Mortality differences between the foreign-born and locally-born population in France

(2004-2007)

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Abstract

In contrast to the situation in many European countries, the mortality of immigrants in France has been little studied. The main reasons for the lack of studies are based on ethical and ideological considerations. The objective of this study is to explore mortality by country of birth in Metropolitan France. Complete mortality data were used to study the relative risks of mortality of the foreign- and locally-born populations by gender, age and cause of death for the period 2004-2007 in mainland France. Analyses were conducted by countries of birth grouped into geographic areas and by the Human Development Index (HDI). The differentials in mortality between foreign-born and locally-born populations were not homogeneous. The figures varied by age (higher foreign-born mortality for the young; lower mortality for migrants aged 15-64 years), gender (female migrants more frequently had higher relative mortality than men migrants), country of birth (Eastern European-born migrants had higher mortality, while those born in Morocco, Central Asia, 'other Asian countries' and America had lower mortality) and cause of death (migrant mortality was higher overall for deaths caused by infectious diseases and diabetes, and lower for violent death and neoplasm). Moreover, mortality relative risks for male, violent deaths and cancer were positively associated with country-of-birth HDI, while female mortality and infectious disease mortality were negatively associated with country-of-birth HDI. Some limitations have to be considered. A strong healthy migrant effect was suggested and its intensity varies with age and gender (which may reflect different reasons for migration). For some specific causes of death, a lifestyle effect seems to explain mortality differentials. The associations between HDI and mortality show that mortality trends are partly related to the educational, sanitary and economic conditions of the country of birth. Further studies would enrich the differential analysis of mortality by country of birth by contributing additional detailed data

on socioeconomic and living conditions in the host country as well as in the country of origin.

Keywords

Mortality differential, France, Country of birth, Cause of death, Healthy migrant effect

Introduction

In contrast to the situation in many European countries, the mortality of immigrants in France has been little studied (Bouchardy, Parkin, Wanner, & Khlat, 1996; Bouchardy, Wanner, & Parkin, 1995; Brahimi, 1980; Darmon & Khlat, 2001; Khlat & Courbage, 1995; Khlat & Courbage, 1996; Méjean C., Traissac P., Eymard-Duvernay S., El Ati J., Delpeuch F., & Maire B., 2007). Most of these studies, conducted in the nineties, focused on causes of death for specific countries of birth (more particularly located in North Africa) (Bouchardy, Parkin, Wanner et al., 1996; Khlat & Courbage, 1995; Khlat & Courbage, 1995). These analyses, carried out in terms of relative risks of mortality, have been conducted using transversal exhaustive data. Several limits were raised in the interpretation of such data among which a plausible differential attrition process (the less healthy foreign-born people are going back to their country of origin) and a lack of explanatory variables (like socioeconomic characteristics). Cancer mortality was found to be very low for those populations compared to France born. Several explanatory factors (for example, demographic, cultural, social factors) were proposed by the authors of these surveys, but not studied empirically. None of these studies depicted a global overview of mortality by country of birth, so they did not determine which of the differentials observed were attributable to country of birth specificities or to more general factors related to migration. Moreover, the situation may have changed since the nineties. The main arguments put forward to justify the limited production of statistics that could be related to ethnicity, in which studies about migrants' mortality are included, relate to ethical, ideological (the French concept of citizen is based on the idea of universal citizenship), and historical considerations (Boissard S., 2006; Tribalat M., Simon P., & Riandey B., 1996). The objective of the present study was to evaluate the impact of several factors, defined in a theoretical model by Kohls (Kohls, 2008) [Figure 1], on recent

migrants' mortality in France. The study is exploratory and was designed with a view to defining hypotheses to be further investigated subsequently.

Several interacting factors may influence the level and characteristics of mortality in populations born outside but residing in France [Figure 1]. All of them are part of the conceptual framework, discussed below, constructed on the basis of the work of Trovato (Trovato F., 2003) and Schenk (Schenk L., 2007) and modified by Kohls (Kohls, 2008). They were explored within the limits of available data. Therefore, some of them could not be tested.

First, foreign-born individuals who have migrated may generally benefit from a healthy migrant effect. This phenomenon, widely reported in the international literature (Fennelly, 2005; Kennedy, McDonald, & Biddle, 2006; Lu, 2008; Razum, Zeeb, & Rohrmann, 2000; Trovato F., 2003), characterizes the superior health and financial status of migrant populations relative to populations that stay behind. However, the migrant population does not constitute a homogeneous group. Various factors such as the reason for migration, specificities of the country of birth, and duration of residence may be related to the intensity of the selective effect on mortality. Those factors influence other effects related to immigration. The impact of selective effects in migration on mortality may vary depending on the reason for migration (health, family, professional and educational reasons, exile, etc.). Women and children frequently come to France to join their spouses or parents (Thierry, 2004). Consequently, compared to men, who more frequently intend to find work in France (which entails a 'healthy worker effect' (Lu, 2008)), women are not subject to the same selective effect (Khlat & Courbage, 1995).

Second, as observed for the reported health status of foreign born population in France (Jusot, Silva, Dourgnon, & Sermet, 2008), mortality of this population may also be linked to the economic, sanitary and educational characteristics of the country of origin. It is likely that the more those characteristics differ from those of the host country, the more mortality will tend to differ (positively or negatively) from that of the locally-born population. Similarly, an effect of cultural differences in lifestyle may be observed and be characterized by confusion on arrival (change in diet, unfamiliarity with the care system, etc.) that will vary, depending on the degree to which the host country is similar to the country of origin (Trovato F., 2003). For some causes of death, migrant mortality in France may reflect the characteristics of home-country mortality. These characteristics could consist in specific 'risk behaviours' (e.g., violent deaths (Eurostat, 2009; Singh G.K. & Siahpush, 2001; Trovato F., 2003), even so this hypothesis is not validated in some studies (Karasik D., Yakovenko K., Lipstein E., & Hiss J., 1999; Trovato F., 1992)), or food habits (e.g. lower prevalence of type 2 diabetes in Africa than in France (Mbanya J-C. & Ramiaya K., 2006)). It could also consist in the sanitary context, when an infectious disease is more likely to be contracted in specific geographic areas than in France (e.g., sub-Saharan Africa for HIV infection (ECOSOC, 2002; Mboup S., Musonda R., Mhalu F., & Essex M., 2006; UNAIDS, 2006; Watkins, Carvajal, Coppard, Fuentes, Ghosh, Giamberardini et al., 2006)).

Lastly, the impact of the healthy migrant effect would be expected to decrease with the length of stay in the host country (Trovato F., 2003). The duration of stay may constitute a determining factor for migrant health (Gordon, 1957) (gain or loss of protective practices) by facilitating acculturation to the host country lifestyle (diet, use of the care system, etc.), especially with regard to social background. In France, even though there are disparities between countries of origin (Insee, 2005), migrants more frequently belong to lower

socioeconomic categories than do the locally-born population (Perrin-Haynes, 2008). This situation may be exacerbated by inferior living and housing conditions of these populations in France (Boëldieu & Thave, 2000). Furthermore, for any given level of care needs, immigrants make less use of the healthcare system than do the indigenous population. This may be explained by linguistic difficulties, unfamiliarity with the healthcare system (prevention campaigns; access to specialists, etc.) and limited access to social welfare (inadequate additional health insurance coverage due to a low standard of living, unfamiliarity with the right of access to care or social coverage) (Couillet M., 2009; Dourgnon, Jusot, Sermet, & Silva, 2009). Social factors may also be considered (discrimination and 'othering' experiences, difficulties related to integration process in the host country (Viruell-Fuentes, 2007)). Given the existence of a marked social gradient in health, the accumulation of disadvantages relative to the indigenous population may lead to general poor health in immigrant populations (Bihr & Pfefferkorn, 2008). In France, no individual data on living conditions, socioeconomic level and length of residence are available on large population samples enabling studies on mortality by country of birth. Thus, this study is not formally disentangling such factors from those specifically related to the country of birth and some interpretations have to be taken cautiously.

This study approached these various issues through an analysis of the mortality variations in France by country of birth over the period 2004-2007. In order to infer on potential explanations for the observed differences, we make distinctions by age, gender and cause of death. Moreover, countries are grouped by Human Development Index (HDI), the latter being used exclusively as a synthetic indicator of the economic, educational and sanitary context of countries of birth.

Methods

Complete mortality data for the period 2004-2007 for the whole population in France, by gender, age, country of birth and underlying cause of death were supplied by Inserm-CépiDc. These data are derived from death certificates, for which the completion by a physician is compulsory on the occurrence of each death (Pavillon & Laurent, 2003). The underlying cause of death, selected according to the rules of the International Classification of Diseases, 10th Revision (ICD-10), is defined as the cause that originated the morbid process leading to the death. The population data on which the calculation of rates is based were provided from the 2006 census by the French National Statistics and Economic Studies Institute (Insee). Since January 2004, the census has consisted in a national multiyear population survey. Over five years, all the homes in cities of less than 10 000 inhabitants and a representative sample of 40% of homes in cities of more than 10 000 inhabitants are surveyed on the French territory. As a consequence, population estimate of each year is a concatenation of five years "collection" (Godinot, 2005). The data were distributed by 5-year age group, gender and country of birth. As nationality at birth is not available in the mortality database, foreign-born categories used in this study include people born abroad holding French nationality. The analyses were conducted on the population aged 5 years or more. Children aged 0 to 4 years were excluded because most of the deaths in that age group occur during the first months of life, which is generally lived in the country of origin. Thus, in the absence of more detailed population data by age, mortality rates of young children born abroad and those born locally are not comparable. In addition, the French population living overseas was excluded from the analyses because of the different mortality patterns by causes of death (Rallu, 1997; Saucedo M., Deneux-Tharaux C., & Bouvier-Colle M., 2010) and a totally different migration context (Borrel, 2006; Monteil & Rallu, 2006).

The low number of deaths led to the countries of origin being grouped. First, the countries were grouped by geographic area. African and Asian countries formerly subject to French administration were distinguished (because of possible cultural differences compared to neighbouring countries relative to their historical link with France and their consequences on migration processes). Fourteen groups were considered (Table 1). In addition, the countries of birth were also grouped on the basis of their Human Development Index score estimate in 2004 (Table A – electronic appendix available in on-line version of the paper ***insert link to online appendix here***). The index measures for each country economic (Gross Domestic Product per capita), sanitary (life expectancy at birth) and educational (with Gross Enrolment Ratio and adult literacy rate) characteristics (Watkins, Carvajal, Coppard et al., 2006). A classification of country of birth based on HDI level was considered (excluding the countries for which the HDI was not available). This classification was determined in order to obtain equal numbers of deaths in each category, maximizing the power of the analysis: high HDI countries (greater than or equal to 0.938), intermediate HDI (greater than or equal to 0.728 and less than 0.938) and low HDI (less than 0.728). The underlying causes of death were divided into six categories (with reference to the main ICD-10 chapters): cardiovascular diseases (ICD-10 codes: I00-I52); cerebrovascular diseases (I60-I69); infectious diseases (A00-B99); neoplasms (C00-D48); diabetes (E10-E14); and violent death (V01-Y98). Because of the rarity of the death event, and the relatively large size of exhaustive population counts, log-linear Poisson models are usually used to estimate relative risks of mortality (Khlat, 1992; McCullagh & Nelder, 1989). These models were used to estimate relative risks and 95% confidence intervals by country of origin, adjusted by age and gender. Thus, foreign-born populations' mortality risks were compared to that of the locally-born population independently of age and gender. The models underwent several stratifications: by age, gender and cause of death. The stratifications by age considered three age groups: 5-

14; 15-64 and ≥ 65 years. For each country of origin, testing for a between-gender difference in the risk of mortality relative to the locally-born population was conducted. The log-linear trends relating HDI to mortality rate were estimated, using the following log-linear Poisson model:

$$\begin{cases} O_{c,a,s} \propto P(\lambda_{c,a,g}) \\ \log(\lambda_{c,a,g}) = \log(pop_{c,a,g}) + \alpha_{a,g} + \beta \cdot HDI_{c} \end{cases},$$

$O_{c,a,s}$ is the number of deaths for the country of birth 'c', age 'a' and gender 'g', follows a Poisson distribution of parameter $\lambda_{c,a,g}$; $pop_{c,a,g}$ is the population estimate, $\alpha_{a,g}$ adjusted for age and gender effects ; β is the log-linear trend.

Results

General characteristics of the mortality of the foreign born population

Even though the foreign-born populations were mainly of working age (15-64 years), some populations consisted in a higher proportion of young people (American-born population) or elderly people (Algeria, Tunisia, Europe) (Table 2). For almost all the foreign-born population, the age at death was more frequently greater than 65 years. However, in the population born in AFFA (African countries formerly subject to French administration), the age at death was more frequently between 15 and 64 years. In the populations born in Morocco, 'other African countries', Central Asia and 'other Asian countries', the age at death was between those two extremes.

The population distribution by gender varied by country of birth. The migrants born in the Maghreb, Central Asia and Turkey mainly consisted in men. Women were predominant in

the populations born in other countries. For all countries of birth, except Other America-Oceania and Eastern Europe, more deaths were observed among males than among females.

Mortality differentials by gender and age

Relative risks of mortality by gender and age allows us, both to explore the impact of demographic criteria on migrants' mortality, and to evaluate broadly the amplitude of the selection effect and its variations.

For all foreign countries considered as a whole, and separately with the exception of Eastern Europe, foreign-born male mortality was significantly lower than that of the locally-born male population. Males born in Central Asia, 'other Asian countries', North America and Morocco had the lowest mortality relative to the reference (French born) population (-30%) (Table 3). The picture was more contrasted for females. Mortality was significantly lower for women born in Morocco, 'other African countries' and 'other Asian countries'. In contrast, mortality was significantly higher for women born in Eastern Europe (+16 %), AFFA (+11%) and Algeria (+4 %).

Most of the groups of migrant children (5 to 14 years) had significant excess mortality (Table 4). The highest relative risks, greater than 2, were observed for the populations born in AFFA, Central Asia, Eastern Europe and Turkey. There were no significant mortality differences by gender.

An overall trend toward lower mortality was observed for the age group 15-64 years, and especially for people born in Turkey, 'other Asian countries', Central Asia, Morocco and

'other American-Oceanian countries' (-40%). The mortality of the population born in Eastern Europe differed from this pattern with 10% higher mortality. Foreign-born women had a significantly higher relative risk than foreign-born men. The largest difference was observed for population born in AFFA (higher mortality for women, lower for men). For the older population (≥ 65 years), only the Eastern European-born population had a risk of mortality that was significantly higher than the mortality of the locally-born population. Except men born in Turkey and Eastern Europe, older foreign-born men had lower relative risk than locally-born men. Women born in European countries, Turkey, Tunisia, ASFA (Asian countries formerly subject to French administration) and Algeria had higher relative risks while those born in 'other Asian countries', 'other African countries' and Morocco had lower relative risks.

Mortality differentials by cause of death

Analyses by causes of death refer to several explanatory factors outlined in the introduction. Nevertheless, for some of these causes (cardiovascular diseases, neoplasms, diabetes), mortality differentials by country of birth might more specifically refer to the acculturation process (relative to the socio-economic status). Indeed, lifestyle adopted more or less gradually in France (nutrition, sedentary lifestyle, alcohol and tobacco consumption…) may have an impact on some specific causes of death (Danaei G., Ding E., Mozaffarian D., Taylor B., Rehm J., Murray C. et al., 2009; van Dam R., Li T., Spiegelman D., Franco O., & Hu F., 2008). For other causes (infectious diseases and violent deaths), some characteristics of the country of birth (risk behaviour, prevalence of specific diseases) could be specifically considered as explanatory factors. However, without additional detailed data on living conditions or health behaviours, these hypotheses have to be taken cautiously.

Foreign-born population mortality due to neoplasms was generally less than that of the locally-born population. This trend was particularly marked for Central Asia, 'other Asian countries', ‘other African countries’, 'other American-Oceanian countries' and Morocco (Table 5). However, some gender specificities were observed. The mortality of women born in Eastern Europe was higher (+10%). Men born in Central Asia, AFFA and Morocco had significantly lower mortality relative risks than females.

For cardiovascular and cerebrovascular diseases, the only significant differences were observed for the populations born in Morocco (25% lower mortality), Eastern Europe (20% higher mortality) and AFFA, ASFA for the latter cause of death (40% higher mortality). Variations by gender were observed. Women born in Algeria and 'other European countries' had slightly higher mortality due to cardiovascular diseases, while males had a lower mortality (significant difference only for 'other European countries'). Overall, except for the Eastern European-born population, men had lower mortality due to cardiovascular diseases.

Higher mortality due to diabetes was observed for most of the foreign-born populations (on average, +40%, except for 'other European countries': +12%). For all foreign countries considered as a whole, females had significantly higher relative risks of mortality than males. By specific groups of countries of birth, the trend did not vary by gender. The population born in 'Other European countries' constituted an exception: men had lower mortality while women had 50% higher mortality.

The relative risk of mortality due to infectious diseases was higher for migrants. However, the differences varied markedly depending on country. Mortality was particularly high for the populations born in AFFA (three-fold higher). There were no significant mortality differences by gender. A large part of the high mortality may be explained by AIDS. The African-born population had the highest relative risks (nine-fold greater mortality due to AIDS for population born in AFFA, six-fold greater mortality for those born in ‘other

African countries'); the population born in 'other American-Oceanian countries' five-fold greater mortality; and the Algeria-born population two-fold greater mortality than the locally-born population (Table B - electronic appendix available in on-line version of the paper ***insert link to online appendix here***).

Foreign-born migrants had markedly lower mortality due to violent death (both genders). People born in 'other European countries' constituted the only population whose mortality was only slightly different to that of the locally-born population (lower mortality). With the exception of deaths due to homicide, migrants' lower mortality was observed for each specific type of violent death (traffic injuries, non traffic injuries, suicides...).

Mortality differentials by Human Development Index score

The association between migrants' mortality and the HDI measured in the country of birth could reflect the impact of the economic, educational and sanitary context on mortality. Indeed, an observed gradient would provide additional evidence that this association is not only reflecting an artefact, but rather the continuous explanatory role played by the country of birth context on mortality differentials. However, the lack of information regarding life conditions and duration of stay in France constitutes an important limitation with regard to these interpretations.

For male migrants, all ages relative risk of mortality increased with HDI score whereas no significant correlation was observed by age (except for the 85 years and over). In contrast, even though female migrants mortality was not significantly associated with HDI, for those aged 5-74 years, the relative risk of mortality decreased with HDI score (Figure 2). By cause of death, a positive correlation (highest mortality for foreign-born populations from countries with high HDI scores and lowest mortality for foreign-born populations from countries with

low HDI scores) was observed for violent death and neoplasm mortality for both genders [Figure 3]. The opposite was observed for infectious diseases in men and women. In other cases, no relationship between the HDI of the country of origin and migrant mortality in the host country was observed. Irrespective of the relationship between HDI and mortality, the mortality of migrant populations born in the highest HDI countries was generally more similar to that of the locally-born population.

Discussion

The differentials in foreign-born and locally-born mortality were not homogeneous. The figures varied by age (higher foreign-born mortality for the young; lower mortality for migrants aged 15-64 years), gender (women more frequently had higher relative mortality), country of birth (Eastern European-born migrants very frequently had higher mortality, while those born in Morocco, Central Asia, 'other Asian countries' and America had lower mortality) and cause of death (migrant mortality was higher overall for deaths caused by infectious diseases and diabetes, and lower for violent death and neoplasm). On the basis of those results, some hypotheses may be advanced with regards to the issues described at the beginning of the article [Figure 1].

Healthy migrant effect

The healthy migrant hypothesis may be supported by the results reported in this study, although without information on length of residence in France or on living conditions in France, the findings are not conclusive. Overall, these analyses show that the foreign-born populations had lower mortality than the locally-born population, while life expectancy in

France in 2004 was greater than the life expectancy found in each groups of countries of birth considered. However, this potential selective effect differed by gender and age. Foreign-born men more frequently had lower relative mortality than women did. For the age group 5-14 years, specific higher mortality was observed. According to the data on residence permit flows from 2004 to 2007 (Ministry of Interior, overseas territories, territorial collectivities and immigration), 54% of women officially migrate for family reasons versus 43% of men. Consequently, for women and children, the reason for migration is likely to lead to a less strong selective effect than that for people who migrate with a professional objective (11% of men officially migrate for professional reasons versus 4% of women). These results seem to be consistent with a 'healthy worker effect' (Kohls, 2008).

Generally, high mortality risk is positively associated with a low social position. Therefore, as most of the migrant populations (in particular from African countries) are more socioeconomically deprived than people born in France (Insee, 2005), adjusting the results by socioeconomic position may increase the gap between mortality of foreign-born and locally-born people. Thus, the suggested selective effect found in this study might be underestimated. The higher mortality observed in this study for foreign born children may be explained by a weak or nonexistent selective effect, reflecting the association of their lower social position and their risk of mortality.

Exposures in countries of origin

The results obtained in this study seem to show that the sanitary context of the country of origin is associated with migrant mortality. Indeed, relative risks observed were higher for people born in AFFA than for those born in “other African countries”, which may be related

to a markedly higher life expectancy in 2004 for the latter group (Watkins, 2006). In absence of detailed data about migrants' health status and behaviours in France, this interpretation should be taken cautiously. Moreover, the populations born in Africa had higher mortality due to infectious disease, partly because they were often infected in their countries of origin. Indeed, in 2002, 44% of HIV infected sub-Saharan Africans, supported in hospital of Paris region declared that they were infected in their country of origin or other African countries, 29% in France and 27% did not know (Valin N., Lot F., Larsen C., Gouëzel P., Blanchon T., & Laporte A., 2004). In those cases, sick people may migrate for healthcare reasons, which would imply an inverse selective effect. However, medical reasons are rarely (average: 3%) reported as the official reason for migration in the statistics for 2004-2007. Nevertheless, migrants of African nationality stand out from other migrant populations in that they have the highest proportion of residence permits issued for health reasons (9%).

Lifestyle effect

In addition to the selective phenomenon, the hypothesis of a lifestyle effect related to the country of birth is also to be considered. The Moroccan and Tunisian migrants' diet may have a beneficial effect on their health (in particular for men), and may result in lower mortality observed in this study for specific causes of death (chronic disease, neoplasm, cardiovascular disease) (Méjean C., Traissac P., Eymard-Duvernay S. et al., 2007). The Moroccan and Tunisian diet is a Mediterranean diet with a high fruit and vegetable content. Alcoholic beverage consumption is limited (mainly Muslims) (Darmon & Khlat, 2001). However, lifestyle may have a beneficial effect on mortality in that it may be resistant to westernization on arrival in the host country (loss of points of references) and during the duration of residence. In addition, the higher mortality by diabetes for foreign-born population observed

in this study may be explained by an increasing incidence of this pathology (type 2) due to the lifestyle changes induced by migration (diet containing more salt and fats, 'sedentary' lifestyle…), particularly when the gap between the socioeconomic conditions of the country of birth and the host country is wide.

However, mortality differentials observed in this study for smoking- and alcohol-related causes of death (oral cavity and pharynx cancer, larynx, trachea, bronchus and lung cancer, liver cirrhosis, mental and behavioural disorders due to use of alcohol) between foreign and locally born people aged 5-64 years do not sustain the hypothesis of a lifestyle effect of the country of origin on migrants' mortality, in particular for the population born in Eastern Europe. In that region, the high alcohol consumption markedly affects male life expectancy (WHO, 2001). Thus, those risk practices may be considered as explanatory factors for a permanently higher mortality observed herein. However, in this study, the smoking- and alcohol-related mortality of the population born in Eastern Europe is not significantly different from that of the locally-born population. In consequence, this factor cannot constitute an explanation of these population's higher relative risks.

In addition to previous explanations, the higher mortality due to infectious disease, and especially AIDS, might be related to poor use of the health care system, strongly linked to socio-economic positions. Indeed, the higher mortality by AIDS could be explained by a late access to care and screening (InVS, 2006) and poor observance of the antiretroviral treatment. Migrants'population, especially those coming from Sub-Saharan-Africa, and irregular migrants, are specifically affected by such problems (Couillet M., 2009; Valin N., Lot F., Larsen C. et al., 2004).

The dose-response association (positive overall for males, violent deaths and neoplasm mortality, and negative for females and infectious disease mortality) between mortality and HDI brings additional evidence that mortality trends are partly related to the educational, sanitary and economic conditions of the country of birth. Indeed, the closer migrant's country of birth HDI was from France HDI, the closer migrants' mortality was from France born mortality.

Limitations

Several biases are to be considered in this study. The first category of bias, 'numerator/denominator bias', is characterized by the incoherence of data from different sources. The overall low mortality observed may be partially explained (e.g. for male cardiovascular disease mortality and even neoplasm mortality for both genders) by bias in mortality data. This bias is characterized, in one hand, by underestimation of the number of migrant deaths, probably caused by health-selective remigration (a phenomenon known as 'salmon bias') (Kohls, 2008). Even though in some publications the impact of salmon bias on migrant mortality is considered negligible or invalid (Abraido-Lanza, Dohrenwend, Ng-Mak, & Turner, 1999), the phenomenon may explain some unlikely results. In particular a 'return effect' characterized by return of less healthy people to their place of birth ('unhealthy remigration effect') is to be considered (Kohls, 2008; Razum, Zeeb, Akgun, & Yilmaz, 1998). This phenomenon would specifically affect men, elderly people (Attias-Donfut & Wolff, 2005), isolated people (living alone or in a community), with limited financial resources (and thus wishing to avoid expensive repatriation of the corpse), with specific religious funeral rites (Khlat & Courbage, 1995), etc. Without additional data (Kibele, Scholz, & Shkolnikov, 2008), the scale of this effect is difficult to quantify and would vary

according to the country of birth and cultural and policy issues (legislation governing repatriation grants (Ordonnance 00-046/P-RM du 25 septembre 2000 portant sur la création de la Délégation Générale des Maliens de l Extérieur, 2000)). On the other hand, in French censuses, some people are difficult to contact (e.g. illegal immigrants (Borrel, 2006; Buffet, 2006) or migrants recently arrived (Desplanques G., 2008)). The official size of the immigrant population in France may thus be an underestimate. This phenomenon may have had an impact on the results reported herein. Immigrants not recorded in the census and who die in France are included in the national mortality statistics. The magnitude of the underestimation may vary with the country of birth, in the case of illegal immigrants it refers for example to the different rules of entrance and stay according to the country of origin (Buffet, 2006). The numerator bias may particularly concern elderly people while the denominator bias would concern preferably younger people. In consequence, these two biases may not counter-balance each other.

On the basis of the data used in this study, it is difficult to disentangle the effect of socioeconomic level on mortality differentials. Since the socioeconomic status of immigrants in France is strongly linked to the country of birth (Insee, 2005), such effect could be of high amplitude. A variable describing the socioeconomic status is reported post-mortem by several possible actors (family, medical staff, funeral directors …) on the death record. This variable is rarely informative. Indeed, over the period 1999-2008, it was filled in for only 8% of all death records. Thus, the use of that variable in the analysis may induce uncontrolled reporting biases, potentially differing by cause of death.

A 'foreign-born' category is used for both population and mortality statistics irrespective of nationality at birth. Thus, French nationals and foreigners born abroad are included in the

same group. The proportion of French nationals born abroad is rather high, particularly for former French colonies (especially Algeria). This may call into question the interpretation of the results: the mortality 'pattern' of foreigners born abroad is associated with that of French nationals born abroad, but the patterns may be different. French nationals born abroad may have a lifestyle and mortality similar to those of the French born in France. Given that hypothesis, the results reported herein may be conservative for immigrant populations (excluding the French born abroad). Immigrant mortality may differ more markedly from the mortality of the locally-born population.

In this study, the HDI is used as a synthetic indicator of the economic, educational and sanitary situation of a country and not strictly as an indicator of "human development". Nevertheless, some limits can be raised relating to its use in this purpose. The input data for its measurement are provided by national statistical agencies, raising an issue of homogeneity. However, the Human Development Report Office, which produce this index, documented convincingly the cautiousness taken to maximised the reliability of data (Watkins, Carvajal, Coppard et al., 2006). Finally, HDI appears to be the most valuable and available synthetic information for each studied country and could easily be used in other similar studies.

The duration of residence in France may have an impact on mortality. But, exhaustive routine mortality data do not contain any reliable information about the duration of residence in France of migrants (which is heterogeneous according to the country of birth) (Insee, 2005). It was not possible to merge the official reasons for migration with the rest of the data. The importance of each reason for migration varies with the HDI of the country of origin (positive correlation for professional and educational reasons; negative correlation for health

and familial reasons). The official reasons for migration also vary with the country of origin: immigrants from 'other European countries' mainly migrate for professional reasons; immigrants from African (including the Maghreb), Eastern European and 'other American-Oceanian' countries mainly migrate for familial reasons; others mainly migrate for educational reasons. In addition, there is a relationship between the reason for migration and migrant health (Wluczka, Kern, & Jamri- Berthou, 2009).

The mortality of foreign-born populations is a complex phenomenon influenced by several factors (cultural, social, economic, statutory, etc.) with interacting effects. In consequence, detailed data generated by specific inquiries addressing immigrant populations (Beauchemin, Lesné, Simon, & Hamel, 2010) (living conditions, socioeconomic characteristics, marital status, social relationships, health) should enrich the analysis of mortality differentials by country of birth. However, the use of the routine data reported herein has enabled the description of large mortality differentials in France, and identification of the priority areas for further investigation. Judged from the excess levels of mortality, health politics should give particular importance to children aged 5-14 years, Eastern European populations, and migrants' death due to diabetes (type 2) and infectious diseases.

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Figure captions:

Figure 1: Model of determinants on migrants' mortality

Figure 2: Relative risk of mortality for foreign-born populations, grouped by countries' HDI, relative to the locally-born population by age and gender (years 2004-2007)

Figure 3: Relative risk of mortality for foreign-born populations, grouped by countries' HDI, relative to the locally-born population by cause and gender (years 2004-2007)

Table 1: Countries grouped by the geographical area of birth

Countries of birth groups	Countries of birth
African country formerly subject to French administration	Benin, Burkina, Central African (REP), Côte d'Ivoire, Djibouti, Gabon, Guinea, Comoros, Cameroon, Mali, Niger, Togo, Chad, Senegal, Madagascar, Mauritania, Congo.
Other African countries	South Africa, Angola, Botswana, Eritrea, Ethiopia, Guinea-Bissau, Cape Verde, Kenya, Lesotho, Liberia, Malawi, Maurice, Mozambique, Namibia, Nigeria, Uganda, Sao Tome e Principe, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Zambia, Zimbabwe, Gambia, Ghana, Congo (democratic REP), Egypt, Rwanda, Burundi, Seychelles, Equatorial Guinea, Libya.
Algeria	Algeria
Morocco	Morocco
Tunisia	Tunisia
Turkey	Turkey
Central Asia - South Asia – Southwest Asia - the Middle East	Arabic Kazakhstan, Kirghizia, Tadjikistan, Uzbekistan, Turkmanistan, Iran, Iraq, Lebanon, Syria, Israel, Afghanistan, Pakistan, Bhutan, Jordan, Kuwait, Emirate Unite, Qatar, Bahrain, Oman, Yemen, Armenia, Azerbaijan, Georgia, Palestine, East Timor, Saudi Arabia, Sri Lanka, the Maldive Islands, Bangladesh, the Cyprus.
Other Asian countries	China, Nepal, Japan, Thailand, the Filipinas, Burma, Brunei, Singapore, Malaysia, Hong-Kong, Indonesia, Taiwan, Korea, Korea (democratic popular REP of), Korea (REP of), Mongolia, India, Macao, Siberia.
Asian country formerly subject to French administration	Cambodia, Vietnam, North Vietnam, South Vietnam, Laos.
North America	Canada, the United States.
Other American and Oceanian countries	Mexico, Costa Rica, Cuba, Dominican (REP), Guatemala, Honduras, Nicaragua, Panama, El Salvador, Argentina, Brazil, Chile, Bolivia, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, the Bermuda Islands, Jamaica, South Georgia and islands Sandwich of the South, Guyana, Belize, Greenland, Netherlands Antilles, Porto Rico, Trinidad and Tobago, the Barbados, Grenada, the Bahamas, Surinam, Dominique, Saint Lucia, St Vincent and the Grenadines, Antigua and Barbuda, Saint Christophe and Nieves, Haiti, Anguilla, Caïmanes (islands), Montserrat, Turks and the Caïques (islands), British Virgins (islands), Aruba, Marianne of the North (islands), the Virgins of the United States (islands), Norfolk (island), Niue, Pitcairn (island), American Samoa, Western Samoa, Nauru, Fiji, Tonga, Papua New Guinea, Tuvalu, Salomon (islands), Kiribati, Vanuatu, the Marshall Islands (islands), Palaos (islands), Australia, New Zealand, Christmas (island), CoOK (islands), Tokelau.
Eastern Europe	Belarus, Bulgaria, Czechoslovakia, Czech (REP), Hungary, Moldavia, Poland, Rumania, Russia, Serbia and Montenegro, Ukraine, Albania, Bosnia and Herzegovina, Croatia, Ex République Yougoslave of Macedonia, Montenegro, Estonia, Latvia, Lithuania, Slovakia, Slovenia, Malta.
Other European countries	Denmark, Sweden, Finland, Germany, Austria, Liechtenstein, Greece, Italy, Vatican, Andorra, Belgium, the United Kingdom, Gibraltar, Spain, Netherlands, Ireland, Luxembourg, Monaco, Portugal, Switzerland, German democratic REP, federal Rep of Germany, Iceland, Norway, the Azores, Madeira, Faroes (islands), Indian Ocean (British Territory of), Saint Helena.

Table 2: Distribution (%) by age and gender of the population and number of deaths, per country of birth (years 2004-2007)

	Population					Mortality				
	% by age			% by gender		% by age			% by gender	
Country of birth	5-14	15-64	≥ 65	M	F	5-14	15-64	≥ 65	M	F
Algeria	2.9	71.2	25.8	50.5	49.5	0.0	19.4	80.6	57.7	42.3
Morocco	2.7	85.1	12.2	51.8	48.2	0.1	38.5	61.4	63.7	36.3
Tunisia	1.9	75.8	22.2	54.2	45.8	0.0	21.9	78.1	56.6	43.4
AFFA (1)	6.4	88.8	4.9	49.8	50.2	0.5	62.0	37.5	62.1	37.9
Other African countries	6.7	86.6	6.7	49.1	50.9	0.2	42.6	57.2	56.5	43.5
Turkey	3.9	91.1	5.0	53.6	46.4	0.2	29.9	69.8	54.0	46.0
Central Asia	6.1	85.6	8.3	54.2	45.8	0.4	35.8	63.8	60.3	39.7
ASFA (2)	4.3	79.6	16.1	47.4	52.6	0.1	26.3	73.6	50.9	49.1
Other Asian countries	6.5	89.0	4.5	41.9	58.1	0.2	41.9	57.9	55.5	44.5
North America	14.2	77.0	8.8	45.3	54.7	0.1	23.8	76.1	50.5	49.5
Other American-Oceanian countries	11.6	83.6	4.9	43.5	56.5	0.6	36.3	63.2	47.5	52.5
Eastern Europe	7.1	70.0	22.9	41.8	58.2	0.1	11.4	88.5	42.3	57.7
Other European countries	3.9	68.2	27.9	47.0	53.0	0.0	13.4	86.6	50.2	49.8”
France	14.1	69.3	17.7	48.2	51.8	0.2	19.9	79.9	51.1	48.9

(1) African countries formerly subject to French administration
(2) Asian countries formerly subject to French administration

Table 3: Relative risk of mortality in the foreign-born population, relative to the locally-born population, by gender (years 2004-2007)

	Deaths	RR[1] (95% confidence interval)			
		Males		Females	
Country of birth					
Algeria	*63,398*	0.93*	[0.90; 0.97]	1.04*	[1.01;1.08]
Morocco	*15,231*	0.69*	[0.65; 0.74]	0.84*	[0.77; 0.91]
Tunisia	*14,553*	0.87*	[0.81; 0.94]	1.03	[0.95; 1.11]
AFFA (1)	*7,804*	0.86*	[0.78; 0.95]	1.11*	[1.01; 1.24]
Other African countries	*2,828*	0.77*	[0.65; 0.90]	0.78*	[0.66; 0.93]
Turkey	*3,725*	0.81*	[0.70; 0.94]	1.12	[0.97; 1.30]
Central Asia	*2,491*	0.66*	[0.55; 0.78]	0.85	[0.70; 1.02]
ASFA (2)	*6,401*	0.82*	[0.73; 0.92]	1.02	[0.92; 1.14]
Other Asian countries	*1,579*	0.66*	[0.53; 0.83]	0.78*	[0.70; 1.02]
North America	*1,178*	0.67*	[0.52; 0.88]	0.90	[0.70; 1.15]
Other American-Oceanian countries	*1,784*	0.71*	[0.57; 0.89]	0.86	[0.71; 1.05]
Eastern Europe	*22,141*	1.14*	[1.06; 1.22]	1.17*	[1.11; 1.23]
Other European countries	*108,552*	0.92*	[0.90; 0.95]	1.01	[0.98; 1.04]
All foreign countries	*251,665*	0.90*	[0.84; 0.95]	1.02	[0.97; 1.06]

*: RR is statistically significantly different from 1, at the 5% level;

[1]: Mortality relative risk.

(1) African countries formerly subject to French administration

(2) Asian countries formerly subject to French administration

Table 4: Relative risk of mortality for foreign-born populations relative to the locally-born population by age and gender (years 2004-2007)

		5-14 years			15-64 years			65 years and more		
Country of birth	*Deaths*	Both genders	Males	Females	Both genders	Males	Females	Both genders	Males	Females
Algeria	*63,398*	1.57	1.89*	1.12	0.83*	0.81*	0.88*	1.03	0.98*	1.07*
Morocco	*15,231*	1.89*	2.02*	1.69	0.64*	0.60*	0.73*	0.82	0.76*	0.90*
Tunisia	*14,553*	1.09	1.18	0.93	0.72*	0.69*	0.82*	1.02	0.97*	1.07*
AFFA	*7,804*	2.74*	2.53*	3.02*	0.98	0.86*	1.30*	0.87	0.83*	0.91
Other African countries	*2,828*	1.24	1.09	1.44	0.80*	0.73*	0.99	0.74	0.79*	0.70*
Turkey	*3,725*	2.53*	2.82*	2.08	0.59*	0.59*	0.58*	1.23	1.09*	1.37*
Central Asia	*2,491*	2.32*	2.74*	1.70	0.62*	0.61*	0.66*	0.70	0.69*	0.92
ASFA	*6,401*	1.17	1.75	0.59	0.75*	0.72*	0.81*	0.98	0.88*	1.08*
Other Asian countries	*1,579*	0.64	0.39	0.96	0.60*	0.56*	0.67*	0.80	0.77*	0.85*
North America	*1,178*	0.28	0.48	0.00	0.59*	0.53*	0.70*	0.84	0.75*	0.97
Other American-Oceanian countries	*1,784*	1.37	1.63	1.00	0.64*	0.60*	0.72*	0.88	0.83*	0.93
Eastern Europe	*22,141*	2.36*	3.19*	1.09	1.11*	1.15*	1.04	1.17*	1.14*	1.18*
Other European countries	*108,552*	1.18	0.82	1.67*	0.74*	0.73*	0.74*	1.01	0.98*	1.04*
All foreign countries	*251,665*	1.64*	1.70*	1.56*	0.76*	0.74*	0.83*	1.01	0.96	1.05*

*: RR is statistically significantly different from 1, at the 5% level.

Table 5: Relative risk of mortality for foreign-born populations relative to the locally-born population by cause of death and gender (years 2004-2007)

		Neoplasm			Diabetes			Cardiovascular disease			Cerebrovascular disease			Infectious disease			Violent death		
Country of birth	*Deaths*	Both genders	Males	Females	Both genders	Males	Females	Both genders	Males	Females	Both genders	Males	Females	Both genders	Males	Females	Both genders	Males	Females
Algeria	*44,698*	0.92*	0.91*	0.94*	1.46*	1.39*	1.54*	1.02	0.95*	1.11*	1.05	1.02	1.08*	1.21*	1.17*	1.28*	0.75*	0.72*	0.84*
Morocco	*11,315*	0.74*	0.69*	0.84*	1.08	1.03	1.12	0.75*	0.69*	0.83*	0.81*	0.76*	0.84*	1.00	0.94	1.10	0.60*	0.60*	0.61*
Tunisia	*10,179*	0.88*	0.84*	0.96	1.33*	1.24*	1.42*	0.95	0.84*	1.07	1.05	1.00	1.08	1.28	1.22*	1.37*	0.70*	0.64*	0.81*
AFFA	*5,855*	0.94	0.83*	1.17*	1.28*	1.21	1.33*	0.92	0.85*	0.98	1.49*	1.55*	1.35*	3.44*	2.98*	4.31*	0.57*	0.52*	0.73*
Other African countries	*1,943*	0.70*	0.66*	0.76*	1.16	1.17	1.14	0.74	0.76*	0.71*	0.95	1.14	0.80	2.20*	2.00*	2.47*	0.53*	0.48*	0.62*
Turkey	*2,593*	0.79*	0.75*	0.88	1.46*	1.14	1.85*	1.22	1.11	1.35*	1.12	0.99	1.23	1.09	0.85	1.46	0.65*	0.59*	0.81
Central Asia	*1,751*	0.67*	0.57*	0.89	0.95	0.76	1.24	0.83	0.82*	0.83	0.78	0.70*	0.89	1.11	1.07	1.17	0.50*	0.46*	0.60*
ASFA	*4,517*	0.87	0.79*	1.00	1.18	1.11	1.26*	0.81	0.73*	0.91	1.31*	1.29*	1.33*	1.69*	1.83*	1.51*	0.69*	0.59*	0.89
Other Asian countries	*1,092*	0.68*	0.57*	0.81*	1.15	1.11	1.23	0.62	0.53*	0.79	0.97	1.07	0.87	1.36	1.55*	1.15	0.48*	0.42*	0.67*
North America	*795*	0.74	0.63*	0.91	0.78	0.88	0.68*	0.74	0.65*	0.87	0.69	0.70	0.68	0.80	0.79	0.83	0.73	0.69	0.86
Other American-Oceanian countries	*1,220*	0.72*	0.61*	0.84	0.84	0.86	0.83	0.76	0.72*	0.83	0.85	0.82	0.88	1.61*	1.82*	1.43	0.62*	0.53*	0.82
Eastern European	*14,633*	1.08	1.05	1.10*	1.44*	1.39*	1.47*	1.18*	1.13*	1.21*	1.16*	1.10	1.18*	1.19*	1.34*	1.07	1.08	1.09	1.08
Other European countries	*74,745*	0.93*	0.91*	0.94*	1.12*	0.90*	1.34*	0.97	0.90*	1.03*	1.06	1.03	1.08*	1.01	1.01	1.01	0.87*	0.81*	0.95
All foreign countries	*175,336*	0.90*	0.87*	0.95*	1.24*	1.11*	1.38*	0.97	0.90*	1.05*	1.06	1.02	1.08*	1.21*	1.20*	1.22*	0.77*	0.71*	0.88*

*: RR is statistically significantly different from 1, at the 5% level.