ARTICLE IN PRESS
YEXEH-01027; No of Pages 19
Explorations in Economic History xxx (2011) xxx–xxx

Contents lists available at ScienceDirect

Explorations in Economic History

journal homepage: www.elsevier.com/locate/eeh

The health cost of living in a city: The case of France at the end of the 19th century

Lionel Kesztenbaum [a,*], Jean-Laurent Rosenthal [b,1]

[a] Institut National d'Etudes Démographiques (INED), 133 Boulevard Davout, 75980 Paris Cedex 20, France
[b] Division of the Humanities and Social Sciences MC 228-77, California Institute of Technology Pasadena, CA 91125, USA

ARTICLE INFO

Article history:
Received 25 March 2010
Available online xxxx

JEL classification:
I18
N33
N93

Keywords:
Migration
Health
Differential mortality
Rural–urban gap
France

ABSTRACT

Despite a long standing debate over urban living conditions during industrialization, the impact of rural–urban migrations on health and mortality remains an open question. We observe both mortality and geographical mobility in a large longitudinal dataset of French males and show that rural–urban migrants benefited from clear advantages over those who already lived in the city. However, this benefit fades in a few years. Further we find no evidence of a spike in mortality among rural migrants as they encountered the more severe disease environment of cities, instead it seems their initially superior physical human capital was depleted over time.
© 2010 Elsevier Inc. All rights reserved.

1. Introduction: standards of living and local health conditions

That cities suffered higher mortality than rural areas was a commonplace among nineteenth century social scientists (Vedrenne-Villeneuve, 1961). As early as the eighteenth century, scholars had used differences between monks' mortality and that of ‘ordinary’ people to show that mortality differs by social and economic conditions (Moheau, 1994 [1778]). Nineteenth century researchers also pointed out the awful living conditions in cities and the very high mortality that prevailed there (Villermé, 1830). However, the role of different factors in the urban–rural gap were unknown. Then, the causes most frequently put forward were overpopulation, poor housing conditions, bad water supply, slope of the land and, of course, poverty. More recent studies have also pointed out that industrialization itself was partly responsible for higher mortality in cities (Landers, 1993: especially chapter 7; Vögele, 1998; Woods, 2000: chapter 8). Not only did cities offer worse living conditions –quality of housing, of food or the disease environment– but working conditions were much harder than in the countryside (Gaspari and Woolf, 1985; Neven, 1997; Szreter and Mooney, 1998).

More broadly we can contrast two views about high urban mortality. One view sees high urban mortality as the consequence of a very low stock of urban infrastructure combined with a high influx of poor migrants. The lack of clean water, healthy food and decent housing meant that cities were very crowded and hazardous. At the same time work was both long and physically taxing for much of the population. Although these living conditions would improve with economic growth, they may have worsened in the initial decades of industrialization (Williamson, 1982; Steckel, 1995; Steckel and Floud, 1997; Komlos, 1998). Most scholars now agree that there was indeed a sharp decline in health during industrialization (Haines, 2004) but that long-term health

* Corresponding author. Fax: +33 1 56 06 21 94.
E-mail addresses: lionel.kesztenbaum@ined.fr (L. Kesztenbaum), jlr@hss.caltech.edu (J.-L. Rosenthal).
[1] Fax: + 1 626 405 9841.

0014-4983/$ – see front matter © 2010 Elsevier Inc. All rights reserved.
doi:10.1016/j.eeh.2010.12.002

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

ARTICLE IN PRESS

conditions improved much more. In other words, the initial cost of industrialization on health was, on a middle and long run basis, more than compensated (Galloway, 1985; Fogel, 2004). The arguments about the low quality of the urban infrastructure extend directly to the health stock of the population. There is a growing literature dealing with the consequences of early life conditions on mortality (Fogel, 1986; Bengtsson and Lindström, 2000; Hong, 2007). It shows that poor living conditions during childhood have negative effects on later life (Elo and Preston, 1992). Just how this specific effect interacts with later mortality differentials remain an open question. In other words, we may wonder what part of the urban–rural mortality differential is due to an adverse environment. To begin with, those born and raised in cities may die at high rates at any age because of poor living conditions in their youth. Those who grew up in the city and survived until 20 years old, however, are heavily selected and may be strong enough to survive longer in the harsh urban environment.

The second approach focuses more directly on the disease environment, as it is well known that most diseases remain endemic in cities. Considering the causes of mortality, Kuagbenou and Biraben conclude that “two-thirds of the deaths were linked to infectious or parasitic disease” in Paris in the 1840s (Kuagbenou and Biraben, 1998: 37). Hence the higher mortality of cities could have come from a higher morbidity that was itself the result of the higher prevalence of infectious diseases. The argument about overall mortality in urban areas has implications for migrants as well. Indeed, some scholars argue for an immunization process: cities attracted people from different regions, each carrying a different disease and different acquired immunities (Lee, 1997; Costa, 2003). Prior exposure reduces the chances of dying later in life from infectious diseases; hence the higher urban mortality in cities may result from the high migration rate to and within cities. In this view, migrants to cities had to confront communicable diseases and their low prior exposure implied a lack of immunity and consequent higher mortality.

Evaluating these hypotheses can help us understand the urban mortality transition: the process in which mortality rates in cities fell below those of rural areas. Was the fall of mortality due to sanitation improvements (Ferrie and Troesken, 2008) or to the diminishing impact of chronic disease (Costa, 2002)? Yet because of problems of selection bias as well as the complex patterns induced by migration, analyses of the comparative mortality of migrants and stayers are very limited. In fact, few studies, if any, have tackled these issues despite the well known importance of migration flows and rural–urban mortality differentials. Without high urbanization and mortality rates the history of the industrial revolution would have been very different and so would the history of the health transition.

Most of the research in these issues has focused on the U.S. in the late nineteenth century based on the Union Army veterans dataset (e.g Cain and Hong 2009). Although both the initial urban mortality penalty and the urban mortality transition are general phenomena, the U.S. and its Union Army veterans lie at one extreme of the circumstances under which urban rural mortality evolved in the later nineteenth century. First U.S. cities were heavily populated with international immigrants, perhaps exacerbating the immunization effect. Second, U.S. rural populations were not nearly as dense as in Europe. Finally, veterans of the Union Army had endured war conditions far harsher that those of other conscripts in the relatively peaceful period between 1870 and 1914. It does seem worthwhile to examine at least one different society where we can quantify urban–rural mortality differences.

We do so for France, at roughly the same time. In the aggregate, France shares a number of similarities with the U.S. and other industrialized countries: first mortality rates increased with settlement size (Tugault, 1973: 32). Moreover, the slope of death attributed to non-infectious diseases has the opposite sign to that of infectious diseases (Table 1). Where tuberculosis, typhoid and other diseases kill at ever higher rates as settlement size increased, the reverse was true for other causes of death which decreased with settlement size. This evidence is inconclusive because it does not control for age or gender. The relatively low mortality of Paris for instance will disappear when we use more comparable populations. But the data are ambiguous in terms of our two hypotheses, as it could be that cities had higher mortality due to higher prevalence of diseases or due to more severe consequences of falling ill because of poor living conditions.

Table 1
Mortality in France by cause and municipality size.
Source: Annuaire statistique de la France 1895–1896.

Population of cities	Mortality rate	Mortality from infectious diseases	Mortality from other causes
Paris	21.84	11.73	10.11
More than 100,000, other than Paris	26.13	13.79	12.34
Between 99,999 and 30,000	25.64	12.45	13.19
Between 29,999 and 20,000	24.46	11.77	12.69
Between 19,999 and 10,000	25.33	11.06	14.27
Between 9,999 and 5,000	24.27	9.93	14.34
Chef lieu with less than 10,000	22.79	8.19	14.60
Other municipalities	21.70	NA	NA

The data for mortality rates by settlement size and cause of death was reported only for canton chef-lieux (the administrative seat of the territorial jurisdiction just above the municipality). Nearly all towns with a population greater than 10,000 were chef-lieux and the localities that reported cause of death comprised a third of the French population. We computed the mortality rate for other localities from the French aggregates.

Infectious diseases include: typhoid, typhus, small pox, rubella, scarlet fever, mumps, diphteria, pulmonary infection, tuberculosis, meningitis, bronchitis, pneumonia, diarrhea, cholera, postpartum fevers and infections. Non-infectious diseases include: cancers and tumor, cerebral hemorrhages, paralysis, cerebral decline, heart disease, senility, suicides and other violent deaths, and other causes, including unknown. Other causes including unknown is about 40% of the total non-infectious diseases but are not related to settlement size.

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

ARTICLE IN PRESS

There is also aggregate evidence that conscripts faced an immunization process during military service, which lasted four years in the 1880s. Indeed mortality was actually higher during the first year of service than during the next years (Table 2). If enough of the mortality differential between first and later years recruits came from changes in the mortality of rural recruits, then it might be that they were immunized during military service. In this case those men from the countryside who migrated to cities after military service would face little or no increase in mortality risk when they encountered the disease setting of cities. Unfortunately the military did not break down mortality between rural and urban conscripts. We do not know if the higher initial mortality of conscripts was due to rural conscripts dying as they encountered urban diseases or to urban conscripts who could not endure the rigor of army life. In any case, it should be noted that conscripts were enrolled nationally: military service brought about a regional mixing which could also explain part of the immunization process during the first year (Roynette, 2000: 116–117).

An ideal data set for such questions must involve individual observations, and allow us to track residence over time. Indeed, migrants are the key to better understanding urban mortality: they acquired their health stock in one location but experienced the living conditions of another. They can help us distinguish between the two hypotheses. If the disease environment was the primary source of urban excess-mortality then rural migrants would encounter a variety of health risks for which they had no prior immunity. As a result, we should observe a spike in the mortality of migrants shortly after they arrive in cities. Then after this initial phase migrant mortality should converge *from above* to that of urban natives. Urban to rural migrants should not experience a spike (because they are moving to a less virulent disease environment) and their mortality should match that of their new rural neighbors. Conversely, if cities' poor disease and infrastructure environment weighted relatively equally on everyone, but rural migrants were healthier than urban residents of the same age, then we should observe no initial spike in mortality. In fact migrant mortality should converge *from below,* to that of urban natives. This process would arise as rural migrants depreciate their health stock in the harsh working and living conditions of cities. In that case, urban to rural migrants should converge from above as their health stock improves, but consistent with the literature on health we would expect this convergence to be less complete than that of rural to urban migrants. Indeed although migrants to the countryside may have been able to rebuild their health stock they probably could not fully offset the negative experiences of their urban youth.

In a recent study, Farcy and Faure compare the mortality of migrants and stayers in a large sample of military conscripts for whom detailed information was collected up to age 46. However, they don't study life-cycle patterns of mortality and perform only a static analysis of death rates (Farcy and Faure, 2003: 461). Yet their sample is ideal for resolving our questions because it provides event history data on the mortality experience of a cohort. The fact that we can track the same individuals over time will help us limit selection bias. The paper proceeds as follows: in the next section we detail the unusual data set compiled by Farcy and Faure, and lay out the basic characteristics of the sample. In Section 3, we compute mortality rates for both rural and urban areas (either as place of birth or place of residence). In Section 4 we focus on migrants and compare their experiences with those of stayers in both departure and arrival areas. To tackle the problem of endogeneity, Section 5 examines mortality experiences for given length of residence in urban and rural areas and Section 6 concludes.

We thus ask the question what was the mortality experience of individuals who reached age 25? In doing so, we distinguish carefully between migrants and non-migrants. As we argue below this is a good first step in distinguishing between the two hypotheses. Overall, we find little evidence in favor of the disease environment hypothesis. Instead it seems that health stocks were far more important.

2. Data

After its defeat in the 1870 war with Prussia, France reformed its army. For our purposes what matters is that everyone, except the physically unfit, had to serve. In particular, all males were conscripted because the replacement and exemptions options that once favored the rich were eliminated (Crépin, 1998). Then in 1872 military obligations were extended to include both active service and a long tenure in the reserves. As a result, conscripts stayed under the army's thumb for twenty-six years (Roynette, 2000). While in the reserves, individuals participated in periodic training sessions and they could be recalled for active service in case of war. Soldiers where thus required to register any change in residence, or risk penalties including jail sentences. Addresses were then transcribed onto individual files in military registers (*registres matricules*) by location of original conscription (see such a file in the Appendix). The files were closed only by discharge from service. Apart from migrations, they also recorded death: each

Table 2
Mortality during military service.
Source: Annuaire statistique de la France 1892–1894, 1895–1896, and 1897.

	Mortality rate (1/00)			
	Army	Soldiers only	Soldiers after their first year	Soldiers in their first year of service
1892	6.24	7.93	6.12	10.56
1893	6.10	6.39	5.70	7.50
1894	6.26	6.47	5.37	7.76
1895	6.56	7.16	5.97	8.64
1896	5.24	5.34	5.34	5.89
1897	5.23	5.32	5.32	6.34

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

time an adult male died, the mayor of his place of residence had to notify the local military authorities (Corvisier, 1992). Further, the army verified the soldiers' residence whenever they were called up for training (Roynette, 2000). The recording system was the key feature of the French military organization at a time of constant tension with Germany. The army had to be able to locate its reserves quickly, so it devoted a good deal of effort to insure that its files were accurate and it seems to have achieved its goal. The data do prove to be very detailed, mentioning even changes of street in the same city.

The data set we use contains information on almost 50,000 young Frenchmen (Farcy and Faure, 2003). All were born in 1860, our data begins in 1880 when they were examined by the draft board (*conseil de révision*). Some of them were then discharged for medical reasons and struck from the army's rolls. The rest were liable for a twenty-six year long military service with an active part of one to four years, from 1881 to 1882 or 1885, and a reserve part until 1906. A draftee is observed from the end of his active military service –between 23 and 25 years old for most of the sample– until one of three events occurred: he died, he received a medical discharge before 1906, or he was released in 1906. The use of failure-time data analysis allows us to take advantage of the richness of the dataset by analyzing each conscript when he is at risk.

Farcy and Faure assembled this data set to study migration to and within Paris. They collected all 1880 draftees from Paris and a sample of ten *départements* (French counties) for which census data revealed high migration rates to the capital. Thus, it is representative of the rural and small city areas that fed Paris with migrants, and contains a large sample of Parisians drafted in 1880. The sample includes 48,136 conscripts, 36,429 come from various areas in France, 8311 from Paris and 3396 from the *banlieue* (the parts of the Seine department not in Paris) (Farcy and Faure, 2003: 30). Two thirds of the conscripts come from a rural area while the last third is equally balanced between Paris and other cities. Overall, the sample is well balanced over France, save for the underrepresentation of the Southern part of the country. In any case there is no reason to believe that regional mortality patterns matter (Fig. 1). The data's unquestionable advantage for studying rural–urban mortality differentials is that we observe both rural and urban areas and all migrations between the two.

The 48,136 conscripts examined by the army's medical board include 6,030 (12.5%) men who were discharged for medical reasons and thus never served. Another 4,683 are not observed due to particular reasons, these include individuals serving in other capacities (e.g. men who enlisted, draftees assigned to the navy) and individuals who were exempted (e.g. teachers or clergymen). The remaining dataset includes 37,423 individuals. They are observed for 758,618 years or an average of twenty years (median of twenty-one years) for each soldier in our sample (Table 3). For our purposes we are mainly interested in where they live after they

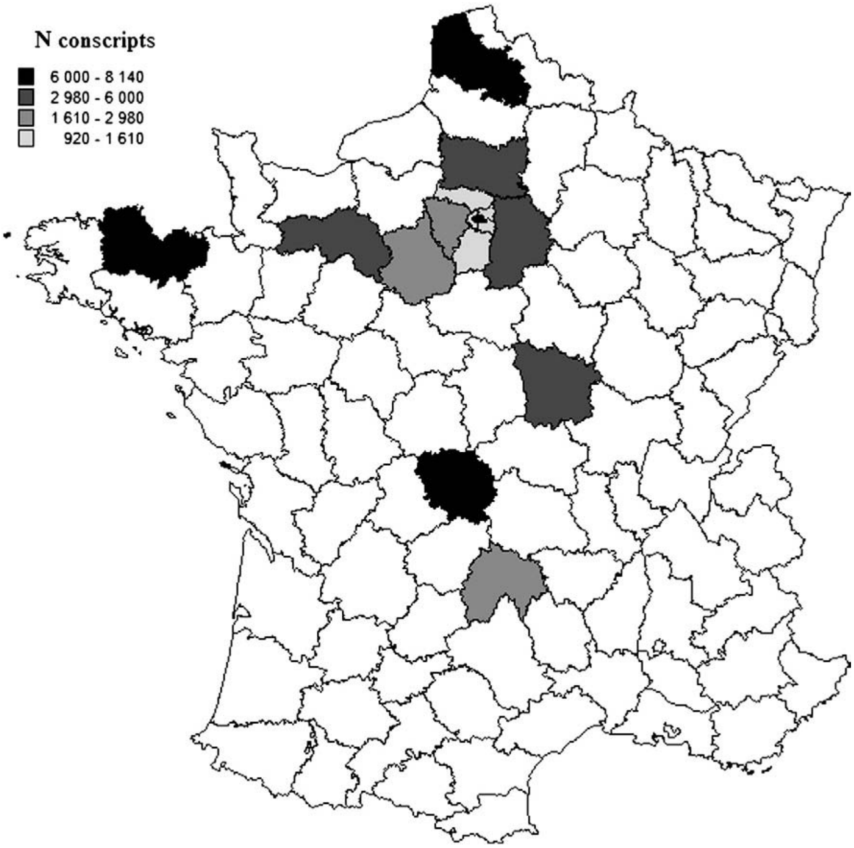

Fig. 1. Départements collected in the sample.

Table 3
Summary of the failure data sample.

Per individual					
Category	Total	Mean	Min	Median	Max
No. of subjects	37,423				
No. of records	115,585	3.088	1	2	27
(First) entry time		2.756	0	2	24
(Final) exit time		23.027	1	26	27
Time at risk	758,618	20.271	1	21	27
Failures	6,300	0.168	0	0	1

completed active military service. On average, conscripts are released into the reserve at age 23 and are observed until 43. Some enter at twenty-one because they have no active military service, others enlist and have very long tenure in the army, these are observed as civilians for the first time only at 44 years old. Overall, 6,300 conscripts die in the years between being released from active duty and reaching 46, they account for almost 17% of those observed for at least one year.

From this sample, we use a hazard model to take into account censoring, both *ex ante* because different conscripts end their active military service at different times, and *ex post* because observation ends if conscripts are discharged from the reserve before their death. The passage of time is critical to our analysis because death only occurs once. A person enters the analysis as soon as he completes active duty but, of course, he was at risk of dying before that. Indeed, time at risk does vary according to most covariates (Table 4).

We therefore face left censoring: those who die before the age of twenty are never observed. This does not cause any damage to our analysis because our interest lies with post-twenty years old mortality differences. Conscripts may also die during active military service. Although we know who suffered this unfortunate fate, such an event is not really comparable to mortality that occurs later. In particular it doesn't occur in a rural or urban place. Conscripts are mostly in barracks, some being in dangerous places including the colonies of North Africa or Indo-China. Such a death is less due to the individual's decisions than to the difficult conditions of military life. So we exclude all those who died in active service, initially at least we censor the data. One might be concerned that most of the disease contact for rural conscripts occurred not when they migrated to cities later in life but rather during their service when they met their urban counterparts. In other words, we potentially bias against the immunization hypothesis because we do not know the cohort's mortality history before service and we censor that same history during service. As we shall see, neither the aggregate data, nor the sample of conscripts, suggests this bias is significant.

Nevertheless, the varying length of military service will have to be taken into account throughout the empirical analysis. Among other things, we will also include this length in regression models later so as to control for the consequences of a longer active service. Choosing this way of building the data set allows us to consider all the years in which an individual is out of the army, independent of when he was released. An alternative would have been to constrain the sample to begin with the end of the military service and not twenty years old. In that case, two conscripts with different ages, for instance twenty-one and twenty-five years old, would have entered at the same time. Thus, conscripts would have been compared according to time elapsed since the end of active military service. What we assume here is that age is the most important determinant of mortality, and not time under observation.

We thus consider a data set of young men observed during their most productive years. Overall, the survival probability is 79.84%: one fifth of the conscripts die before reaching 46. The survival rate declines monotonically with age (Fig. 2). This is not surprising since we consider adults in their prime and during a time without large wars or severe epidemics. The other feature of the data set is that the sample grows in size as people complete active service and then decline. The maximum size of the sample is at 27 years old when a little more than 30,000 conscripts are at risk of dying. From this moment on, conscripts die or are discharged from the army for medical reasons.

In sum, we observe all French young males who reached twenty and whose parents were living in one of the sampled area. We only analyze the deaths of those who entered the reserve after their active service; we observe them until they die, were dismissed for medical reasons, or finished their time in the army at forty-six years-old; all conscripts are observed wherever they reside[2]. All the mortality rates we compute are conditional on conscripts being still alive and fit for the reserve at the end of active service. Overall, this selection bias is not a problem for us: if we observe a higher mortality for urban areas, we may suppose this gap would have been even higher without the bias. We focus on death rather than morbidity because one is recorded accurately (we know to the day when a reservist died) while the other is recorded with tremendous censoring (the only diseases recorded are those that lead to discharge and they are recorded only at specific moments of time). We repeated all our analyses based on risk of discharge (for death or any other reason) and the results were extremely similar to those that focus on the risk of death.

We compare people that share many features: they were born the same year, they did their military service at the same moment and they are all in good health, enough to be accepted in the army during the whole part of their life cycle. In these conditions, finding differential mortality between areas is even more convincing.

[2] We also record international migrants. However as our focus is on rural–urban differences, we have little interest in such moves. Therefore, we consider migration out of France as censure. And in fact, only a very small number of conscripts are concerned by such mobility.

ARTICLE IN PRESS

Table 4
Descriptive statistics of the covariates.

	N subjects	%	N observations	Mean time at risk	Survival function	Khi²
All conscripts	37,228		742,096	20.29	80.95	
Place of residence						
Rural	24,546	65.93	463,406	20.86	84.92	648***
Urban	8,977	24.11	141,296	19.69	78.66	
Paris	3,705	9.95	137,394	17.96	68.15	
Birth and 20						
Rural	24,207	65.02	498,150	20.81	83.78	348***
Rural then city	2,012	5.40	38,092	19.41	75.43	
Rural then Paris	2,108	5.66	39,593	19.28	75.01	
City	1,656	4.45	31,898	19.72	75.86	
City then rural	440	1.18	8,568	19.90	78.76	
City then Paris	783	2.10	14,484	19.12	74.26	
Paris	3,701	9.95	68,994	19.12	73.60	
Paris then rural	644	1.73	12,914	20.36	82.28	
Paris then city	648	1.74	11,967	19.05	75.57	
Missing	1,029	2.76	17,434	18.79	78.09	
Education						
Read, write and calculate	4,321	11.61	87,971	20.61	82.15	16***
Illiterate	9,090	24.42	182,321	20.35	81.40	
Read and/or write	21,060	56.57	418,087	20.22	80.77	
Secondary education	680	1.83	13,554	20.80	82.73	
Missing	2,077	5.58	40,163	19.83	77.77	
Parental status						
Both alive	24,887	66.85	496,893	20.29	82.38	86***
No mother	3,268	8.78	63,731	19.84	79.26	
No father	6,694	17.98	135,783	20.75	78.15	
Orphan	2,379	6.39	45,689	19.60	76.58	
Occupation						
Farmer	8,386	22.53	174,776	21.05	85.12	126***
Unskilled	20,931	56.22	416,281	20.19	80.47	
Skilled	3,715	9.98	70,364	19.63	76.78	
White collar	1,414	3.80	26,589	19.81	78.46	
Other	2,782	7.47	54,084	19.88	78.60	
Height						
Average height	24,802	66.62	493,651	20.22	80.84	11**
Small	5,663	15.21	116,214	20.84	82.05	
Tall	5,588	15.01	110,210	20.13	80.94	
Missing	1,175	3.16	22,021	19.76	77.74	
Military service						
Regular active service	20,632	55.42	389,610	19.15	83.02	63***
Short service	9,587	25.75	208,198	22.13	79.75	
Auxiliary service	3,761	10.10	86,120	23.25	79.60	
Conditionnal service	1,269	3.41	25,492	20.99	82.81	
Volunteer	1,979	5.32	32,677	17.14	75.32	
Campagnaining						
No	34,246	91.99	690,216	20.50	81.06	2.70
Yes	2,982	8.01	51,880	17.88	77.42	

Note: *** $p<0.01$, ** $p<0.05$.

3. Urban rural differences in life expectancy

We begin our investigation with life expectancy by place of residence. The results from this section serve as a base-line and must be taken with caution. Indeed one should be concerned that individuals chose their residence because of access to medical care or jobs that suit their physical status. Such endogeneity could either exacerbate the true urban–rural mortality differential or mitigate it. In effect this first effort neglects the endogeneity of residence. Here we consider conscripts between the end of their active military service and their dismissal from military duties (from death, disability or reaching the age of 46). During this period, we have longitudinal data that allow us to observe any occurring death and consequently to estimate mortality rates. Moreover, at any point in time, a conscript either lives in a city or in the countryside. Consequently, each individual's residence can change over time. For each year between 1880 and 1906, we have the number of individuals living in rural or urban areas and we know how many die in each group.

Living in cities was dangerous: municipalities with more than 15,000 inhabitants had a mortality rate almost twice as large as that of places with less than 3,000 inhabitants (Table 5). Fig. 3 shows that, as in the U.S. in the same period (Cain and Hong, 2009), the disadvantage of urban residence grows with the size of the city. Rural areas had significantly lower mortality than small cities, and large cities were not as deadly as Paris (the largest city in France). Note that this is in striking contrast with the aggregate data in Table 1 that does not correct for age. Even at this late date, the Paris statistical office warned that due to the practice of sending

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

ARTICLE IN PRESS

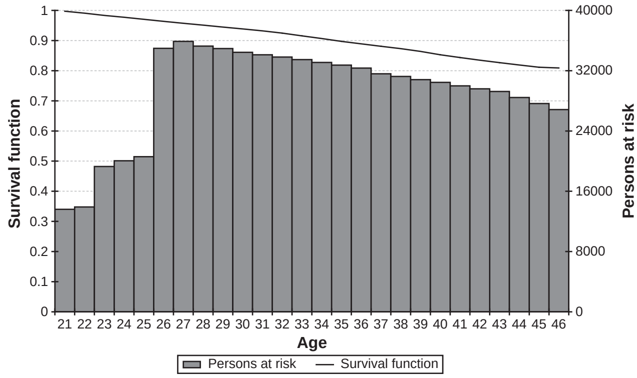

Fig. 2. Survival function and size of the sample. Note: the line shows the survival rate: the probability for a given conscript to be both alive and under observation at a given age (values on the left axis). The bins refer to the number of conscripts under observation at a given age (values on the right axis).

babies out to the countryside for wet nursing infant mortality rates were unreliable. Moreover the large migratory inflows of young adults gave Paris an age pyramid quite unlike the rest of the country. If we assume that cities are deadlier than the countryside then urban inhabitants may have a higher mortality either because most of them were born in a city or because of their current exposure to the cities' risks, or both. Later on, we will try to disentangle these two effects by comparing migrants and stayers.

To continue the analysis, we have to delimit what we mean by "city". To do so, we need to define a threshold between urban and rural areas. We identify a municipality as urban according to its size: the number of inhabitants at the census immediately before the moment an individual is observed[3]. To decide where the threshold to distinguish rural and urban area is, we consider all thresholds between 3,000 and 14,000 inhabitants. We then compare mortality before and after that threshold (Table 5). The table confirms what was seen on Fig. 3: rural mortality increases steadily as we raise the threshold, but there is a substantial jump in urban mortality at 9,000 inhabitants. Further the difference between the urban and rural rates is also markedly higher. Finally the mortality rates for municipalities between 9,000 and 15,000 is almost the same as that for cities of 15,000 or more. Thus, we set the town/country break at 9,000 inhabitants. While one might have wanted to use more city size categories, this was not possible because of sample size issues. Using an alternative threshold, like the 2,500 that is the common French definition, does not alter the results.

Thus we will group locations with less than 9,000 inhabitants as rural, based on their close relation in terms of mortality. Next, we consider as cities all places with more than 9,000 inhabitants. This is not to say there is no heterogeneity in this group. But we cannot measure such heterogeneity with enough accuracy. Finally, we put Paris in its own category.

The fact that we observe the cohorts' mortality allows us to evaluate the possibility that immunization occurred during military service. Recall from Table 2 that in the first year conscripts' mortality was at least a third higher than in the second year. To decide if this is the result of an immunization effect, we compare the mortality of conscripts coming from different areas during their military service. As Table 6 shows, we can put a bound on the size of the immunization effect during military service: it is small. To be sure mortality in the first year of service is higher than in later years for conscripts from the countryside while it is almost constant for those coming from cities. This result does show some immunization process for country folks. However, if we also include medical discharge during the military service, the difference between rural and urban fades away because urban soldiers are more likely to be discharged. And Paris is simply an extreme example with a much lower mortality than rural places but a much higher rate of medical discharge. Overall, when we add medical discharge to mortality, Parisian conscripts have significantly higher chances of leaving the army. In fact, 4% of them are excluded during their first year, compared with 3% of rural recruits. This is consistent with two hypotheses: first, there is some immunization process taking place during the military years for conscripts from the countryside but it is rather limited; second, despite this higher mortality, country dwellers do have a much better health stock than city dwellers as they are much less frequently discharged from military service.

In fact, discharge from military duty for medical reasons is far more frequent in soldiers from urban areas or Paris than those from the countryside: 1.5% against 5.8% of the conscripts observed at least once. And, even more significant, the diseases that led to discharge for city -or Paris-draftees are much more frequently lethal than in rural areas. More to the point, we find the same kind of difference at initial conscription. For instance, the risk of being immediately discharged from the draft for tuberculosis is nearly three times as high for urban conscripts than for rural ones.

[3] In the second part of the nineteenth century, censuses were performed every five years—in years ending by 1 or 6. For instance, in order to assign the type of area a conscript living in Tréguier in 1887 is living in, we use Tréguier's population at the 1886 census, which is 3,193 inhabitants. This means we take into account changes in size over time as our definition of urbanity evolves with time. Some places may change size only because of administrative reasons, for instance as they absorb surrounding municipalities but such instances are rare.

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

ARTICLE IN PRESS

Table 5
Mortality rates in rural and urban areas depending on the threshold between the two areas (per 1,000).

Threshold	Deaths in rural areas	Person-year in rural areas	Rate in rural areas	Deaths in urban areas	Person-year in urban areas	Rate in urban areas	Difference
3,000	2,302	356,193	6.463	966	114,250	8.455	1.992
4,000	2,494	381,083	6.545	774	89,361	8.662	2.117
5,000	2,675	399,563	6.695	593	70,880	8.366	1.671
6,000	2,755	413,090	6.669	513	57,353	8.945	2.275
7,000	2,819	420,451	6.705	449	49,993	8.981	2.277
8,000	2,884	428,541	6.730	384	41,902	9.164	2.434
9,000	2,959	438,996	6.740	309	31,448	9.826	3.085
10,000	3,037	446,517	6.802	231	23,926	9.655	2.853
11,000	3,076	450,660	6.826	192	19,783	9.705	2.880
12,000	3,132	457,228	6.850	136	13,216	10.291	3.441
13,000	3,172	460,240	6.892	96	10,204	9.408	2.516
14,000	3,226	466,860	6.910	42	3,584	11.720	4.810
15,000 and over				1,210	122,695	9.862	
Paris				1,863	164,764	11.307	

For instance, if we consider that rural areas are all municipalities with less than 5000 inhabitants, then the mortality rate in rural areas is 6.695. In that case, “urban areas” is defined by all municipalities having between 5000 and 14,999 inhabitants and their mortality is 8.366. The last two rows of the table give mortality for all cities with over 15,000 inhabitants and for Paris.

Beyond these blunt aggregate figures, the mortality differential between Paris or other towns and the countryside grows with age. Not only is this evolution crucial to understanding mortality patterns during industrialization, but it can also help us determine the causes of the massive urban–rural gap. In the case of a higher prevalence of infectious diseases in cities, we expect age-related patterns to be identical in the city and the countryside, with the difference between the two being roughly constant. If, instead, higher urban mortality is related to harsh living –and working– conditions, we should observe a growing gap between the two, as mortality in urban areas increases over time. In the hostile environment of cities health capital would depreciate with age at a faster rate than in bucolic settings. We take advantage of the longitudinal feature of our dataset and compile hazard of dying depending on the place of residence (Fig. 4).

In all three areas the hazard starts low and then rises. This is hardly surprising: mortality inevitably rises with age. However, there is an important difference between the two areas in the magnitude of the increase. When in their 20s, former conscripts face a yearly risk of dying around 6 per 1,000 in the countryside, 8 per 1,000 in cities and almost 10 per 1,000 in Paris. In the countryside, the hazard then increases to a ceiling around 8 per 1,000 for individuals in their 40s. In cities, however, the picture is dramatically different. Past age 20 men's mortality risk jumps; in their 30s they face a risk of 12 per 1,000, and later, in their 40s, one of 14 per 1,000 and even 16 per 1,000 in Paris. Thus the age effect is critical to understanding the differences between cities and countryside. Moreover the pattern is the reverse of what one might have expected if infectious diseases drove death rates: at the beginning, urban or Paris conscripts would die at high rate but as time passed, they would become immunized and their mortality would converge towards that of rural areas. Instead, the sharply rising curve is more consistent with the argument that residents of cities degraded their physical capital. People in cities suffered from poor water, expensive food, and crowded living conditions for their entire lives: at the beginning, their mortality is quite comparable to that of their rural counterparts but after ten years, the toll is such that they die at higher rates.

The obvious limitation to this first analysis is that the structure of the three populations is very different. Even if we neglect the migration problem, we cannot assume that people living in rural and urban are identical. They have different incomes, education levels, and family conditions. In other words, they not only differ in the environment they live in but also in their personal characteristics. Because in cities wages were higher, as were literacy rates, and fertility rates were lower (Tugault, 1975), it could well be that adjusted mortality rates differences were even greater than the unadjusted one. To account for those differences, we use a regression model introducing some observed characteristics of the conscripts at the age of twenty: height, education, being an orphan, occupation on entering the army, type of military service. We also consider markers of early-life conditions as they may have later consequences on mortality. To do so, we interact the rural–urban–Paris character of the place of birth with that of the place of residence at twenty years old.

We estimate three Cox relative risk models to measure the effect of these covariates on the time until death. For our simplest model we assume there is a baseline hazard shared by all individuals and the covariates act multiplicatively on this hazard[4]. To put it differently, the risk of dying of two conscripts with different values of the same covariates are proportional to one another. This implies that the effect of a given covariate is independent of time—and we assume that the effect of living in an urban area or in Paris is time-invariant. We then relax this assumption in a second frame where we assume this interaction is purely linear: the mortality differential between rural and urban places –or between rural places and Paris– monotonously increases or decreases

[4] This assumption is not quite true for the type of military service. Using a stratified Cox model allows us to correct this flaw but it doesn't alter the results for the other variables. We also ran a complete discrete failure time model where every conscript-year is represented by one observation, allowing for more precise studies of time-varying covariates. Results, however, were similar to those from the Cox model.

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

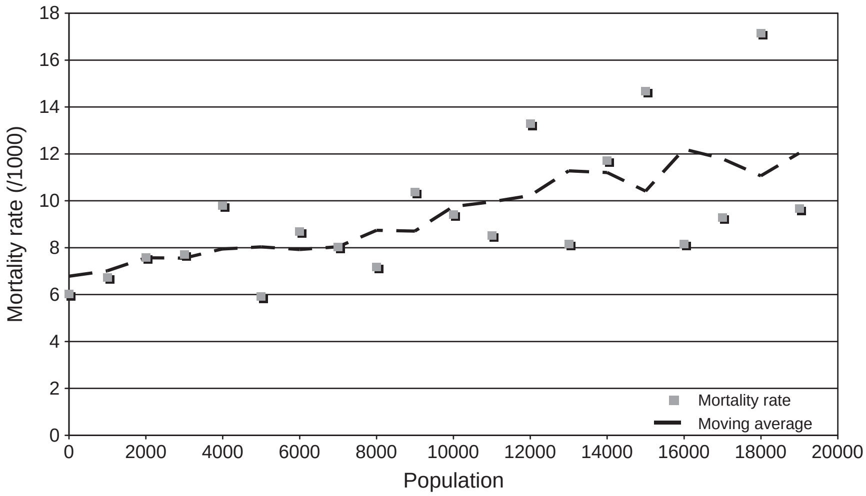

Fig. 3. Mortality rate according to municipality size.

over time. This seems consistent with the idea that the pernicious consequences of living in a city have cumulative effects. If city life leads to a more rapid degradation of health than in the countryside, we expect that mortality will rise faster with age in cities. Finally, from Fig. 4 we may also think that effects of living in a city or in Paris are mostly non-linear: in a third model, we assume that they change non-monotonously over time. We look at mortality differentials over five-year time-spans, under the implicit assumption that these effects are constant within five years.

More specifically, our hazard ratio is: $\lambda(t, x) = \lambda_0(t)\phi(X\beta)$ where $\lambda(t, x)$ is the hazard function. It depends on time and on covariates, X, whose influence go through a function ϕ (), and $\lambda_0(t)$ is the baseline hazard depending solely on time. To model the influence of covariates we use the simplest functional form: $\lambda(t, x) = \lambda_0(t)\exp(X\beta)$[5].

The first model assumes that the effect of living in a city is independent of time. Thus it can be written as: $X\beta = \beta_1$ urban + $\gamma_1$paris + αZ where Z is a vector of control variables.

The second model assumes a linear relationship between the hazard of death and the rural–urban–Paris differential of mortality or:

$$X\beta = \beta_1\mathrm{urban} + \gamma_1\mathrm{paris} + \beta_2\mathrm{urban} \times \mathrm{time} + \gamma_2\mathrm{paris} \times \mathrm{time} + \alpha Z.$$

The third model decomposes the influence of time on the difference in three dummies indicating each five-year period since the beginning of observation. The model is then:

$$\begin{aligned} X\beta = {} & \beta_1\mathrm{urban} + \beta_2\delta(10 \le t < 5)\mathrm{urban} + \beta_3\delta(15 \le t < 20)\mathrm{urban} + \beta_4\delta(20 \le t \le 26)\mathrm{urban} + \gamma_1\mathrm{paris} \\ & + \gamma_2\delta(10 \le t < 15)\mathrm{paris} + \gamma_3\delta(15 \le t < 20)\mathrm{paris} + \gamma_4\delta(20 \le t \le 26)\mathrm{paris} + \alpha Z \end{aligned}$$

where $\delta(10 \le t < 15)$ is a dummy variable taking value 1 when an individual has resided the majority of time in cities between 10 and 15 years after the beginning of observation time. The first dummy, $\delta(3 \le t < 9)$–, is omitted. In that formulation, β_1, the coefficient on urban, measures the average effect over the life cycle of living in an urban place instead of living in a rural area on mortality, whereas β_2 to β_4 estimate the non-monotonic part of rural-urban mortality differentials. The coefficients γ_1 to γ_4 do the same for the effect of living in Paris compared to living in a rural area. For instance, β_4 expresses the additional disadvantage (or advantage) in terms of mortality of living in urban places compared to living in the countryside between 40 and 46 years old, relatively to that disadvantage between 23 and 29 years old, while γ_4 expresses the additional advantage or disadvantage of living in Paris instead of living in the countryside.

The coefficients of the control variables are almost identical in the three models, hence the primary value of the different estimations lies with the time interactions (see Table 7). The control variables mostly have expected effects on the hazard of death. For instance, conscripts with only one parent still alive when reaching twenty years of age have a higher mortality risk than those with both parents alive. However this effect is not gendered: the sex of the remaining parent does not matter. But having lost both is an even greater handicap. The coefficient is strong and highly significant; orphans at the age of twenty have one quarter chance less to survive after that age than conscripts with both parents alive. This turns out to be one of the largest effects considering that we only assess the consequences of parental loss on mortality at adult ages. Beyond the obvious fact that the loss of a parent has

[5] For details, refer to (Courgeau and Lelièvre, 1992; Kalbfleisch and Prentice, 2002 42–45).

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

ARTICLE IN PRESS

Table 6
Mortality during military service according to rural–urban status.

		Residence at 20 years old		
	All	Rural	Urban	Paris
Panel A: mortality rates (per 1000)				
First year	12.06	13.35	9.59	8.17
Second to fourth year	8.90	9.11	7.14	7.71
Panel B: medical discharge rates (per 1000)				
First year	22.21	19.71	22.03	31.75
Second to fourth year	12.10	11.14	14.77	14.55
Panel C: both mortality and discharge (per 1000)				
First year	34.26	33.06	31.63	39.92
Second to fourth year	20.99	20.24	21.91	22.26

adverse consequences, the interpretation of these results is not straightforward. For instance we do not know if the death of a parent is a cause or the result of poverty.

Education matters less with small differences between groups. All coefficients have the expected sign: illiterates and those who can only read and write have a higher mortality than those who are also able to count (the vast majority of conscripts), whereas those with secondary education have the lowest mortality. The only large coefficient is the one between conscripts with secondary education and the rest –the former having at least a 15% advantage over the latter– but it is not significant, a fact that is certainly explained by the small number of individuals with secondary education, less than 2% of our sample, a proportion standard for France at that time.

Perhaps surprisingly, there are only small differences by occupation, except for farmers who have substantially lower mortality than all other occupational groups. This may be connected either to their way of living –better access to food for instance– or to higher wealth, as, here, being a farmer means owning some land, something that may be linked to lower mortality (Ferrie, 2003). To be sure, however, we only record occupation at the age of twenty, which may explain why differences between occupations are so small.

Military service shows the complex effects of selection: people doing a shorter active military service are more exposed to mortality risk in later life. This is likely due to two complementary effects. First, at conscription, those selected for a long service were probably in better health than those slotted into shorter duties. Secondly, those who survived the army may have been in better physical condition after their service. The same issue appears when considering the effects of height. We do not find any significant differences in mortality related to height –which may be due to the fact that we control for early-life conditions through place of birth and place of residence at the age of twenty– except for one surprising result: the smallest individuals have the lowest mortality[6]. This is clearly due to the selection effect of the military service: the smallest conscripts are excluded from the army as unfit. Those remaining are thus heavily selected.

We take into account place of birth and place of residence at the age of twenty and the interaction between the two in a single variable so as to estimate the consequences of early-life living conditions on later mortality. There are nine different situations: one could be born in a city, in Paris, or in the countryside, and one may reside continuously in one area or one could move. The analysis clearly shows that conscripts born in the countryside and still living there when drafted have the lowest mortality. Those born in cities or in Paris and still there at twenty years old have the highest death rates closely followed by those who were born in the countryside and moved to the city before being called up. In contrast, migrants from the city to the countryside during their childhood are less likely to die than urban or Paris stayers. Being born in a city, therefore, is not in itself permanently damaging; what hurts is long residence in a city. And it is all the more true for Paris. We don't have detailed information on migration between birth and twenty years old so we cannot say more about how early-life conditions influence adulthood mortality.

What about the mortality effects of simply living in a city, no matter where one was born? That question brings us to our main interest: rural–urban–Paris mortality over the life-cycle. Because the control variables have stable effects across the statistical models, we will not return to them. Our goal is to estimate both an average penalty for urban or Paris residence, and the consequences of longer residence in cities. If we take the whole sample, the average effect is statistically significant and large; mortality risk in urban areas is a third higher than in rural areas and mortality risk in Paris is almost double than that in rural areas (model 1). The time effects have the right signs and reasonable magnitudes: under the linear hypothesis, the rural–urban mortality differential increases yearly by 26‰ over the baseline (model 2).

Table 7 also gives us important information about the structure of mortality for Paris relative to other cities. On net both have higher mortality than the country-side (and the estimated hazard in Paris is much larger than elsewhere). When we try to break out the effect by time of residence a striking difference emerges. In Paris, mortality risk is much higher from the beginning with a

[6] We consider as “small” conscripts who belong to the smallest quartile of height in their *département* of enlistment, taking into account all conscripts (including those unfit for the army). Reciprocally, “tall” are those who belong to the highest quartile. Overall, the interquantile range in our sample is 8 cm, with an average height of 165 cm.

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

ARTICLE IN PRESS

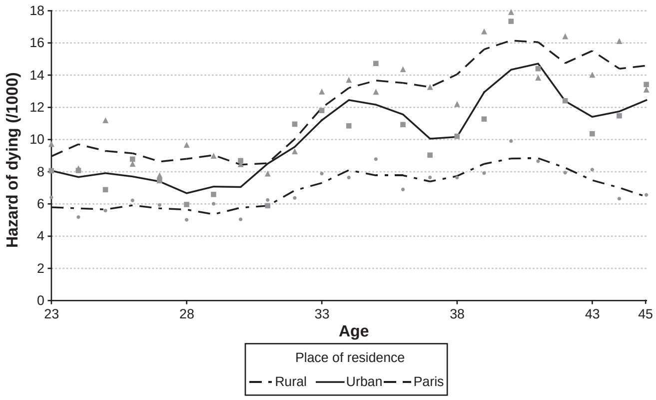

Fig. 4. Hazard of dying according to the place of residence. Note: hazard and 3-years moving average; these are unadjusted for any other characteristic of the individuals under consideration.

difference decreasing slightly over time, while in cities mortality risk is not significantly different from rural area at first but it rises much faster over time. It seems that mortality is so severe in Paris overall that it cannot get much worse over time while cities are not that different from rural areas (recall that we mostly have small cities and that our sample captures large cities other than Paris only poorly except for Paris). Model 3 adds precision to this result: first, the difference between rural areas and cities regularly increases with time; second, the mortality risk in Paris decreases a little with respect to the risk in rural areas only for the first age group, for the last two time spans there is no significant mortality differential (coefficients are insignificant and close to zero). This may be a consequence of Paris' labor market: most migrants from rural areas to Paris came before turning thirty. If migrants are the healthier part of the rural population, their mobility both increases mortality risk in rural areas and decreases that risk in Paris. Overall, however, the pattern of increasing relative mortality risk in cities is consistent with the health deterioration hypothesis not with the immunization thesis. In the next section, we analyze the mortality of migrants to cities. We will address the questions of what degraded health stocks, and of migrants' need to acquire immunities from diseases prevalent in urban areas.

4. Migrants and stayers

Migration plays an important role in population dynamics, even in a country as stable as France in the nineteenth century (Blanchet and Kessler, 1992; Moch, 1992; Pinol, 1996; Farcy and Faure, 2003). Migration was also crucial to urbanization. As most cities had a negative demographic balance, they would not have been able to grow without migrants. Therefore we have to study more carefully migrants' and stayers' mortality patterns. They are the key to understanding the urban–rural gap. The two questions we ask are straightforward. What was the life expectancy cost of a year's residence in the city? What share of the mortality differential was due –or might be attributed to– migrants? In other words, had there been no migrants, would the rural–urban mortality differential have been higher or lower?

To start, we focus on early-life conditions. It has been demonstrated that early-life conditions have long-term consequences: the worse the childhood conditions, the higher the later mortality (Elo and Preston, 1992; Bourdieu and Kesztenbaum, 2004; Van den Berg et al., 2006). Here, we cannot directly look at infant mortality since we observe individuals only after age twenty. But we do have some clues on the later effects of childhood living conditions; all we need to know is where people grew up. We can do so by using the residence of parents and assuming that, had they moved, they would have taken their children with them. Thus, we compare conscripts whose parents changed municipality during their childhood to those who stayed in place. Doing so, we consider directly migrants' mortality without having to worry about selection effects.

The global rural-urban gap we uncovered in the earlier section is still present here as we compare adulthood mortality depending on childhood conditions (Table 8). First, the difference between country stayers on the one side and urban or Paris stayers on the other side is quite high, averaging 7 years of life expectancy at 25 years old (the diagonal of the matrix in Panel B). This represents a life that is one sixth shorter for those born and raised in cities. Second, if we consider migrants: on the one hand, conscripts who migrate to a city or to Paris as a child experience much higher mortality during their adulthood than their counterparts who stayed in the countryside; in fact, they have almost the same mortality as city natives. This means they lose all advantage of being born in a rural place. On the other hand, those who move to the countryside after being born in a city or in Paris have a lower mortality than those who stayed in the city or in Paris during their childhood. At age 25, compared with those who were born and grew up in the countryside, those born in a city who moved to rural areas' life expectancy is only four years less, so they make up nearly half the seven year difference with those who were born and stayed in those in the city. Those born in Paris have only two years less of life expectancy; the differences between the two groups –urban and Paris born– may be explained by selection effects. However one considers the question, a person who grew up in a city has a higher mortality; it does not matter

Table 7
Effects of individual characteristics on the hazard of dying—Cox relative risk model.

	Model 1		Model 2		Model 3	
	Coef	Se	Coef	Se	Coef	Se
Urban	0.282***	0.041	−0.114	0.088	0.008	0.071
Paris	0.660***	0.039	0.814***	0.082	0.483***	0.062
Urban × t			0.026***	0.005		
Paris × t			−0.011**	0.005		
Urban × t > 10					0.232**	0.095
Urban × t > 15					0.222**	0.094
Urban × t > 20					0.310***	0.093
Paris × t > 10					−0.140*	0.083
Paris × t > 15					0.027	0.081
Paris × t > 20					−0.017	0.082
Birth and 20						
Rural then city	0.184***	0.058	0.203***	0.058	0.248***	0.058
Rural then Paris	0.011	0.058	0.030	0.058	0.125**	0.058
City	0.158**	0.064	0.176***	0.064	0.230***	0.064
City then rural	0.177	0.113	0.171	0.113	0.187*	0.113
City then Paris	0.028	0.085	0.048	0.085	0.147*	0.085
Paris	0.052	0.049	0.074	0.049	0.179***	0.049
Paris then rural	−0.086	0.102	−0.084	0.102	−0.053	0.102
Paris then city	0.087	0.094	0.110	0.094	0.169*	0.094
Missing	−0.081	0.087	−0.077	0.087	0.012	0.086
Education						
Illiterate	0.052	0.043	0.050	0.043	0.042	0.043
Read and/or write	0.061*	0.032	0.060*	0.032	0.058*	0.032
Secondary education	−0.176	0.108	−0.177	0.108	−0.176	0.108
Missing	0.127**	0.054	0.126**	0.054	0.129**	0.054
Parental status						
No mother	0.136***	0.045	0.134***	0.045	0.141***	0.045
No father	0.139***	0.034	0.139***	0.034	0.142***	0.034
Orphan	0.210***	0.050	0.208***	0.050	0.215***	0.050
Occupation						
Unskilled	0.108***	0.036	0.108***	0.036	0.117***	0.036
Skilled	0.117**	0.053	0.118**	0.053	0.135**	0.053
White collar	0.187**	0.076	0.188**	0.076	0.195**	0.076
Other	0.177***	0.055	0.177***	0.055	0.190***	0.055
Height						
Small	−0.088**	0.037	−0.089**	0.037	−0.090**	0.037
Tall	0.007	0.037	0.008	0.037	0.008	0.037
Missing	0.052	0.071	0.052	0.071	0.056	0.071
Military service						
Short service	0.116***	0.032	0.115***	0.032	0.118***	0.032
Auxiliary service	0.153***	0.042	0.154***	0.042	0.154***	0.042
Conditional service	−0.159*	0.083	−0.154*	0.083	−0.152*	0.083
Volunteer	0.150**	0.060	0.147**	0.060	0.157***	0.059
War service	0.043	0.050	0.043	0.050	0.047	0.050
Number of observations	759,801	759,801	759,801			
N_fail	6,141.000	6,141.000	6,141.000			
N_sub	37,228.000	37,228.000	37,228.000			
Risk	742,095.875	742,095.875	742,095.875			
Log-likelihood	−62,879.26	−62,857.09	−62,938.61			

References are as follows: for birth and 20: both rural; for education: read, write and calculate; for orphanage: both parents alive; for occupation: farmer; for height: average height; for military service: regular active service.
*** $p<0.01$.
** $p<0.05$.
* $p<0.1$.

whether a conscript was born there and stayed there (compared to those who left) or he was born in the countryside and moved to a city as a child with his parents. This is consistent with previous findings on child mobility (Kasakoff and Adams, 2000).

Let's now turn to the direct influence of the place of origin on mortality. We compare mortality hazards according to the place of residence at 20 and migrations after that age. We begin by comparing the mortality risk in the cities between urban stayers versus rural migrants. Again there is a clear gap between the two groups at the beginning (Fig. 5). At the same time, rural migrants face an increasing mortality and, slowly but surely, they converge to the same mortality patterns as urban natives. The gap in the first years is huge with a mortality rate of less than 2‰ for migrants against more than 10‰ for natives. However, after 8 years of residence in a city, the mortality of rural dwellers is almost identical to that of their urban counterparts. Of course, some of those migrants did not remain in cities so we overestimate average years of urban residence, but the bias is of no consequence as it

ARTICLE IN PRESS

Table 8
Adult mortality according to place of residence between birth and twenty years old.

		Residence at 20 years old		
		Rural	Urban	Paris
Panel A: mortality rates (per 1000)				
Birthplace	Rural	6.98	10.90	11.09
	Urban	9.53	11.38	11.41
	Paris	7.99	10.75	11.76
Panel B: life expectancy at age 25				
Birthplace	Rural	39.44	33.13	32.89
	Urban	34.98	32.54	32.50
	Paris	37.48	33.32	32.09

Row refers to the place of birth and columns to the place of residence at the age of twenty. Panel A mortality rates are computed from the sample for individuals in a cell spanning the ages 20–46. In Panel B we computed life expectancies which are extrapolated from Meslé and Vallin (2001): we use the mortality rate from Panel A until 46 years old. Then we computed the ratio between this mortality rate and that of the total population given in Meslé and Vallin. We then multiply the Meslé–Vallin mortality rates after 46 years old by that ratio so as to obtain the complete mortality table. In other words, we implicitly assume that the mortality difference between our sample and the total population given in Meslé and Vallin does not change with age. Consequently, we assume the mortality differences among the three areas are constant after 46 years old.

dampens the urban penalty. In any case because only few migrants return to the countryside after some years spent in the city, the bias is small. The initial advantage of rural dwellers, thus, fades away after less than ten years.

The comparison above, however, mixes together various effects: mortality is lower in the countryside so even if migrants were not selected, they have an advantage over urban stayers as they are less likely to die before they migrate; they also have a lower mortality due to their early-life living conditions; and, finally, they may benefit from positive health selection. Therefore, the difference between rural out-migrants and urban natives is a combination of the difference between rural out-migrants and urban stayers, on the one side, and that between rural out-migrants and rural stayers on the other side. To get an idea of the selection effect we can compare the mortality of out-migrants against those they left behind, rural stayers (Fig. 5). We consider migrants' mortality only after they moved to the city so as to eliminate the effect of migrants having to stay alive until they migrate. This means that the difference between the two curves (rural migrants and rural stayers) truly represents the selection effect. And it is quite large. But, more surprising, it vanishes quickly. In fact, after five years, rural out-migrants have the same mortality as their staying counterparts and, from that moment on, they will have a higher mortality than permanent urban dwellers. In later ages rural migrants have a mortality pattern closer to that of urban dwellers than to that of rural stayers. These curves provide a dramatic picture of migrants' mortality advantage. But they mix two very distinct effects: duration of residence in the city and age at arrival. These two patterns are very difficult to disentangle but, using a Cox relative hazard model drawn from the previous section, we will try to do so.

To establish that the mortality gap between rural migrants and urban or Paris stayers closes over time we must compare their mortality experience while taking into account the time they spent in cities. As we observe only one cohort, we cannot simultaneously control for time and time spent in cities: we do observe migrants with different length of residence in cities but it is only because they enter the city at different ages. We can, however, distinguish migrants according to the moment they arrived in the city. Besides selection, one clear limitation to the comparison between stayers and migrants is the fact that migrants have to stay alive until they migrate. We remedy this problem by first separating migrants according to the age at which they enter the city. Second, we also consider urban stayers during an identical period. For instance, take migrants who arrived in the city at 26 years old: their reference group is city dwellers who survived to age 26, and we compare the mortality of these two groups. For simplicity, we treat return migrants (those who return to the countryside) as censored[7].

In sum, we compute hazard ratios conditional on being alive until a given age and living in a city of more than 9,000 habitants or Paris and we compare these hazards for city stayers and migrants from the country once they live in the city. Although the procedure takes into account that migrants must survive until they move, it still does not deal with the endogeneity of migration. Each migrant chooses at what age to move (we will tackle this issue in the next section). As before, our interests are not so much mortality differentials between migrants and stayers as their evolution over time. We compute only non-linear interactions with time; using smaller time-span than in previous models to increase the precision of our analysis (linear interactions show the same results and are less precisely estimated).

The results confirm the convergence between migrants and stayers' mortality hazard, the former having, at the beginning, lower mortality rates (Table 9). The coefficient on migrant is always high, negative and significant. And in almost all cases, interactions with time are positive and significant. Overall, migrants to cities have a much lower mortality than urban or Paris stayers. But they lose this advantage over time as their mortality increases faster than to that of stayers. For instance, migrants arriving in Paris between 26 and 29 years old die at a third of the rate of Paris dwellers between 26 and 29 years old. However,

[7] There may be an issue of lowering mortality of migrants if those in bad health leave the city. But return migrations are rather scarce and most of them happened at later ages. Therefore, such a bias would reinforce –not weaken– our conclusions (as it would mean we underestimate migrants' mortality increases with age).

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

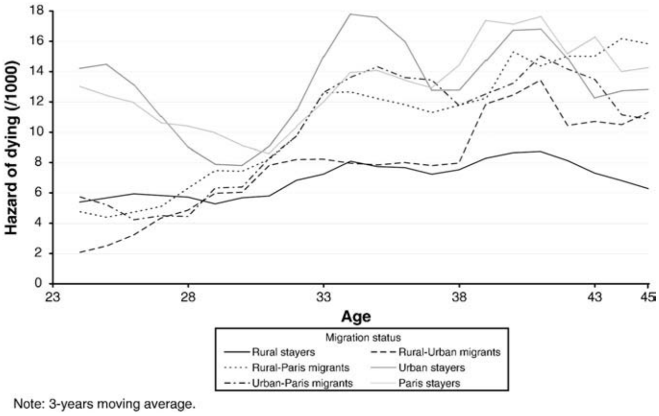

Fig. 5. Hazard of dying depending on the place of residence and the migration status. Note: 3-years moving average.

between 29 and 32, this advantage has almost disappeared, their mortality being only 11% lower. The convergence is then dramatic as between 32 and 35 years old, their mortality is now more than twice that of Paris stayers. The effects vary very little with the age of entry and they are quite similar whether considering migrants to the cities (excluding Paris) or migrants to Paris. The effects in the case of migrants to cities other than Paris are less clear but both the total sample and the number of migrants are much lower, which may explain why results are less clear in that case. However, the effects are consistent: they all present a robust pattern characterized by a lower mortality for migrants that rises faster with age than that of urban or Paris stayers.

We can return briefly to the rural–urban and rural–Paris gaps, by considering first a sample of stayers (individuals who always resided either in the countryside or in cities) and collapsing the residence dummies into decades. In this case the mortality risk is always higher for urban or Paris stayers compared with rural stayers but it does not change with time (Table 10, Panel B). Then we run the same estimation contrasting migrants to cities versus rural stayers, coefficients are comparable to those opposing migrants to city stayers, though smaller (Table 10, Panel C). They lead to the same conclusion as in the previous case: migrants initially have a health advantage but their mortality rises faster than that of stayers. Thus we find strong support for the idea that an individual's physical capital or health stock degraded over time in cities: even excluding city dwellers there is both a sharp urban penalty and an increase of this penalty over time for migrants.

These results ignore the fact that migrants are selected (even when excluding the fact that they must survive until they migrate) as their mortality at the beginning is lower from both urban and rural stayers. But in both cases their mortality increases significantly faster with time and they finally end with higher mortality than rural stayers and similar to urban dwellers. Therefore, they must be treated with special care in the analysis.

This section has established that migration to urban areas was costly in terms of life expectancy in nineteenth-century France as the differential in risk of death between rural migrants and urban dwellers rose with age. These results are strong and consistent for both groups of urban areas, be it Paris or smaller cities. Therefore, in the next and final section where we discuss selection issues related to migration, we will consider urban areas as a whole, without distinguishing Paris from other cities of more than 9,000 habitants.

5. Selection

Migrants are self-selected, given all the evidence above it seems most likely that ours were healthier and stronger than the population they left behind. From an economic perspective, the decision to migrate is an investment and depends on the expected net value of migration (Sjaastad, 1962; Borjas, 1994). So if wages are higher at the place of destination, the more time spent there the higher the net value of migration. This explains why young people migrate more. The same holds true for healthier individuals: as their life expectancy is higher, so is their migration return. Other factors may influence both migration choice and health: migrants often have better networks and thus more people are to take care of them in case of trouble; they may have better habits and cultural differences that favor them over natives; and so on.

Empirical studies –most of them focusing on today's migrations from Mexico and Latin America to the US– have explored the extent of the migrant–stayers mortality gap. Almost all studies conclude that there is a health advantage for migrants but they diverge on the causes of such advantage[8]. Some authors argue that migrants' lower mortality is related to cultural factors (Abrafdo-Lanza et al., 1999; Deboosere and Gadeyne, 2005); others conclude they are selected on socio-economic basis (Akresh and Frank, 2008) while, on the other side, some scholars challenge the existence of such effect, arguing either that they come from

[8] An interesting exception is Rubalcava et al. (2008) who, using panel data from the Mexican Family Life Survey, compare various health measure of Mexican migrants and stayers. They found no evidence of better health for those who migrate.

Table 9
Hazard of dying in cities for migrants and cities stayers—Cox relative risk model.

	Age of arrival in the city					
	Between 23 and 25 years old		Between 26 and 29 years old		30 years old and over	
	Coef	Se	Coef	Se	Coef	Se
Panel A: migrants to cities (Paris excluded)						
Migrant	−0.959 ***	0.294	−0.586 ***	0.215	−1.017 ***	0.165
Migrant × age 26 ≤ t < 29	1.108 ***	0.392				
Migrant × age 29 ≤ t < 32	1.373 ***	0.404	1.065 ***	0.311		
Migrant × age 32 ≤ t < 35	0.701 *	0.387	0.090	0.308		
Migrant × age 35 ≤ t < 40	0.785 **	0.356	0.468 *	0.268	0.423 **	0.215
Migrant × age 40 ≤ t < 46	1.047 ***	0.351	0.399	0.276	0.674 ***	0.213
Panel B: migrants to Paris only						
Migrant	−0.877 ***	0.249	−1.045 ***	0.240	−1.173 ***	0.227
Migrant × age 26 ≤ t < 29	0.833 **	0.323				
Migrant × age 29 ≤ t < 32	1.222 ***	0.321	0.935 ***	0.324		
Migrant × age 32 ≤ t < 35	0.790 **	0.316	1.032 ***	0.295		
Migrant × age 35 ≤ t < 40	1.031 ***	0.285	0.965 ***	0.277	0.462	0.289
Migrant × age 40 ≤ t < 46	0.603 *	0.314	1.193 ***	0.280	1.308 ***	0.266

All regressions include controls for education, parental status, occupation, height and length of military service as in Table 4 (not shown here).
N = 59,257–62,370–68,824 person-years for cities.
N = 93,110–87,899–66,278 person-years for Paris.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

statistical errors or that they are an artifact due to return migration: the 'salmon bias effect' postulate that immigrants go back to their country of origin when they are sick and so are more prone to die without being observed (Palloni and Arias, 2004).

Our case study of rural–urban migration in France at the end of the nineteenth century is somehow different. First, contrary to the contemporary migrations from developing to developed countries, living conditions were worse at the place of origin than at the place of destination. Therefore, even without any selection effect, we expect migrants to be in better health than natives of the place of destination. Secondly, rural migrants are not much different, culturally speaking, than urban stayers. The difference in way

Table 10
Effects of individual characteristics on the hazard of dying: alternative sub-samples comparing cities and rural—Cox relative risk model.

	Urban = cities (excluding Paris)		Urban = Paris only	
	Coef	Se	Coef	Se
Panel A: full sample				
Urban	0.166 **	0.071	0.303 ***	0.065
Urban × 10 ≤ t < 15	0.158 *	0.091	−0.066	0.082
Urban × 15 ≤ t < 20	0.108	0.091	0.147 *	0.080
Urban × 20 ≤ t < 26	0.109	0.092	0.187 **	0.081
Panel B: stayers only				
Urban	0.580 ***	0.124	0.764 ***	0.081
Urban × 10 ≤ t < 15	−0.171	0.193	−0.208 *	0.125
Urban × 15 ≤ t < 20	0.030	0.187	0.039	0.121
Urban × 20 ≤ t < 26	0.109	0.188	−0.171	0.130
Panel C: urban migrants versus rural stayers				
Migrant	−0.381 ***	0.080	0.010	0.075
Migrant × 10 ≤ t < 15	0.488 ***	0.108	0.131	0.107
Migrant × 15 ≤ t < 20	0.611 ***	0.107	0.305 ***	0.105
Migrant × 20 ≤ t < 26	0.697 ***	0.107	0.465 ***	0.104

Stayers means no migration between birth and exit of the sample.
City migrants are those who live in a city at least once between birth and exit from the sample.
All regressions include controls for education, parental status, occupation, height and length of military service as in Table 4 (not shown here).
N = 607,445–388,024–512,115 person-years for cities.
N = 656,079–414,109–484,334 person-years (5,223 individuals; 1,112 failures) for Paris.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

ARTICLE IN PRESS

Table 11
Mortality rate at a given age according to the place of residence before that age.

	20–24		25–29		30–34	
Age	Rural	Urban	Rural	Urban	Rural	Urban
Panel A: place of residence at age…						
25–29	6.23	10.29				
30–34	7.60	12.32	7.07	11.54		
35–39	8.73	13.38	7.71	13.48	7.79	13.50
40–46	7.44	11.88	6.92	11.62	6.81	11.89
Panel B: life expectancy at age…						
25	41.81	34.75				
30	38.05	31.45	38.19	30.85		
35	34.43	28.29	34.58	27.66	35.13	27.80
40	30.86	25.07	30.94	24.55	31.52	24.70

Here ‘urban’ aggregates all municipalities over 9000 inhabitants (cities and Paris). Panel A mortality rate are computed from the sample for individuals in a cell spanning the ages 20–46. In Panel B the computed life expectancies are extrapolated from Meslé and Vallin (2001). See Table 8 for details.

of life, food habits or networks, shouldn't be underestimated but it is clearly not that of today's Mexican immigrants in the US. Thirdly, thanks to the structure of our data, we don't have any under-reporting problem to bias our estimates. Fourthly, similar to the contemporary situation, most, if not all, migrations are labor-related and there is both network linked mobility (Rosental, 1999) and a relatively high rate of return migrations (Farcy and Faure, 2003: 326). And indeed, it has been shown that nineteenth-century French migrants were positively selected, for instance according to literacy (Heffernan, 1989) or wealth (Bourdieu et al., 2000).

We wish to estimate the cost of migrating to the city and to do so we must take into account migrants' selection. But we cannot control for it directly because we do not observe migrants' mortality *before* they migrate—it is of course impossible to do so as you have to be alive to migrate (assessing the interaction between two events is difficult in itself, as in the case of fertility in Courgeau and Lelièvre, 1986). But we can compute mortality conditional to the previous place of residence. Contrary to the previous section we do not take into account whether conscripts live in a rural or an urban place. We compute mortality at a given age depending on whether they were in such a place in the years before the moment we observe their mortality.

A straightforward way to do so is to take a conscript living in the countryside between 20 and 24 years old. Will his mortality between age 25 and 29 be higher or lower than his urban counterpart, no matter where they live in this later interval? As Table 11 shows, his mortality is much lower than his urban counterpart. More important, the differences increase with age; and this is true no matter which benchmark age is considered. This means health is degrading quickly in cities relative to the countryside. As with our previous results, these results also strongly support the hypothesis of a degradation of health stocks in the city.

Table 12
Mortality rate at a given age according to prior trajectory.

Rural at 20–24								
25–29	6.23							
	Rural				Urban			
30–34	7.24				11.37			
	Rural		Urban		Rural		Urban	
35–39	8.32		10.50		–		13.21	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
40–46	6.67	10.14	–	10.00	–	–	–	13.98
Urban at 20–24								
	Urban							
25–29	10.29							
	Rural				Urban			
30–34	8.48				12.60			
	Rural		Urban		Rural		Urban	
35–39	9.12		–		13.53		13.88	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
40–46	–	–	–	–	–	–	–	12.63

Here ‘urban’ aggregates all municipalities over 9,000 inhabitants (cities and Paris). Figures give the mortality rate at a given age considering the localization during the previous time span. For instance, conscripts living in the country between 20 and 24 years old have a mortality rate of 6.23 (/1000) between 25 and 29 years old. Among them, those who survive and stay there between 25 and 29 years old have a mortality rate of 7.24 between 30 and 34 years old. Those who moved to the city between 25 and 29 years old have a mortality rate of 11.37 between 30 and 34 years old. And so on. Some trajectories are not filled due to lack of observations.

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

ARTICLE IN PRESS

Table 13
Height and education of migrants and stayers.

	N	Average height	% Illiterate	% With secondary education
Rural stayers	17,118	165.54	15.26	0.79
Urban stayers	887	164.92	7.87	2.25
Paris stayers	2,381	165.39	6.67	4.10
Rural migrants to cities	3,720	165.07	16.17	1.63
Rural migrants to Paris	2,643	165.60	5.50	4.75
Urban migrants to Paris	430	165.76	6.13	3.68

We cannot directly measure selection as we do not observe variables that would influence migration behavior without influencing mortality patterns. But we can still get some clues. First, we complete the previous table by considering the full scope of the previous trajectory. Second, we compare migrants' and stayers' height and education as evidences of selection.

As in the previous part, we only condition mortality rates on prior residence, excluding present residence. And again we observe that individuals have a higher mortality in urban areas and that the gap increases with time, especially for early migrants who stay in the city until 46 years old (Table 12). More interesting, going to the countryside after having lived in the city has positive effects: mortality rates go down in the next period although they never get as low as those of rural stayers. In both cases, the speed of the phenomenon is quite remarkable. A change of trajectories over a five-year period has immediate consequences on mortality in the next period. But what is more important is the fact that mortality never diminishes in urban area. There are no signs that would confirm an immunization process. Unfortunately, the number of return migrants (conscripts who moved back to the country after staying in a city for a while) is too small to draw any conclusion.

A more direct way to assess selection is to observe characteristics that may reveal some advantages for migrants. For instance, it is accepted that both height (Humphries and Leunig, 2009) and education (Abramitzky and Braggion, 2006) may be higher for migrants. We assume height and education denote a selection process and we use them as proxies for migrants' better position (Table 13). Surprisingly, there is no significant difference between stayers and migrants with regard to height. Migrants to city don't seem to be in better health than either rural or urban stayers. This may be due to a more complex process of selection within migrants. However, no height differences appear even after controlling for conscripts' other characteristics, such as occupation at 20. Although one might want to examine these issues more fully, our concern here is to bound the extent of migrants' self selection in terms of health status. On the education side, there are some signs of selection: migrants are both less illiterate and more prone to have achieved secondary education than the average rural dweller. However, there were few conscripts with secondary education and it is not clear what kinds of consequences this status had on mortality. These data point out the important heterogeneity within each group: city dwellers are very diverse whereas migrants may also be from mixed origins, which may limit the overall impact of the selection mechanisms.

In sum, we have shown that mortality patterns conditional on previous places of residence are consistent with those depending on present residence. The differences between rural and urban places increase with age, which strongly support the idea of a degradation of health capital. All these elements confirm that the urban penalty is linked with bad city conditions.

6. Concluding remarks

A large urban penalty prevailed in nineteenth-century France, it also had severe consequences for rural out-migrants' mortality. The evidence strongly supports the thesis that migrants were in better health than the rest of the rural population, and the urban population. Yet their mortality increased rapidly overtime and after a decade and a half in the city their mortality experience was the same as that of the native urban population. However, it should be noted that living conditions were also very heterogeneous *within* cities—not only between them but even inside one single metropolis. For instance, Paris at the end of the 19th century was one of the largest cities in the world, a place that housed both the poorest and the wealthiest people of France. Living conditions were very different between poor and rich neighborhoods. In other words, was it better to live in the countryside or in the wealthiest part of large cities? This issue questions the assumption that we can reduce the rural urban mortality gap to simple averages. Another issue concerns working conditions: they also vary a lot between urban and rural areas and change quite fast over time. They are very important to understand the evolution of health during the industrialization process and they may explain part of the urban disadvantage. We leave these issues for further research.

The history of the Industrial Revolution is full of controversy about the rise, stagnation or fall of living standards (Bengtsson et al., 2004). There is a general consensus that during the nineteenth century cities were harsh environment whether considered from the point of view of living conditions or mortality (Biraben, 1975; Woods, 2003). However the way this differential affected people over their life cycle is less well known and has not been extensively studied until recently (Cain and Hong, 2009). The evidence for France suggests that one should extend the research in the geography of mortality to cover a broad range of settings. Indeed although we can document an urban penalty in both cases, it seems to have quite a different micro structure since in France it seems to be exclusively associated with a depreciation of an individual's health stock. It remains difficult to decide whether the differences between the U.S. and France are due to the different characteristics of the samples of individuals examined, or to differences in environmental conditions like the extent of international versus domestic in-migration to cities.

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

ARTICLE IN PRESS

In this study, we use the detailed analysis of one cohort to measure rural–urban differential mortality in detail. We compare people that are almost completely identical: they were born in the same year, they did their military service at the same moment and they were in sufficiently good health to be accepted in the army during a long part of their lives (from age 20 to 46). In these conditions, finding substantial difference in mortality between areas is even more convincing. And yet there is a huge disadvantage of being born in a city, growing up in one and living there as an adult. There is no evidence of a reduction of the urban penalty with age. On the contrary, the differential increases in favor of rural dwellers.

Surprisingly, rural migrants to cities lose their initial advantage very quickly even though they were in good health when they arrived. Indeed, such migrants came from safer places and were positively selected, but these advantages faded away within a few years after their arrival. Overall, we find no evidence of an immunization process in the cities. Our results strongly support the interpretation that the nineteenth century urban penalty was largely due to bad living conditions. This is consistent with recent research demonstrating how improving cities' sanitary conditions reduced mortality (Cain and Rotella, 2001; Cutler and Miller, 2005; Ferrie and Troesken, 2008). In the case of France, access to water –and especially to clean water– started to democratize during the 19th century (Goubert, 1986). The rise of new standard of cleanness and the development of the hygienist movement during the last part of the century as can be seen in Paris (Gandy, 1999) or Rennes (Merrien, 1994) undoubtedly contributed to reduce cities' bad sanitary conditions. However, the process of rationalizing water access was neither simple nor linear (Baret-Bourgoin, 2005) and much remains to be done both to analyze it precisely and to explore its consequences on mortality.

Supplementary materials related to this article can be found online at doi:10.1016/j.eeh.2010.12.002.

Acknowledgments

The authors would like to thank Jean-Claude Farcy and Alain Faure for sharing their magnificent data set. Tracy Denison, Timothy Guinanne, Eva Lelièvre, and two anonymous referees gave extremely helpful comments.

References

Abrafdo-Lanza, Ana F., Dohrenwend, Bruce P., Ng-Mak, Daisy S., Blake Turner, J., 1999. The Latino mortality paradox: a test of the “salmon bias” and healthy migrant hypotheses. American Journal of Public Health 89 (10), 1543–1548.
Abramitzky, Ran, Braggion, Fabio, 2006. Migration and human capital: self-selection of indentured servants to the Americas. Journal of Economic History 66 (04), 882–905.
Akresh, Ilana Redstone, Frank, Reanne, 2008. Health selection among new immigrants. American Journal of Public Health 98 (11), 2058–2064.
Baret-Bourgoin, Estelle, 2005. Politiques urbaines et accès à l'eau dans la cité: la révolution des eaux à Grenoble à la fin du XIXe siècle. Le Mouvement Social 213, 9–29.
Bengtsson, Tommy, Campbell, Cameron, Lee, James, 2004. Life Under Pressure. Mortality and Living Standards in Europe and Asia, 1700–1900. MIT Press, Cambridge (MA).
Bengtsson, Tommy, Lindström, M., 2000. Childhood misery and disease in later life: the effects on mortality in old-age of hazards experienced in early life, southern Sweden, 1760–1894. Population Studies 53 (3), 263–277.
Biraben, Jean-Noel, 1975. Quelques aspects de la mortalite en milieu urbain. Population 30 (3), 509–522.
Blanchet, Didier, Kessler, Denis, 1992. La Mobilité Géographique de la Naissance au Mariage. In: Dupâquier, J., Kessler, D. (Eds.), La Population Française au XIXeme Siècle. Traditions, Transitions, Transformations. Fayard, Paris.
Borjas, George J., 1994. The economics of immigration. Journal of Economic Literature 32 (4), 1667–1717.
Bourdieu, Jérôme, Kesztenbaum, Lionel, 2004. Vieux, riches bien portants. Une application de la base “TRA” aux liens entre mortalité et richesse. Annales de Démographie Historique 79–105.
Bourdieu, Jérôme, Postel-Vinay, Gilles, Rosental, Paul-André, Suwa-Eisenmann, Akiko, 2000. Migrations transmissions inter-générationnelles dans la France du XIXe du début du XXe siècle. Annales Histoire. Sciences Sociales 55 (4), 749–790.
Cain, Louis, Hong, Sok Chul, 2009. Survival in 19th century cities: the larger the city, the smaller your chances. Explorations in Economic History 46 (4), 450–463.
Cain, Louis, Rotella, Elyce, 2001. Death and spending: urban mortality and municipal expenditure on sanitation. Annales de Démographie Historique 1, 139–154.
Corvisier, Alain (Ed.), 1992. Histoire Militaire de la France. T III. De 1871 à 1940. Paris, PUF.
Costa, Dora, 2003. Health and Labor Force Participation Over the Life Cycle. Evidence from the Past. University Chicago Press & NBER, Chicago.
Costa, Dora L., 2002. Changing chronic disease rates and long-term declines in functional limitation among older men. Demography 39 (1), 119–137.
Courgeau, Daniel, Lelièvre, Eva, 1986. Nuptialité et agriculture. Population 41 (2), 303–326.
Courgeau, Daniel, Lelièvre, Eva, 1992. Event History Analysis in Demography. Clarendon Press, Oxford.
Crépin, Annie, 1998. La Conscription en Débat ou le Triple Apprentissage de la Nation, de la Citoyenneté, de la République (1798–1889). Artois Presses Université, Arras.
Cutler, David, Miller, Grant, 2005. The role of public health improvements in health advances: the twentieth-century United States. Demography 42 (1), 1–22.
Deboosere, Patrick, Gadeyne, Sylvie, 2005. Adult migrant mortality advantage in Belgium: evidence using census and register data. Population—E 60 (5–6), 655–698.
Elo, Irma T., Preston, Samuel H., 1992. Effects of early-life conditions on adult mortality: a review. Population Index 58, 186–212.
Farcy, Jean-Claude, Faure, Alain, 2003. La Mobilité d'une Génération de Français : Recherche sur les Migrations et les Déménagements Vers et Dans Paris à la fin du XIXe Siècle. INED, Paris.
Ferrie, Joseph P., 2003. The Rich and the Dead: Socioeconomic Status and Mortality in the U.S., 1850–60. In: Costa, D. (Ed.), Health and Labor Force Participation Over the Life Cycle: Evidence from the Past. University of Chicago Press, Chicago, pp. 11–50.
Ferrie, Joseph P., Troesken, Werner, 2008. Water and Chicago's mortality transition, 1850–1925. Explorations in Economic History 45 (1), 1–16.
Fogel, Robert W., 1986. Nutrition and the Decline in Mortality since 1700: Some Preliminary Findings. In: Engerman, S.L. (Ed.), Long-Term Factors in American Economic Growth. University of Chicago Press, Chicago and London, pp. 439–527.
Fogel, Robert W., 2004. The Escape from Hunger and Premature Death. 1700–2100 Europe, America and the Third World. Cambridge University Press, Cambridge New York.
Galloway, Patrick Richard, 1985. Annual variations in deaths by age, deaths by cause, prices, and weather in London 1670 to 1830. Population Studies 39 (3), 487–505.
Gandy, Matthew, 1999. The Paris sewers and the rationalization of urban space. Transactions of the Institute of British Geographers 24 (1), 23–44.

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002

ARTICLE IN PRESS

Gaspari, K. Celeste, Woolf, Arthur G., 1985. Income, public works, and mortality in early twentieth-century American cities. Journal of Economic History 45 (2), 355–361.

Goubert, Jean-Pierre, 1986. La Conquête de l'eau: L'avènement de la Santé à l'âge Industriel. Robert Laffont, Paris.

Haines, Michael R., 2004. Growing incomes, shrinking people—can economic development be hazardous to your health? Social Science History 28 (2), 249–270.

Heffernan, Michael J., 1989. Literacy and geographical mobility in nineteenth century provincial France: some evidence from the department of Ille-et-Vilaine. Local Population Studies 42, 32–42.

Hong, Sok Chul, 2007. The burden of early exposure to malaria in the United States, 1850–1860: malnutrition and immune disorders. Journal of Economic History 67 (4), 1001–1035.

Humphries, Jane, Leunig, Tim, 2009. Was Dick Whittington taller than those he left behind? Anthropometric measures, migration and the quality of life in early nineteenth century London? Explorations in Economic History 46 (1), 120–131.

Kalbfleisch, John D., Prentice, Ross L., 2002. The Statistical Analysis of Failure Time Data. J. Wiley & Sons, Hoboken (N.J).

Kasakoff, Alice, Adams, John, 2000. The effects of migration, place and occupation on adult mortality in the American north, 1740–1880. Historical Methods 33 (2).

Komlos, J., 1998. Shrinking in a growing economy? The mystery of physical stature during the industrial revolution. Journal of Economic History 58 (3), 779–802.

Kuagbenou, Victor Kuami, Biraben, Jean-Noël, 1998. Introduction à l'étude de la Mortalité par Causes de Décès à Paris Dans la Première Moitié du XIXe Siècle : Présentation de Données Inédites. INED, Paris.

Landers, John, 1993. Death and the Metropolis: Studies in the Demographic History of London, 1670–1830. Cambridge University Press, Cambridge.

Lee, Chulhee, 1997. Socioeconomic background, disease, and mortality among union army recruits: implications for economic and demographic history. Explorations in Economic History 34 (1), 27–55.

Merrien, François-Xavier, 1994. La Bataille des Eaux—L'hygiène à Rennes au XIXe Siècle. Presses Universitaires de Rennes, Rennes.

Meslé, France, Vallin, Jacques, 2001. Tables de Mortalité Françaises Pour les XIXe et XXe Siècles et Projections Pour le XXIe Siècle. INED, Paris.

Moch, L.P., 1992. Moving Europeans; Migrations in Western Europe since 1650. Indiana University Press, Indianapolis.

Moheau, Jean-Baptiste, 1994. Recherches et Considérations sur la Population de la France. [1778] INED/PUF, Paris.

Neven, Muriel, 1997. Epidemiology of town and countryside: mortality and causes of death in East Belgium, 1850–1910. Revue Belge d'Histoire Contemporaine 27, 39–82.

Palloni, Alberto, Arias, Elizabeth, 2004. Paradox lost: explaining the hispanic adult mortality advantage. Demography 41 (3), 385–415.

Pinol, J.L., 1996. Mesurer les Mobilités Urbaines. Strasbourg 1870–1940 : Trajectoires Individuelles Espace Urbain. Enquête, vol. 4. EHESS/Parenthèses, Marseille, pp. 93–106.

Rosental, Paul-André, 1999. Les Sentiers Invisibles : Espace, Familles et Migrations Dans la France du 19e Siècle. Paris, Éd. de l'École des Hautes Études en Sciences Sociales. .

Roynette, Odile, 2000. "Bons Pour le Service", l'expérience de la Caserne en France à la fin du XIXe Siècle en France. Belin, Paris.

Rubalcava, Luis N., Teruel, Graciela M., Thomas, Duncan, Goldman, Noreen, 2008. The healthy migrant effect: new findings from the Mexican family life survey. American Journal of Public Health 98 (1), 78–84.

Sjaastad, Larry A., 1962. The costs and returns of human migration. The Journal of Political Economy 70 (5), 80–93.

Steckel, R., 1995. Stature and the standard of living. Journal of Economic Literature 33 (4), 1903–1940.

Steckel, Richard H., Floud, Roderick (Eds.), 1997. Health and Welfare during Industrialization. University of Chicago Press, Chicago.

Szreter, Simon, Mooney, Graham, 1998. Urbanization, mortality, and the standard of living debate: new estimates of the expectation of life at birth in nineteenth-century British cities. Economic History Review (1), 84–112 vol. LI.

Tugault, Y., 1973. La Mesure de la Mobilité. Cinq Études sur les Migrations Internes. INED, Paris.

Tugault, Yves, 1975. Fécondité et Urbanisation. INED, Paris.

Van den Berg, Gerard J., Lindeboom, Maarten, Portrait, France, 2006. Economic conditions early in life and individual mortality. The American Economic Review 96 (1), 290–302.

Vedrenne-Villeneuve, Edmonde, 1961. L'inégalité sociale devant la mort dans la première moitié du XIXe siècle. Population 4, 665–698.

Villermé, LouisRené, 1830. De la Mortalité Dans les Divers Quartiers de la Ville de Paris, et des Causes qui la Rendent Très Différente Dans Plusieurs d'entre eux, Ainsi que Dans les Divers Quartiers de Beaucoup de Grandes Villes. Gallica, link: http://gallica.bnf.fr/ark:/12148/bpt6k81421x.

Vögele, Jörg, 1998. Urban Mortality Change in England and Germany, 1870–1913. Liverpool University Press, Liverpool.

Williamson, Jeffrey G., 1982. Was the industrial revolution worth it? Disamenities and death in 19th century British towns. Explorations in Economic History 19 (3), 221–245.

Woods, Robert, 2000. The Demography of Victorian England and Wales. Cambridge University Press, Cambridge.

Woods, Robert, 2003. Urban–rural mortality differentials: an unresolved debate. Population and Development Review 29 (1), 29–46.

Please cite this article as: Kesztenbaum, L., Rosenthal, J.-L., The health cost of living in a city: The case of France at the end of the 19th century, Explor. Econ. Hist. (2011), doi:10.1016/j.eeh.2010.12.002