Short and long-term impacts of famines. The case of the siege of Paris, 1870-1871

> "Paris n'a succombé ni sous l'effort de l'artillerie prussienne, ni été vaincu par la supériorité militaire de l'assiégeant. Il a cédé devant un ennemi que personne ne peut dompter, ni seulement combattre: devant la famine ; et encore il l'a supportée gaîment, il l'a presque défiée, jusqu'au moment où la disette absolue vint faire tomber le fusil des mains défaillantes de nos soldats."[1]
>
> Arnold Henryot (1871)

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Abstract
From September 1870 to May 1871, the siege of Paris, first by the Prussian army then by 'legalist' French troops, resulted in a harsh famine: Parisians were forced to eat rats and even the elephant of the zoo. We study the impact of this shock on both child mortality and the height stature of survivors, taking into account of the selection effects linked to mortality as well as to fertility and migration. To this aim, we collected original data on 20 year-old military conscripts born in one of the poorest district of Paris between 1850 and 1880. Most sources are congruent on the general level of mortality and lead us to conclude that mortality almost double during the very short period of the siege. However, the analysis of individual death records shows no specific selection by age or origin. The height stature evolution across birth cohorts reveals little, if any, effects of the siege itself but rather the long term evolution of nutrition. We tentatively argue that early-age children benefited from improved living conditions in the city in the aftermaths of the siege.

Keywords: height, health, Famine, France

[1] "Paris did not bow to Prussians canons, neither was it vanquished by the military superiority of the opponent. Paris lost in front of an enemy that cannot be tamed nor fought: hunger; and yet, it endured it joyfully, it almost defied it, up until the moment when absolute famine made the failing hands of our soldiers drop their rifles" (translated by the authors).

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Introduction

It is both obvious and quite well known that the level of nutrition has a strong impact on health. Robert Fogel (1994; 2004) attributes almost all the decrease in mortality from the 18th century to the end of the 19th century to improvements in net nutrition. The role of alternative factors like public health, hygiene, and medical technology are still very much debated, for the European context as well as for other historical cases (Cutler, Deaton, and Lleras-Muney 2006).

However, the precise relationship between (net) nutrition and health remains difficult to observe. There are several reasons for this but the most important is the large number of channels through which nutrition might potentially influence health, and then mortality. This includes many indirect and lagged effects. The recent and now dominant trend in the literature is to look at long-term consequences of early-life conditions. The so-called Barker hypothesis postulates that living conditions during infancy or while in the womb impact health and survival later in life (Barker 1990). Many scholars have attempted to investigate this hypothesis, looking at survival rates, morbidity or the occurrence of specific diseases, but evidence remain scarce, especially given the many disturbance that could occur between early- and later-life and the potential cofounders that may explain both early-life conditions and later-life mortality (Lee 2003; D. L. Costa 2000; Barham, Macours, and Maluccio 2013 among others).

As better fed children end up taller and taller adults seem to die later, height stature is often used as an intermediate variable that allows studying the relationship between parental income–or more generally living conditions (food availability, diseases during infancy, and so on) in early ages–and long-term health (Bozzoli, Deaton, and Quintana-Domeque 2009). Still, the causal impact of nutrition improvements on height–and then on life expectancy–is debated both in terms of magnitude and of timing over the stature growth period (in utero, early ages, adolescence). Thus the validity and accuracy of height as an indicator of health and welfare is still questioned (Bodenhorn, Guinnane, and Mroz 2014). Such an assumption relies on a series of hypotheses that must be clearly stated. First the timing of human growth had to be known accurately. And it has to be a rather short time span. As a consequence, for instance, catch-up effects need to be absent or limited. Second selection effects, especially those related to mortality, have to be small or nonexistent.

There is no way to test experimentally how exogenous changes in nutrition would affect adult stature. Recent works exploit the natural experiments generated by exogenous agricultural income failures, either due to droughts (Maccini and Yang 2008), pests (Banerjee et al. 2010), or commodity price falls (Cogneau and Jedwab 2012). Most works tends to acknowledge persisting effects of childhood living conditions on height. But the precise chronology of the effect and the intensity are still rather unclear. For instance, many would agree that the most decisive years are below two years old but some find effects at later age, for instance 5/6 and 9 years old for migrants to Sweden (Berg (van den) et al. 2011).

Another set of literature is more specifically dedicated to analyzing the consequences of famines (Scholte, Berg (van den), and Lindeboom 2012), with an important focus on the Chinese Famine during the Big Leap Forward (Almond et al. 2010). As famine not only results in lower caloric intakes but also in higher mortality, lower fertility, and possibly migration out of famine stricken areas, these contributions devote great effort in trying to isolate the nutritional channel from selection effects that potentially confound it (Gørgens, Meng, and Vaithianathan 2012; Meng and Qian 2009). Our contribution adds to this latter strand.

Finally, our paper is also related to a third set of literature, on which we largely draw without contributing much: the vast historical literature analyzing the French-Prussian 1870 war and the Paris Commune. Both events had huge political implications, not only for France but for Europe as a whole, and even beyond that. The war–and the harsh siege of Paris–ended with the unification of Germany but also produced bitter resentment from the French (who did lose substantial part of their territory in addition to the humiliating siege and defeat, and the celebrations of German unification in Versailles). This is undoubtedly one of the factors

leading to WW1. The Paris Commune was depicted as a life-and-death struggle between bourgeoisie and working class and, as such, it was widely watched–and commented upon–from all over the capitalist world, both in Europe and in the US. We won't get too much into those details but they are certainly important to fully understand our analysis. On the war and the siege, the main references are probably Howard (2001) and Wawro (2003). On the Paris Commune, a huge work has been done by Jacques Rougerie (e.g. Rougerie 2004) and Robert Tombs (e.g. Tombs 1999). A recent synthesis provides the many details of this episode (Merriman 2014). We rely heavily on those works and refer the reader to them for more details and in-depth analysis on the specific history of both events.

We aim at measuring the causal impact of famine on the mortality and the height stature of children who were inside Paris during the 1870-71 siege by the Prussian army then by 'legalist' governmental French troops. We take advantage of the high quality of French administrative data to assess precisely the extent of that shock. Of course data from the siege itself are scarce, not to say nonexistent. But there are many individual data covering both the periods immediately before and after the event as well as the rest of the country. Therefore we can make a double comparison in both time and space so as to assess the consequences of the shock.

The event we observe constitute a kind of pure experiment of closed population famine. More precisely it is a short blockade (four months) with a very high mortality. In that respect, the one event already studied it is closest to is probably the Leningrad siege (Sparen et al. 2004), although even shorter in duration than the latter.

This paper has three goals related with the nutrition shock occurring during the 1870-1871 siege of Paris. The first one is to establish the size of the infant mortality increase linked to the shock. The second is to measure the height penalty linked with the shock, if any, and to determine which cohorts were affected. The third is to link both phenomena to understand more precisely how famines affect adult height.

Context and method

In a context of general tension in Europe and growing power of German states and Prussia, a wire (the *Dépêche d'Ems*) was written by the Prussian chancellor Otto von Bismark so as to humiliate the French and trigger them to declare war on Prussia. Falling into that trap, the French did so on July, 19th 1870. After a brief preparation, Prussian troops and their German allies invaded France at the beginning of August. From that moment on, the war was a succession of French defeats and a month after the beginning of the invasion, on September 2nd, the French Emperor, Napoleon the Third, surrendered in Sedan with a large chunk of the French army (Howard 2001). This swift defeat was completely unexpected by many in France, especially in the capital city. In Paris, a new government formed and, as the Prussian army rushed toward the city, prepared for defense. On September 14th–ten days after the news of the surrender reached Paris–all moves in and out of the city were forbidden. The next day Prussian armies cut all railway lines from the city and two days later Paris was completely surrounded. The move was so swift and so unexpected that few people, mostly among the wealthiest part of the population, were able to flee the city. Contemporary reports estimate that at most 300,000 people escaped the city, out of 1.9 million (Sueur, 1872 p. 9 for instance).

It was the beginning of a long and painful siege. The Prussian surrounded the city and blocked all exits, preventing both people and food to move in the city. Again, due to the swiftness of the defeat and the level of surprise in the face of it, little, if any, preparation had been made for the siege. Everyone thought France would win the war or, at worse, that it would have been limited to the borders areas. As a result food started to run short quite early in the siege. Already in the beginning of October, meat was rationed and city butcheries were organized. Early November proper meat ran short and butcher start to sell dogs, cats and sparrow; an open air

rats market opened in front of the town house. At the end of December both elephants of the zoo were shot down and sold. The winter was particularly harsh due to the temperature (it was an exceptionally cold winter with temperatures around Christmas going as low as minus 10), the lack of heating (both wood and coal were in short supply and soon started to lack), Prussian bombings (starting December 27th after 100 days of siege), and, of course, food shortages (by mid-December there was no more meat and bread, wheat and potatoes were soon rationed). By the end of January the city was on its feet and forced to surrender, negotiating a ceasefire for January 26th 1871. The following peace talks acknowledge the defeat of France in early March 1871.

But the end of the Siege was not the end of the story for the city, as a revolution–the *Commune de Paris*–soon broke out as a direct result of the defeat (Tombs 1999). The Paris Commune resulted in another siege, this time by the French governmental forces (the so-called "Versaillais" because the temporary government was located in Versailles). That siege was even fiercer as it had a strong class related background, the Commune being viewed as a threat not only to the French dominant group but also to the whole European Bourgeoisie (Rougerie 2004); on the opposite side, the Commune remained for decades a symbol of the resistance of the working class, with its myths, its songs, and its heroes. That siege was much shorter but ended up in a bloodbath at the end of spring 1871, the infamous *Semaine sanglante* ("bloody week").

All in all, the city was plagued by war for almost nine months, in two phases. It was entirely shut down from mid-September 1870 to the end of January 1871 and then again besieged from mid-March to the end of May 1871. The two sieges follow one another but are very different by nature. As contemporary testimony makes clear, food shortage and very harsh living conditions were characteristic of the Prussian siege and lead to a high mortality. The food constrain seems much less important during the Commune and neither contemporary accounts (Lissagaray 2004) nor historians mention any famine or additional deaths linked with the lack of food. The main reason is probably that the mobility constraint was less severe during the Commune and there are numerous accounts of getting in and out of the city during that period. Overall, there was much less food shortage and more people killed as a result of fighting during the Commune than during the Prussian siege.[2] This should without doubt influence the age distribution of mortality.

For our study, several issues matter here. Firstly, the progression of the Prussian armies was so swift that few people had the time to leave the city before the city became completely surrounded. This limits the selection effect from migration on the population who bore the burden of the siege. Secondly, the siege resulted without doubt on a generalized famine that was the main cause of death (either directly or indirectly through diseases erupting because of hunger) while war related casualties (for instance related to Prussian bombings) remained very limited. The contemporary descriptions of the famine are both numerous and converging. Thirdly, the limited extension of the siege, both in space (contrary to large-scale famines in China or India for instance), and in time (contrary to Leningrad WWII siege for instance) means that the population to study is quite limited but easy to identify.

As a result, the double difference empirical strategy we follow amounts to making a comparison in both time and space so as to get an indirect measure of the consequences of the famine on mortality and on height stature. We compute the same indicators (mortality rates or stunted people) for different cohorts born in one of the poorest districts of Paris. This provides a first estimation of the effect of the famine by comparing the conditions for those who were children at the time with individuals who were older or who were born after, i.e. belonging to other birth cohorts. Then we compute the same simple difference for other places in France that are as comparable as possible to our Parisian districts, but did not experience the siege: we select in particular the poorest district of the French second largest city, Lyon. Provided that the trends

[2] Below, we will use "the siege" for the Prussian siege, "the Commune" for the second siege, and "the crisis" for the whole nine months period.

in height gains were similar in Paris and Lyon before the shock, the double difference will provide us an unbiased estimate of the impact of the shock on the distribution of height stature.

However, this reduced form impact could mix many potential channels: one is nutrition, but another one is selective mortality. Hence we need to explore at the same time mortality and heights. First, famines have short term effects through mortality: many people are dying either from the lack of food itself or from the diseases that take advantage of the weakened bodies. Yet, famines also have long-term effects, by impeding the physical growth of survivors. The brutal and severe lack of nutriment endured by the body during famine periods means that even those who survive the famine will face its consequences for some time. Second, both effects may be linked. On the one hand, people who survived are selected and may therefore bias heights up: if those who died as a result of the famine are the shortest, then we may observe unusually tall individuals after the famine. On the other hand, everyone, including those who survived, experienced a lack of food and thus we may think that on average people would be shorter as a result from the famine.

Data and implementation

We gather different sources in order to measure both mortality and height for the different cohorts who lived through the crisis. It is especially important to evaluate the mortality during the winter 1870-71 at the heart of the Prussian siege. To do this we take advantage of different sources both qualitative and quantitative. Qualitative sources make clear the extent of the famine and the harshness of life during the siege. For instance Henryot (1871) describe in great details the intake of animal calories over the course of the siege (first beef then horse then smoked fish then whatever can be found). On page 129 he details the prices of various sources of meat at the end of December 1870, with chicken or goose (very expensive) but also dog, rats, sparrow or crow. Those are more suggestive, if not simply anecdotal evidence, than proofs but they converge with all sort of descriptive accounts of the difficult of life in Paris. By mid-January bread, already of poor quality, started to lack and various ways to supplement it were developed, including adding grinded bones from the local catacombs. More indicative, perhaps, is the huge rise in the prices of basic food that has been widely documented by both contemporary accounts and historical works. Hence, in three months, between the end of September and the end of December, the price of a dozen eggs is multiplied by 13, that of a measure of potatoes rose tenfold; ham seven times. Henryot goes on to describes people queuing day and night for a food that is less and less nutritious and seems less and less to be food. Finally, he gives, as others also do, various accounts of the high mortality: the epidemics (especially a strong smallpox one that claimed many lives); the hospitals without heat, by mid-December for lack of coal (herbal tea freezing in the cups); the young children lacking milk (as both their mother and the few remaining cows lack food).

All this is both useful and insufficient. We need to complement them with quantitative measures of the number of deaths. To estimate them we rely on three sets of arguments. The first one is direct contemporary comments and computations. The second one is computing mortality from published aggregated sources throughout the periods, mainly civil records of births and deaths and aggregated results from both 1866 and 1872 censuses. For the third one we rely on a detailed recollection of individual death records in the 19th arrondissement before, during, and after the crisis. Those will help us established the age-profile of the mortality during the siege and its immediate aftermaths. Indeed, our aim is not only to compute a global account of deaths from the crisis but to detail that mortality and characterize those who experienced it. Furthermore, we aim at detailing what happened immediately after the crisis, for instance if mortality stays high in the years immediately following the crisis or return immediately to its pre-crisis level (Song 2009; Zarulli 2013).

Whatever the method we use, be it direct or indirect, migration is a real and difficult issue. Out-migration just before the beginning of the siege may lead us to overestimate mortality rates during the siege and also, if many migrants did not come back after the end of the war, lead us to overestimate indirect mortality. But, as we argue before, out-migration was rather limited. Two key issues remain. A first one is the regular yearly migration in and out of Paris. As for any big city in that era, Paris experienced huge migration flows that contributed to the growth of the city (the net migration flux being positive). So in any case, we have to assume a somehow stable structure of these migrations before and after the siege. We could then make different assumptions on the structure of migration (and its evolution over time) and see how they are likely to affect our results. A second issue is the change in the composition of the population that occurred–to an extent that is hard to determine–as a result to the crisis, mainly as workers and working class people were either arrested or deported or flee the city.

To compute height measures over time, we rely entirely on individual data from the military registers. Immediately after the 1871 defeat to Prussia, France switched its military organization from a small professional army to universal conscription. Starting in 1872, all men had to report to the army at the age of twenty years old. The military authorities tested their fitness for the service and, in particular, registered their heights. This means that we can have access to height information at the individual level for all cohorts born after 1851. We aim at collecting all cohorts born between 1850 (aged 20 at the time of the siege) and 1880 (born after the siege) to get a full sense of the trend in height and its change caused by the siege. Of course, we cannot collect all the data for all those cohorts: there are approximately 10,000 conscripts in Paris in each year. So we choose to focus on one particular district (*arrondissement*). We focus on a working class stronghold, the 19th district for obvious reasons. First, it seems clear that the poor would suffer more from the context of famine. Second, they were the less prone to flee the city either in between the two sieges or after the second one.

For comparison purposes, we collect the data for Lyon, France's second largest city, because it seems to be the closest comparison point. Lyon is not only a large city but, just like Paris, it is also a quite industrial one. We focus on a working-class district (the 4th district) which provides a good comparison point with Paris' 19th district. Lyon was not directly affected by the war; there was neither a siege nor any direct presence of the Prussians[3].

Mortality during the siege

To start, let us evaluate the impact of the crisis on mortality. Both direct evidences and historical sources are more easily available for the siege by the Prussian than for the Commune when all public services were in disarray. There is no doubt, though, that casualties were much higher during the former period. Overall, most sources are congruent for the total mortality during the siege with a very strong peak of mortality in January and February that represent four or five times the normal level of mortality. It seems the Commune by itself did not experience specific over-mortality, besides the remaining consequences of the siege and the *Semaine Sanglante*. For the latter, no final estimation is agreed upon, between the semi-official figures of 17,000 deaths that come from different reports on both side (général Appert for the army and Lissagaray for the insurgents) and the work of historians who put that figure below, around 10,000 (Tombs 1994). All in All, it is probably safe to say that mortality over the whole period (9 months) was more than twice the regular level.

To put the crisis in perspective, Paris was already quite a deadly place, even in regular times, with mortality significantly higher than the rest of the country. In the years preceding the siege,

[3] To be sure, there was also a Commune in Lyon but, despite being led by one of the key anarchist figure (Mikhail Bakounine) it was short-lived: twice it failed to establish itself and was stopped before it could even began (in September 1870 and March 1871 in both cases in relation with the events in Paris).

the number of deaths in Paris is around 45,000 for a TMR of 24‰, with variations in both ways (1865 and 1866 for instance experienced a cholera breakout which lead to an additional 10% mortality, but 1867 is a bit lower than this figure). As can be expected, the bulk of the mortality is concentrated on early ages, with children under 1 year old accounting for almost a fifth of the deaths, and children between one and ten dying in almost equal number as children under age 1. Overall the mortality rates for children are approximately: 150‰ (infant); 65‰ (1-4); 10‰ (5-9).

Total mortality

For the siege, various quantitative accounts told the story of the global number of deaths; sometimes disentangling further that total by weeks, sex or age. Du Camp (1881) gives the total deaths count for the first two months of the siege, 5222 in September and 7543 in October. D'Alméras (1925) details the count from mid-September to mid-February (23 weeks in total) as 64 154 deaths. Sheppard (1877), one of the most detailed first-hand report of life within the besieged Paris, details the number of deaths by weeks in the siege up until January: 46 861 deaths (over 19 weeks).

The most reliable source is probably Sueur (1872) who compiled various vital statistics to assess the number of deaths by week from early September to mid-March (28 weeks in total). During that period, according to Sueur, the total number of deaths is 75,167. Since he covers the whole siege, we can use its estimation as a benchmark and compare it with the others. All these estimates are congruent, sometimes almost identical, probably because they rely on the same sources and sometimes borrow figures one another. For instance, over the 19 weeks he covers Sheppard gives almost the same account of deaths as Sueur; over the period he covers, D'Alméras gives 6% more deaths than Sueur. All in all, those figures reveal an incredible toll: given that the total number of deaths for an average year is around 45,000 there is without doubt a strong excess of deaths during the siege. For instance, if we are to believe Sueur, the mortality for the first two months of the year 1871 (the worst period of the siege) is an astonishing 37,169 deaths, more than 80% of the total mortality for a regular year.

Another way to express these figures is to compute yearly estimates. To be sure, the various official publications give us mortality count for 1870 up until the end of August and for 1871 starting early June. For 1870, there are a little less than 40,000 deaths (which already put that year in the upper ones in terms of mortality). If we had to that the number of deaths for the remaining four months, we obtain a total number of deaths for 1870 somewhere between 72,000 (Sueur) and 73,590 (*Annuaires* or Vacher (1871)), to be compared with 45,800 for the two previous years.

For 1871, deaths from June 1st are given at 30,000 in published yearbooks. Before that date, data shortage is to be divided in two periods: from the beginning of the year to March 14th we can rely on different accounts of deaths for the siege, the same we mentioned earlier. For the transition and Commune periods (from mid-March to the end of May) we have less precise information on regular mortality. Without the Commune period, the total number of deaths is also a little more than 72,000. If we substitute for the missing period the figures for 1869, the number of deaths for the year 1871 would be around 83,000 in total, to which we must add at least 7,000 executions (and probably more). To be sure, a lower bound is around 90,000 deaths for the year 1871.

But overall, these figures must also be linked to the actual population. Before looking at deaths in more details, we need to discuss a little bit the evolution of the population. Indeed, the presence of any excess mortality would be meaningless had the population increase before the siege. On the contrary, we could be underestimating total mortality if a sufficiently large number of inhabitants had managed to flee before the beginning of the crisis or during it. In fact, if anything, the population did probably rise before the start of the Prussian siege: as part of the population from the wealthy neighborhood flew the city, the inhabitants of the nearby municipality found shelter in it. Vacher (1871) quotes different censuses made by the military to

organize the besieged population: one in October gives 2,116,000 inhabitants, another one the next month reveals 2,095,700 inhabitants. The true is probably somewhere in the middle but in both cases it is an increase from the previous census (which, to be true, is already four years old, dating from 1866) which was at 1,800,000 inhabitants. This increase in population, although far from negligible (16%), remains very small compared with the increase in mortality. As for the population during the Commune period, it is even harder to comprehend: the borders of the city were much more porous than during the Prussian siege; a larger share of the population (the wealthiest inhabitants) had left the city, although probably less than one usually think. Merriman (2014) mentions more than 200,000 additional inhabitants in Versailles as the government flew the capital.

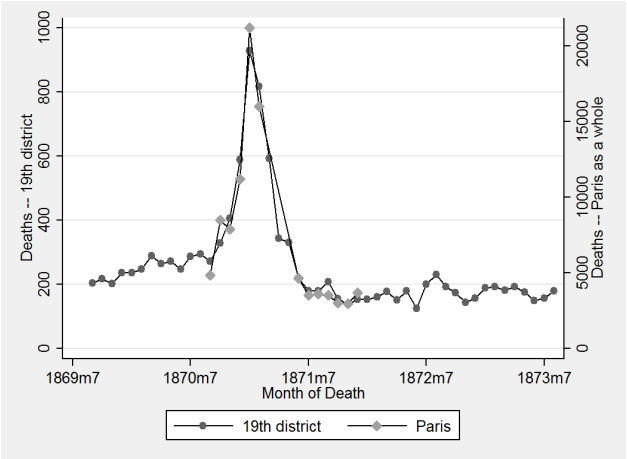
A direct way to assess the population of the city during that period is to compare the previous and subsequent censuses. This does entail various difficulties (for instance when considering inter-census migration) but give us a preliminary picture of the population during the period under study. We can mobilize the 1866 and 1872 censuses (since the 1871 census was not performed for obvious reasons) to assess the population of Paris at those dates, a few year before and almost immediately after. All in all there is little evidence that population changes explain the variations in mortality. In fact, total population increases between the two censuses, although very slightly (from 1,800,000 to 1,850,000 inhabitants). It's almost three times lower than the rate of increase in the previous intercensus period (1861-1866) but still it shows that, mostly, the evolution of the population cannot account for the huge increase in mortality.

Mortality by age in the 19th arrondissement

A key issue remains, that is how this huge over mortality was distributed among age groups, especially for the youngest which might be the most affected group. If we assume that total mortality doubles, does it means that mortality doubles at every ages or some ages are more affected than others. Another important feature is the distribution of dead between those born in Paris and those born outside. This is especially important in relationship with the evolution of height that we will investigate in the next section.

To detail mortality, we rely on collected data from individual death records for the 19th arrondissement of Paris. We have collected all individual records for the year preceding the crisis–September 1869 to August 1870–for the crisis itself–September 1870 to May 1871 and the following months–June 1870 to August 1871. In addition we collected a sampled (half of the individual records) for the subsequent two years, that is from September 1871 to August 1873. We collected additional information (place of birth, age) only for men, since we want to link mortality with height stature data from the military.

Figure 1 Deaths by months, 19th arrondissement and Paris



Note: Data for Paris as a whole only cover September 1870 to December 1871 with no data for the Commune period: March to June 1871.

This allows us to draw a first picture of the evolution of mortality over time both during and immediately after the crisis. As can be seen (Figure 1), mortality in the 19th district is rather comparable to that of Paris as a whole, months by months. In addition, the effect of the crisis is rather short-lived with mortality higher than normal between October 1870 and May 1871 (and much higher in the winter) but returning back to regular levels as soon as June 1871.

With no baseline population, we cannot evaluate if those who die where a specific group within the general population. But we can still draw some descriptive statistics of those who die during the crisis (Table 1). The change in the structure of mortality goes in the expected directions: more male, more foreign born, and more people in age to bear arms. Indeed, the two latter effects are probably related as the share of Parisians (alive) born outside of Paris rise strongly with age.

In fact, the only major change in the age structure is the strong reduction in the share of still-births and infant deaths during the Commune, in favor of adults. This is obviously related to the fact that, as we mentioned above, and contrary to the siege period, food shortage was much less an issue than actual fighting. It should also be remembered that those statistics do not include the Semaine Sanglante which would have add even more young adult male deaths, thus reinforcing the already clear opposition between the Siege and the Commune.

Table 1 Characteristics of those who died in the 19th district

	One year before	Siege	Commune	2 years after
Months	12	6	3	27
N	3016	3345	1268	4714
Age				
Still birth	7.7	5.8	2.6	8.7
1 month at most	7.5	8.4	4.7	8.8
1 m. to 1 year old	16.8	14.4	9.9	17.5
1-4	19.1	19.2	20.1	18.2
5-9	3.5	2.7	4.2	3.1
10-20	3.4	3.4	3.3	2.1
20-40	13.7	16.5	19.8	12.7
40-60	16.8	15.8	18.9	16.8
60+	11.5	13.7	16.4	12.2
Share Men	50.9	52.5	57.3	51.6
Share born in Paris	60.1	50.4	52.2	60.1

The distribution of age tends to be relatively stable from one period to another, with few exceptions. This would tend to demonstrate that mortality increase for everyone the same during the crisis (this contradict many contemporary accounts that tend to describe, probably because it was more intuitive, a higher mortality for young infant and old persons). To test this hypothesis, we can simply measure the excess mortality between crisis and regular period, assuming that the pre-crisis year we collected is representative of the regular conditions of mortality. In other words, we consider as a baseline the number of deaths from September 1869 to August 1870. For each subsequent month we report the number of deaths in that month to the number of deaths in the same month in the baseline period. Table 2 presents the average of that ratio taken over the three periods (the siege, the Commune and the two years following the end of the Commune). To take into account the change in the structure of deaths revealed in Table 1 we do this only for male born in Paris.

Two striking features immediately appear. The first one was expected: excess mortality during both the Siege and the Commune but falling on different age groups in the two periods. During the siege excess mortality is much higher for infant and old person. In fact the mortality for those between one month and 1 year old is three and a half time higher during the siege compared with regular period. In the commune period, on the contrary, it is almost back to standard levels but it

is the mortality of those between 10 and 40 years old who has increased three times. But the most surprising result of this result is undeniably the lower mortality post-siege. The period that started in June 1872 saw a strong decline in mortality for all age groups (with the slight exception of still-births, a group always at risk of measurement errors). This mortality decline is rather impressive. Different hypothesis may be formulated to explain it. First, population declined substantially in that period which would explain less deceased. Given the size of the decrease in mortality, however, this implies a substantial decline in population. Second, sanitary or living conditions improved as a result of the reconstruction of Paris after the crisis (Preston and van de Walle 1978). Third, the population has not decreased but changed and the people who inhabit the 19th arrondissement before and after the crisis are not the same. To discuss these hypothesis, we now turn to measuring mortality–and survival–by cohorts.

Table 2 Change in the mortality level over time

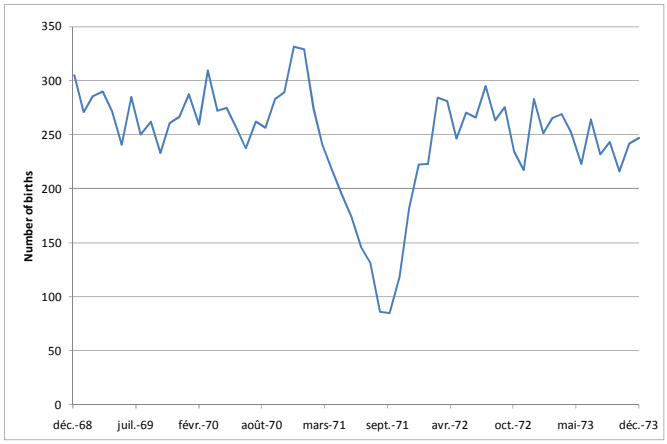
	Siege	Commune	2 years after
Still birth	2.59	0.74	1.25
1 month at most	2.14	1.03	0.71
1 m. to 1 year old	3.47	1.28	0.84
1-4	2.15	1.95	0.66
5-9	2.89	2.36	0.64
10-20	1.75	3.78	0.43
20-40	1.77	3.03	0.85
40-60	2.50	2.42	0.94
60+	2.88	2.37	0.73

Reading: there are on average 2.15 times more deaths aged 1-4 years old in the months of the siege period compared with similar months between September 1869 and August 1870.

Fertility and cohort effects

To start, we can measure the size of each cohorts by monthly births. As the crisis lasted nine months (or almost) it did reduce fertility but only afterwards (the conception that did not occurred during the siege). And indeed the fertility decline resulting from the crisis is short-lived (Figure 2).

Figure 2 Monthly birth in the 19th district



We now combine the mortality and fertility figures so as to get a sense of survival rates for each cohort as it went through the crisis. We do have a limited window on the crisis itself and so we capture only four years of the life of each cohort through that period. But, with minimal hypothesis, it already allows us to document mortality variations between cohorts. To do so, we consider observed mortality for the year before the crisis (September 1869-August 1870) as

"baseline mortality" that we will use for all cohorts for the ages we do not observe. To this we add the mortality really observed during the siege and compute the ratio of survivors at 20 years old for each cohort. In other words the only source of between cohorts variation is the mortality between September 1870 and August 1873.

The results show that mortality is limited to a few age groups and a few cohorts (Table 3). As we shown and discussed before, mortality increases roughly by the same magnitude for all age groups (but higher for the youngest) which means that excess mortality will be proportional to the initial mortality strength; the latter being obviously much higher for those under one year old. As we discussed before the mortality rates are around 150‰ for the 0-1 year old compared with 10‰ for the 5 to 9 years old. This means that doubling all mortality would affect much heavily those before one years old than the older ones. And this leads in turn to major differences in final surviving rates at 20 years old: for the most affected cohort (those born in 1870), half of them didn't make it to twenty, compared with around 70% for the cohorts who experienced more regular mortality conditions.

Table 3 Mortality and survival rates by cohorts in the 19th arrondissement

Age	Survivial baseline	Cohort 1866	Cohort 1867	Cohort 1868	Cohort 1869	Cohort 1870	Cohort 1871	Cohort 1872
		3183	3548	3318	3406	3648	2666	3303
0	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1	80.6%	80.6%	80.6%	80.6%	80.6%	63.6%	76.7%	87.4%
2	76.7%	76.7%	76.7%	76.7%	64.0%	57.9%	74.2%	83.2%
3	75.8%	75.8%	75.8%	70.1%	60.4%	56.8%	73.3%	82.2%
4	75.2%	75.2%	72.2%	67.6%	59.5%	56.6%	72.7%	81.6%
5	74.9%	73.9%	71.3%	67.1%	59.3%	56.1%	72.5%	81.3%
6	73.9%	72.9%	71.1%	66.4%	58.8%	55.6%	71.8%	80.5%
7	73.4%	72.8%	70.7%	66.1%	58.5%	55.3%	71.4%	80.1%
8	73.2%	72.6%	70.6%	65.9%	58.3%	55.2%	71.3%	79.9%
9	73.0%	72.4%	70.4%	65.8%	58.2%	55.0%	71.1%	79.8%
10	72.8%	72.3%	70.3%	65.7%	58.1%	54.9%	71.0%	79.6%
11	72.7%	72.3%	70.2%	65.6%	58.0%	54.9%	70.9%	79.5%
12	72.6%	72.2%	70.1%	65.5%	58.0%	54.8%	70.8%	79.5%
13	72.5%	72.1%	70.1%	65.5%	57.9%	54.8%	70.8%	79.4%
14	72.4%	72.0%	70.0%	65.4%	57.9%	54.7%	70.7%	79.3%
15	72.3%	72.0%	69.9%	65.4%	57.8%	54.7%	70.6%	79.2%
16	72.2%	71.9%	69.8%	65.3%	57.7%	54.6%	70.6%	79.1%
17	72.1%	71.8%	69.8%	65.2%	57.7%	54.6%	70.5%	79.1%
18	72.0%	71.8%	69.7%	65.2%	57.6%	54.5%	70.4%	79.0%
19	71.9%	71.7%	69.6%	65.1%	57.6%	54.4%	70.3%	78.9%
20	71.8%	71.6%	69.6%	65.0%	57.5%	54.4%	70.3%	78.8%

Note: the second column ('baseline') gives the survival rates resulting from the mortality observed before the crisis (Sep. 1869 to Aug. 1870). The colored cells are based on observed mortality during the crisis and the two subsequent years (from Sep. 1870 to Aug. 1873). For all other cells, baseline mortality applies.

To conclude the analysis of mortality, three salient facts emerge. First, most of the excess mortality falls on the very young and the very old. This is mostly because, even though mortality increase by almost the same magnitude for all ages, their standard mortality is the highest, by far. Second, there are no apparent lasting effects of the siege on mortality. Although excess mortality continue once the siege has ended, it is for a couple of months only and things soon go back to

normal. In fact it seems that it is the combination of famine and harsh winter that brings excess mortality and both ended at the same time. Third, mortality declines after the crisis compared with a typical years before. This may be related to the reconstruction of Paris that improved the quality of life or to a change in the socio-economic composition of the population, as the poorest left the city after the failure of the Commune.

Overall, the effect of the crisis on mortality are large but very limited in time. In a way, it is a short lived phenomenon. The famine we observe is very intense indeed but also very short (compared to other historical experience such as Leningrad, Finland or China). This may explain why its effects are not long-lasting and mortality immediately come back to its pre-crisis level. This is also something that must be kept in mind when studying the effect of the famine on height, to which we turn now.

Height

We explore the consequences of the siege on heights at twenty years old when those who went through the siege were measured by the army. We observe only people that are still in Paris at the age of twenty years old and we derive the consequences of the siege from those born in Paris. This means we assume that all these individuals experienced the siege. Or, more precisely, that there was no differential migration out of Paris just before the war across cohorts. This is not a very strong assumption since, as we argue before, few people were able to leave Paris just before the beginning of the siege and it is very likely that this was random over age groups but not over social groups and we consider a working class neighborhood where few may have been able to leave. Second, we assume that postwar migration patterns across cohorts are stable. In other words, we assume that there are no differences in the migration between 1870 and twenty years old for the different cohorts. Indeed out-migration is rather important for any district of Paris.

Thus, we compare conscripts born in Paris observed in the 19th district across cohorts,[4] differentiating those who went through the siege and the Commune from those who were born latter.

Shocks and trends in the evolution of height

We compute the average height of cohorts born in Paris (Figure 3). All those individuals are born in Paris and they are still living there, but in the 19th district, at twenty years old. So we may expect that they grew up there. This is the most precise assessment about their childhood we can make. We have data on all cohorts that went through the crisis, those born between 1850 and 1871. Of course those individuals experienced the crisis at different ages and this is one of the variation we intend to exploit. The other variation we exploit is to compare those with the conscripts born later, those born between 1871 and 1880.

The evolution of height is rather peculiar since there is no visible effects of the crisis itself: conscripts born around 1870-71 are not, as one would expect, smaller than the subsequent or previous cohorts. Quite the contrary in fact, the smallest conscripts are those who were between 7 and 9 years old during the siege. More broadly, those who were born around 1860, so who were aged between 5 and 13 years old at the time of the siege, are significantly smaller than all other cohorts. In five years, Parisians born conscripts lost two centimeters in average height, which is a rather significant amount (it corresponds roughly to the average gain in France as a whole over the 19th century). A key question, though, is whether this evolution is linked to the crisis or is related to external factors, for instance food availability over time. On the other side, the relatively high stature of those very young at the time of the siege may be explained by selection

[4] To be sure, a more accurate comparison would be to consider only those born in the 19th district. But this reduce a lot our sample and does not alter much the results.

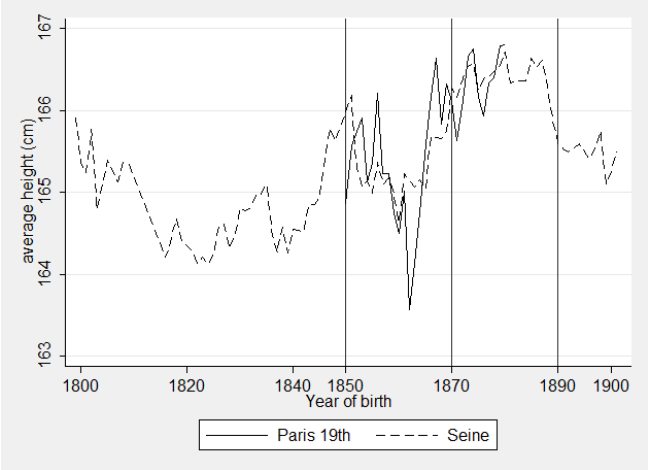
effects due to the very high mortality experienced by those cohorts. We'll come back to this below.

Figure 3 Average height of conscripts born in Paris' 19th district according to their year of birth.

To put this evolution in perspective, we need to look at the bigger picture and to consider the whole evolution of height over a century. Basically we ask: first if a variation of two centimeters over five years is exceptional; and, second, if this evolution fits into the structural trend for Paris. To do so, we can rely on aggregated data produced yearly by the Army. One limitations on those data is that they are by départements (France main administrative unit, the country as a whole is divided in a bit less than 100 départements): they give height for all those who reached 20 years old and who are examined in a given département. In case of large migrations, the people observed in a given département would be very different from those who grew up in that département if: a département see many people leave before they reached 20 years old and they are different in terms of height from those who stay (selective out-migration); or a département receive many migrants and their height profile is different from those who grew up in that département (large in-migration). Unfortunately the département which encompass Paris falls, as might be expected, in both category, although the second issue is probably the more problematic. Paris experienced rather strong in-migration and, as a result, a large share of the conscripts recruited at twenty years old in the Seine were not born there. This share changes over time but is roughly half of the recruits in our period (Farcy and Faure 2003). It varies also by district, the poorer and working-class districts–such as the 19th district–were less attractive to migrants and thus encompass a larger share of Parisian natives. In our sample the share of natives is quite stable over the period under study, around 60% of the recruits.

So, keeping in mind that both series are not completely comparable ("Seine" includes migrants who might or might not have grew up there; it also includes rural parts of the département outside the wall of Paris itself) we can put the evolution observed immediately before and after the crisis in perspective (Figure 4). At this scale the evolution around 1860 looks both more dramatic and less abnormal. Indeed it seems to fit in a pattern of ups and downs that affects height stature in the Paris area all over the century. In that perspective the downward spike for the 1862 cohorts seems to be the only differences between the two series. And both series share the pattern we discussed above: those born around 1860 are smaller (although in perspective they are taller than those born in the first half of the 19th century) whereas those born around 1870 are significantly taller than all those born before. And this last effect remains for at least twenty years. Besides the variations between 1850-1870, it would be noted that the other major health shocks, for instance the two major cholera epidemics in 1832 and 1849, are not clearly visible on the overall evolution of height.

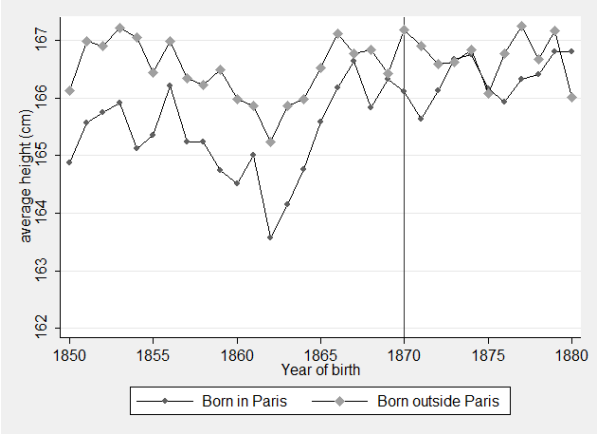
Figure 4 Average height in Paris 19th district and in the Seine département by birth cohort, 1797-1902



The most remarkable (and unexpected) feature of the previous analysis is probably that the results from the aggregated data are very close to those of the individual data, despite the latter excluding migrants. This is quite puzzling because migrants constitute a large share of the population–half of the total population of Paris in the second part of the 19th century–and they did not grew up in the city (or at least most of them probably did not). So we would expect migrants and natives to show different heights patterns, related to their local conditions of living during childhood. We can test that directly on our sample by comparing, among recruits in the 19th district, those born in Paris and those born outside of Paris (Figure 5). Again the same general pattern appear with a decrease of average height for those born in the late 1850s and early 1860s for both migrants and natives. Two notable differences remain, though. First outsiders are always taller than natives before the crisis, with approximately one centimeter between the two. Second, both the correlation between the two series and the height advantage experienced by non-Parisians disappear for those born after 1867 (or so). This latter effect would rule out measurement errors (which would be the prime explanation for variations in height that are correlated between groups measured the same year but are not supposed to be experiencing the same conditions at birth), expect if we think they might suddenly change.

So it seems that a large share of the migrants experienced the same living conditions as Parisians, either because they moved to Paris when very young or because the nutrition conditions of areas where migrants to Paris live are close to that of the capital city. This is not completely hypothetical since many migrants come from areas around Paris (admittedly a few hundred kilometers around) where food availability, for instance, may have been correlated to that of Paris. But further investigation is needed to test precisely this hypothesis.

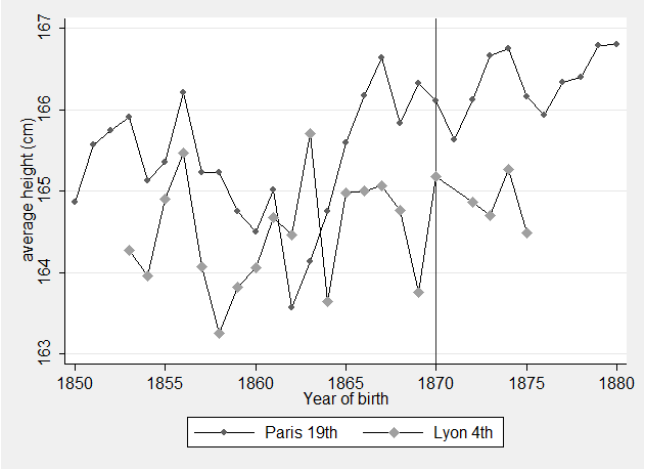
Figure 5 Average height in Paris 19th depending on the place of birth



Lyon and Paris

From the previous results it seems that the variations in average height we observe are more related to broad evolution of living conditions (change in nutrition for instance) than to the famine from the siege. One final robustness test we perform is to compare height of Parisians born (observed in the 19th district) with that of Lyonnais observed in a comparable working class neighborhood, the 4th district of Lyon. The general pictures is that there is little connection between the two (Figure 6). The height of Lyonnais does oscillate from one year to another but the general trend seems flat with an average height somewhere between 164 and 165 centimeters.

Figure 6 Average heights, born in Paris or in Lyon, 1850-1880



Selection issues

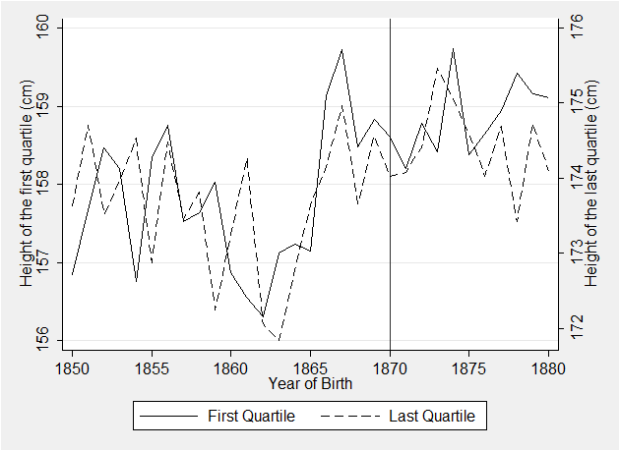
Our results can be summarized as such. First, mortality was much higher during the Siege than in regular time and the excess mortality fall mostly on very young children, under two or three years old (at least for those who were at most twenty years old during the crisis). Second, the evolution prior to the crisis is rather similar for those born outside of Paris and those born in Paris, which means that, at least for those over 5 years old at the time of the crisis, there is no effect of the famine. Third, there is no clear break in trend in 1870 for either Lyonnais or those born outside of Paris. The only clear break appear for those born in Paris but it is an upward break: those born after 1867 are taller. But (and this is most surprising) this remains true for latter cohorts, even though they did not experienced the siege. We might explain this by: one, a selection effect linked to the very high mortality experienced by those under three years old at the time of the siege; two, by improving living conditions in Paris after the siege or (and) change in the population living in working class districts in Paris after the Commune.

Indeed, selective mortality during childhood can lead to taller individuals in adulthood: when mortality is sufficiently high, selection might dominate scarring and, as a result, the survivors would be taller (Bozzoli, Deaton, and Quintana-Domeque 2009). To test this effect we looked at changes in the distribution of height. The idea of selection by mortality is that there is a mortality gradient among children according to their future (potential) adult height. In other words, the children who will become, once adults, the shortest among their cohort will die more frequently during famines than those who will be among the tallest. The rational for that argument is that being short once adult reflect a frailty that is already expressed during childhood. Moreover, there's no reason that this effect would be constant over age (for instance it might be that the frailty linked to potential height appears only at a given age). What is clear is that in that case (mortality selection), the whole distribution of height should be affected with the left tail of the distribution being relatively smaller (in numbers) compare to non-affected cohorts (given that the shortest died more often during the famine).

In our cases, mortality was higher for the youngest so we would expect that the shortest died relatively more for the youngest cohorts during the famine and hence these cohorts would be

taller (since their share of small people will be lower). This would be consistent with both results on mortality and height. However selection by mortality would imply changes in the distribution of height (and not only of the mean) with the smallest being taller for the cohorts with higher mortality. This is not what we observe here (Figure 7). There are little differences in the effect of the famine on the first and last quartile of height. The change in mean height for those born at the time of the siege (and in fact at all ages) we observed in the previous section is linked to a decrease at all points of the distribution and not to a stronger decrease of the height of the smallest. The whole height distribution is shifted to the left, the effect being quite the same over it. We do not see any clear confirmation of the presence of selection by mortality here.

Figure 7 Average conscripts' height. First and last quartiles



Conclusion

This paper investigates the impact of the Prussian siege of Paris from September 1870 to March 1871 on both mortality and height stature of survivors from one of the poorest area of the city (19th arrondissement). The siege was responsible for a harsh, although short-lived, famine that occurred during a very cold winter. It was followed by a revolutionary attempt (Paris Commune) that ended up in a bloodbath.

Using original data on individual death records, we calculate that mortality more than doubled–and even tripled on short periods–for almost all age ranges, with the 10 to 39 year-old being a bit less affected. Given the age profile of mortality risks, this means that the bulk of excess mortality concerned children aged from 0 to 5 year-old. Among the children born in 1869 or 1870, we estimate that little more than half of them reached the age of 20, compared with more than 70% under mortality conditions that prevailed before (1869) or after (1872) the siege. For children aged above 2 years old in 1870, or for those born in 1871, over-mortality is more limited in absolute levels.

Surprisingly enough, using military conscription data, we find the 20 year-old height stature of children born 1865 to 1870 to be little different on average from children born 1871 to 1875, and even taller on average than children born from 1853 to 1858. We examine whether selective mortality (deaths of more children with shorter height potentials) could account for this pattern. Given orders of magnitude, whereas such a selection effect is plausible for the youngest cohorts (below 2 year-old at the time), it is much less so for cohorts aged 3 to 5. Besides, top and bottom quartiles exhibit the same evolutions, which raise doubts on selection at the bottom of the height distribution. We rather conclude that surviving children were able to catch-up in height after the famine shock.

After the crisis, living conditions in Paris progressively improved, thanks in particular to the development of sanitation. More research is needed for looking at whether some of the poorest

were ousted from the city after the Commune, exile or forced migration thus contributing to both a significant and swift drop in mortality and a rather tall height stature.

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