mortality between ages 20 and 45

Following France's defeat, the Third Republic imported the Prussian military model, particularly with the introduction of time in the reserve force. Starting in 1872, a typical conscript would be examined at 20 years old, sent into active military service for 3 years, and then assigned to the reserve army until age 46. As the army wanted to know the whereabouts of all reservists, they were required to declare changes in residence. Furthermore, municipality mayors had to report their deaths. Consequently, we can observe conscripts until they left the army (at 46 years old), died, or were discharged for medical reasons. We can therefore look at adult mortality in relation to age at the time of the sieges. In contrast with many studies in the literature, our sources prevent us from looking at mortality beyond age 45 and from considering women, though they might be less affected (Zarulli et al., 2018).

(13) In the online Supplementary Material (Figure B.2), we show that this same feature is also reflected in the Seine *département* data in comparison to surrounding *départements*.

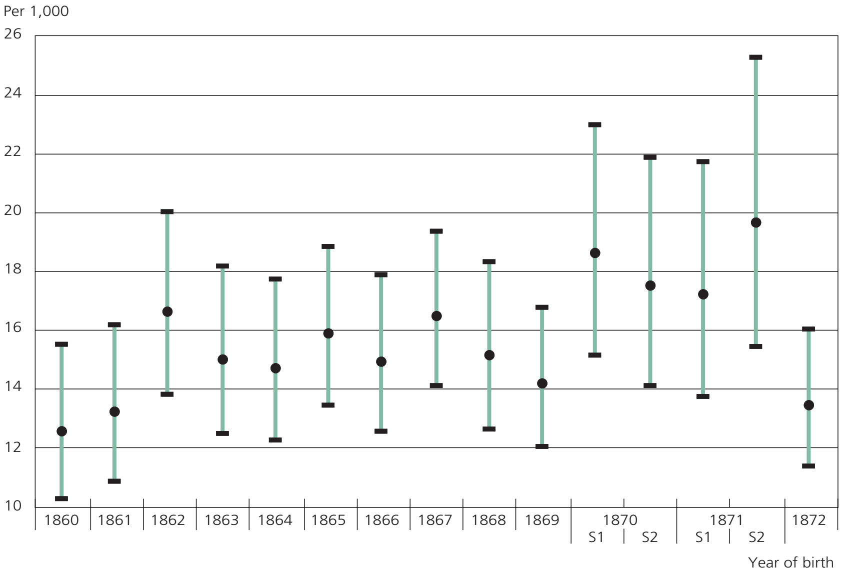
(14) Height data for the 3rd arrondissement reveal the same low height for the 1860 cohort but not for the four others that followed. However, the 1862 and 1863 birth cohorts are still 8 to 10 percentage points more likely to be declared unfit (see Supplementary Material, Figure C.1). Although also rather poor, the 3rd arrondissement was less peripheral than the 19th and thus perhaps benefited from a better health infrastructure.

We compute mortality rates by dividing the number of persons who died by the number of person-years lived. Our data allows us to control for time at risk, since we know when people enter and exit observation, which is, respectively, when the average conscript ends active military service at 23 years old and when either they are excluded from the reserve army for medical reasons, die, or reach 46 years old.(15)

Figure 3 plots the death rates of conscripts born in Paris between the end of their active service and the end of their reserve period. Mortality is higher for the 1870 and 1871 cohorts, with rates above 17.0 per 1,000 for each birth semester; whereas the average is 14.8 per 1,000 for the men born in the 1860s, or 13.4 per 1,000 for the 1872 post-crisis birth cohort.

Figure 3 also reveals that the cohort born in the second semester of 1871 yet again distinguishes itself, this time with a mortality risk that reaches 19.6 per 1,000. Table 3 shows the results of a simple Cox proportional model, and it provides for each birth cohort the equality test results for comparing the values of mortality risk to those of the post-crisis period (1872). Only for the 1870 and 1871 birth cohorts can the equality be rejected at a 95% confidence

Figure 3. Male mortality rate (20–45 years old), by birth cohort



Note: The figure shows mortality rates and 95% confidence intervals computed with a Poisson regression model. One estimate per birth year, except for 1870 and 1871, which are each divided into two semesters.

Coverage: 19th arrondissement military draft.

Source: Conscription records of the 19th arrondissement of Paris.

(15) Our estimates assume that mortality is independent of exiting observation before 46 years old. Even if those who exited earlier were discharged mostly for medical reasons, not all of them were dismissed because of lethal diseases like tuberculosis, and other reasons like myopia could not have led to premature death. Even when treating all exits as death events, the difference between the 1870–1871 and other cohorts still holds.

level. Both cohorts come out with mortality risks that lie 30% above the post-crisis level, and the gap even reaches 40% for the 1871-S2 cohort. The mortality rates of these cohorts are also significantly higher than the average of the earlier-born cohorts, even when we omit 1860 and 1861, which are marked by lower mortality.

Table 3. Cox proportional hazard model on male mortality, ages 20–45

	Hazard ratio compared to 1872		Test (H_0: ratio = 1)
	Estimate	Standard error	*p* value
1860	0.93	0.13	.593
1861	0.96	0.13	.769
1862	1.22	0.16	.135
1863	1.10	0.14	.460
1864	1.09	0.14	.531
1865	1.17	0.15	.200
1866	1.11	0.14	.421
1867	1.20	0.15	.139
1868	1.11	0.15	.422
1869	1.03	0.13	.833
1870	1.29	0.15	.035
1870-S1	1.33	0.19	.045
1870-S2	1.24	0.18	.139
1871	1.31	0.16	.029
1871-S1	1.24	0.18	.155
1871-S2	1.42	0.22	.026
N			5,222

Coverage: 19th arrondissement military draft; conscripts born in Greater Paris.
Source: Conscription records of the 19th arrondissement of Paris.

Overall, those very young during the crisis or born just after were at higher risk of adult mortality, particularly those who began their gestation during the sieges. This higher risk is incompatible with any substantial selection of the strongest or richest children by mortality during the sieges. The higher mortality risk in the 1871-S2 cohort is still compatible with selection by fertility as a result of the lowest-income groups having more offspring while the highest were more able to delay their births until after the crisis. This kind of selection would also explain why height is significantly lower in the 1871-S2 cohort. Yet, the conscripts born in 1871-S2 do not appear to be less educated or more often in unskilled occupations.[16] As for other cohorts, we conclude that selection effects are certainly limited.

(16) Another way to look at the famine's long-term effects would be to investigate the cognitive abilities of those most affected by it. Unfortunately, individual data on the education and occupation of conscripts are not very informative. Education is collected in six groups, from illiterate to university graduate; yet, 90% of the sample belongs to the literate category (i.e. able to read, write, and count). Education improves over time and, if anything, the last two cohorts (1871 and 1872) have a higher rate of literacy. Regarding occupation, we constructed three simple groups (unskilled, skilled, and higher-level occupations) to measure qualifications and human capital. Again, no effect of the sieges can be discerned, although this might only be due to the overly limited scope of our observations.

Finally, the 1860 to 1864 cohorts display no excess mortality at adult age, despite their shorter height. These results put into perspective both the famine's impact on stature and the possible selection of famine survivors. First, the youngest children who survived the famine did not escape its effects on adult mortality, although this did not reflect much in their height. Second, those who ended up shorter did not come out with lower chances of survival. In this respect, height is not necessarily a reliable indicator of health status, at least regarding mortality. It seems that latent damage to health can be revealed after growth has been completed, as in the case of children who experienced gestational stress yet were born with normal weight (Almond and Currie, 2011).

Conclusion

This paper investigates the impact of the two sieges of Paris from September 1870 to May 1871 on child mortality, adult height, and adult mortality, specifically among males in one of the lowest-income areas of the city. The first siege by Prussian forces caused a harsh but short-lived famine during a particularly cold winter. In the spring, a revolutionary uprising (the Paris Commune) ended in a bloodbath.

Using original data from individual death records, we calculate that the number of deaths more than doubled for almost all age ranges. However, given the age profile of mortality risks, the bulk of excess mortality concerned children under 5. Among the children born in 1869 and 1870, we estimate that only a little more than 40% reached the age of 20, which is notable when compared to the over 50% found under the prevailing mortality conditions observed before and after the sieges.

Using military conscription data, we also analyse the height at age 20 of cohorts that experienced the famine, as well as their risk of dying between ages 20 and 45. In addition to higher child mortality, the 1870 and 1871 birth cohorts also suffered from lower life expectancy after age 20. Among them, the worst cases are found for the few children that were conceived and partially gestated during the sieges: this group ended up significantly shorter at age 20 and faced 40% higher adult mortality. After running tests on height distribution and simulating the selection effects from excess mortality and reduced fertility, we conclude that selection could partly account for the relatively tall height of some survivors in the youngest cohorts. Yet, selection cannot account for differences in adult mortality.

From the mid-1860s onward, the living conditions in Paris began to improve quickly, thanks in particular to developments in sanitation. These gradual improvements continued and even accelerated after the crisis, thus allowing Paris natives to grow increasingly taller than natives from other regions. For the children aged between 2 and 5 during the sieges, the famine was sufficiently short-lived for survivors to recover in height and benefit from these improved conditions, which protected them from suffering any related lifelong health consequences. For those aged 6–10, we cannot exclude the possibility that they maintained their short stature because they were too old to catch up, even though their life expectancy was not affected.

A few methodological lessons might be drawn from this case study, especially to the benefit of the literature on early childhood development, nutrition issues during famine, anthropometrics, and economic history. Variations in height due to childhood living conditions currently persist even among European countries (Cavelaars et al., 2000), and long-term improvements in nutrition and health have been found to be linked to economic and social development—provided that height data are sufficiently representative and not too contaminated by selection. In contrast, short-term variations in height may not be as easy to trace, even in the case of a severe famine circumscribed in time and place. Measurement errors and noisy data continue to be issues, but other obstacles must also be addressed. First, the way a nutritional shock translates into short-term variations in stature is complex and depends not only on the duration of the shock itself but also on general living conditions before and after the shock, which themselves interact with selection effects and critical age windows for physiological growth. The same is true for the long-term effects of these shocks on mortality, as demonstrated by the contradictory findings in the literature. Secondly, height is not necessarily a reliable indicator for the chances of survival at adult age, or at least for famine survivors under 50 years old. Although the youngest children in our study who survived the famine were rather tall, they could have incurred other kinds of organ damage leading to higher mortality in later life—unlike the older children, who ended up shorter but without lower chances of survival.

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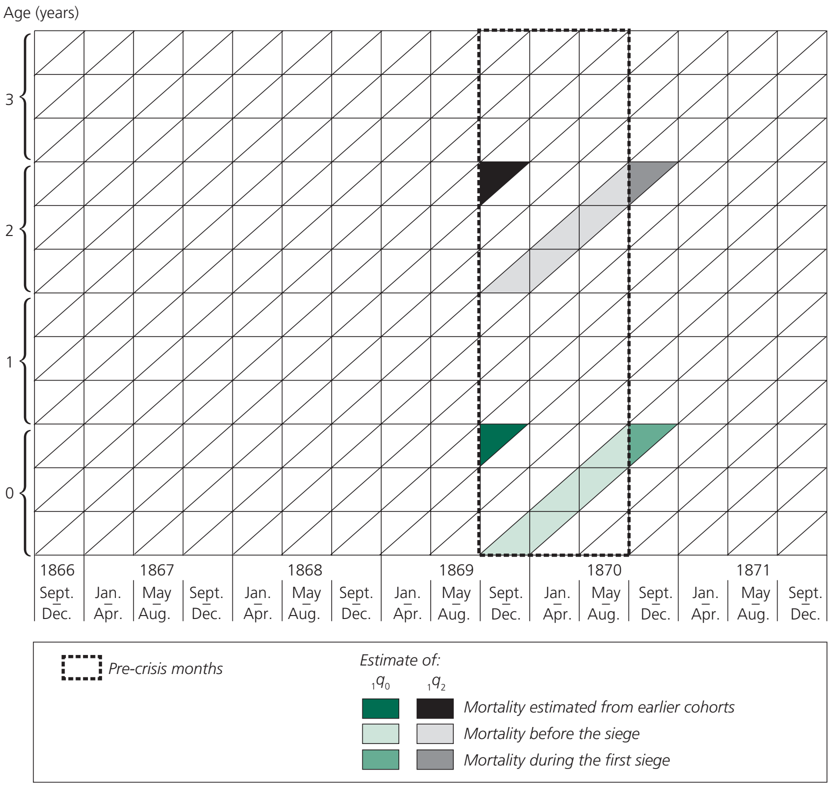
APPENDIX

Pre-crisis benchmark probabilities of dying

Figure A.1. Estimates of baseline mortality (${}_1q_0$ and ${}_1q_2$)



Note: This diagram illustrates pre-crisis mortality estimates based on our sample's 4-month birth cohorts beginning in September 1869. The estimate of ${}_1q_0$ is indicated in green and ${}_1q_2$ in grey. The triangles outside of the dotted rectangle correspond to mortality during the first siege, replaced by mortality estimated from earlier cohorts (darkest green and black triangles).

Table A.1. Comparison of pre-crisis probabilities of dying (%) for children born in the 19th arrondissement

	Pre-crisis benchmark	Van de Walle & Preston, 1974[a]
${}_1q_0$	24.6	19.7
${}_1q_1$	10.4	—
${}_1q_2$	3.0	—
${}_1q_3$	2.0	—
${}_1q_4$	1.4	—
${}_4q_1$	16.0	20.6
${}_5q_0$	36.7	36.2
${}_5q_5$	6.6	4.9
${}_{15}q_5$	18.4	—
${}_{20}q_0$	48.4	—

(a) Girls in the Seine *département*, 1866–1870 cohort.

Table A.2. Lexis table of survival rates in the 19th arrondissement by cohort

Age (years)	Baseline	1866	1867	1868	1869	1870		1871		1872
						S1	S2	S1	S2	
0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
1	**75.4**	75.4	75.4	75.4	75.4	**70.6**	**58.1**	**67.8**	**69.9**	**76.5**
2	**67.5**	67.5	67.5	67.5	**59.1**	**60.7**	**53.5**	**62.4**	**63.7**	68.5
3	**65.5**	65.5	65.5	**61.1**	**54.4**	**58.8**	**52.1**	60.5	61.7	66.5
4	**64.2**	64.2	**62.0**	**58.3**	52.7	57.6	51.1	59.3	60.5	65.1
5	**63.3**	**62.9**	**60.9**	**57.0**	52.0	56.8	50.4	58.5	59.7	64.2
6	**62.5**	**61.8**	**59.9**	56.3	51.3	56.1	49.7	57.7	58.9	63.4
7	**61.6**	**61.5**	59.1	55.5	50.6	55.3	49.0	56.9	58.1	62.5
8	**60.8**	60.6	58.3	54.8	49.9	54.6	48.4	56.2	57.3	61.7
9	**60.0**	59.8	57.5	54.0	49.2	53.8	47.7	55.4	56.5	60.8
10	**59.2**	59.0	56.7	53.3	48.5	53.1	47.1	54.7	55.7	60.0
11	**58.4**	58.2	56.0	52.6	47.9	52.4	46.4	53.9	55.0	59.2
12	**57.6**	57.4	55.2	51.9	47.2	51.7	45.8	53.2	54.3	58.4
13	**56.8**	56.7	54.5	51.2	46.6	51.0	45.2	52.5	53.5	57.6
14	**56.0**	55.9	53.7	50.5	46.0	50.3	44.6	51.8	52.8	56.8
15	**55.3**	55.1	53.0	49.8	45.4	49.6	44.0	51.1	52.1	56.1
16	**54.5**	54.4	52.3	49.1	44.7	48.9	43.4	50.4	51.4	55.3
17	**53.8**	53.7	51.6	48.5	44.1	48.3	42.8	49.7	50.7	54.6
18	**53.1**	52.9	50.9	47.8	43.5	47.6	42.2	49.0	50.0	53.8
19	**52.3**	52.2	50.2	47.2	43.0	47.0	41.6	48.4	49.3	53.1
20	**51.6**	51.5	49.5	46.5	42.4	46.3	41.1	47.7	48.7	52.4

Note: The baseline column gives survival rates based on pre-crisis mortality (September 1869 to August 1870). In the other columns, bold numbers indicate observed mortality during the crisis and for the next 2 years (September 1870 to August 1873), while baseline mortality applies to the non-bold numbers.
Source: Vital records of the 19th arrondissement.

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Denis Cogneau, Lionel Kesztenbaum • **THE DEMOGRAPHIC IMPACTS OF THE SIEGES OF PARIS, 1870–1871**

Paris came under siege twice between September 1870 and May 1871, first by the Prussian army and then by the Versailles government's assault on the Commune. The first resulted in a severe famine; the second in a bloodbath. We investigate the impact of this crisis on child mortality, adult height, and adult mortality, using original vital records and military register data from one of the city's lowest-income areas. Deaths more than doubled at all ages during this period, and under-5 mortality rates increased by 30% for children born in 1869 and 1870. Those conceived and gestated during the crisis ended up significantly shorter and faced 40% higher adult mortality than unaffected cohorts born afterwards, but children aged 2–5 later recovered in height as living conditions quickly improved. A nutritional shock's translation into short-term variations in stature and into lifetime survival thus seems to depend not only on the shock's duration but also on preceding and subsequent living conditions, which themselves interact with selection effects and critical age windows for physiological growth.

Denis COGNEAU, Lionel KESZTENBAUM • **LES CONSÉQUENCES DÉMOGRAPHIQUES DES SIÈGES DE PARIS, 1870-1871**

Paris a subi deux sièges entre septembre 1870 et mai 1871, d'abord par l'armée prussienne, puis par le gouvernement versaillais contre la Commune. Le premier a entraîné une terrible famine, le second un bain de sang. Nous étudions les répercussions de cette crise sur la mortalité infantile, la taille des adultes et leur mortalité à partir d'archives inédites de l'état civil et de la conscription militaire collectées dans l'un des arrondissements les plus pauvres de la ville. Pendant la crise, les décès font plus que doubler à tous les âges et la mortalité des enfants de moins de 5 ans nés en 1869 et 1870 augmente de 30 %. Une fois arrivés à l'âge adulte, les enfants en gestation pendant la crise sont notablement plus petits et leur mortalité est supérieure de 40 % à celle des cohortes nées plus tard ; en revanche, les enfants âgés de 2 à 5 ans pendant la crise ont rattrapé leur retard de taille, en lien avec l'amélioration des conditions de vie après 1871. L'impact d'un choc nutritionnel sur la taille et la durée de vie semble donc dépendre non seulement de la durée de ce choc mais aussi des conditions de vie antérieures et ultérieures, qui elles-mêmes interagissent avec d'éventuels effets de sélection et les âges critiques pour la croissance physiologique.

Keywords: famine, height, excess mortality, health, malnutrition, Siege of Paris, Paris Commune, France