UNDERSTANDING AGE VARIATIONS IN THE MIGRANT MORTALITY ADVANTAGE

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Acknowledgements: Research for this paper was funded in part by a grant from NICHD (R01 R01HD079475). This work is also supported by a public grant overseen by the French National Research Agency (ANR) as part of the « Investissements d'avenir » program (reference : ANR-10-EQPX-17 – Centre d'accès sécurisé aux données – CASD).

INTRODUCTION

In the context of growing international mobility, health and mortality patterns among migrants are playing an increasingly-important role in many receiving countries, with implications for health care, health insurance schemes, and pension systems.[1,2] Increases in proportions of foreign-born individuals in receiving countries also imply that mortality patterns among migrants carry an increasing weight on national mortality levels of host countries, potentially affecting international mortality rankings.

In the literature on mortality among migrants, the most pervasive finding is that migrants tend to exhibit lower mortality than the non-migrant population of their host countries. This phenomenon, termed the Migrant Mortality Advantage (MMA), has been observed in a wide variety of receiving countries, including Australia,[3,4] Belgium,[5,6] Canada,[7,8] France,[9,10] Germany,[11,12] the Netherlands,[13] Switzerland,[14] the UK,[15-17] and the US.[18-23] The MMA has been explained using various hypotheses, including in-migration selection effects ("healthy migrant effect"), return migration selection effects ("salmon bias"), cultural effects, and data artifacts. The relative contribution of each of these hypotheses in various contexts remains highly debated in the literature.

One limitation of this literature is that it largely ignores age variations in the relative risk of mortality among migrants. For the most part, mortality ratios for foreign-born vs. native-born individuals are documented over wide or open-ended age groups[17,24-27]. This lack of age detail is perhaps due in part to the increasing reliance on Cox proportional hazard models which make the assumption that relative risks are constant over age. Poisson regression models that simply control for age (i.e., age-adjusted risk ratios) without age interactions, or comparison of life expectancies, also hide possible age variations in mortality ratios.

As a result of this lack of age detail, conclusions about the existence and scale of the migrant mortality advantage are often made without any reference to age. This gives the distorted impression that relative to the native-born population, migrants exhibit a relative mortality risk that remains constant over age. Likewise, theories and explanations for the MMA are often discussed with little or no reference to age. For example, when discussing the role of migrant selection at entry for explaining the migrant mortality advantage, little or no reference is made to the fact that migrant selection may be vary greatly by age[28,29]. Arguments about data artifacts are also often made as if they operated equally at every age, even though this explanation may not be equally relevant at all ages.[30]

It is important to document age patterns of relative migrant mortality, because such age variation can help uncover the underlying mechanisms generating the MMA. For example, if migrant selection at entry is the main explanation for the migrant mortality advantage and its effects on mortality tapers with duration of stay in the host country, we would expect the migrant mortality advantage to be smaller at the ages where there is little in-migration or at the ages where most migration is the product of family reunification. Rather than testing hypotheses for the migrant mortality advantage in reference to overall levels of relative mortality, it is useful to test such hypotheses in reference to age variations in these relative risks. So far, there has been no attempt in the literature to accomplish this task in a systematic and comprehensive manner.

In this paper, we first examine each of the four main hypotheses that have been proposed in the literature for explaining the migrant mortality advantage: (1) migrant selection at entry; (2) migrant selection at exit; (3) cultural effects; and (4) data quality issues. For each explanation, we discuss whether it should generate an increase, a decrease, or no change in relative mortality over the life course. Whenever possible, these expectations are substantiated by additional data documenting underlying mechanisms for age variation, including information on the age pattern of international in- and out-migration.

We then examine typical age variations in foreign-born vs. native born mortality ratios, using data from France, the US and the UK. Our methodological approach relies on unlinked death information (from vital registration) and exposure information (from censuses), by sex and country of birth, for five-year age groups from ages 5-9 until ages 85+, for periods around 2010. We focus here on unlinked census and death registration data, rather than on linked data sets, because their large sizes allow us to detect age variation of relative migrant mortality by sex and country of origin with a greater level of precision. We calculate mortality ratios by country of origin to examine the extent to which age patterns follow regularities or are highly specific to each country of origin.

Finally, typical age patterns of migrant relative mortality found in France, the US and the UK are examined in light of our theoretical background. We discuss which explanations are most consistent with observed age patterns, and which explanations are not so consistent. We pay particular attention to explanations that are consistent with overall, age-adjusted risk ratios but do not hold once age variations in risk ratios are taken into account.

THEORETICAL BACKGROUND

In this section, we review the different hypotheses that have been proposed to explain the MMA, and examine how they may operate over age. This review focuses specifically on how these hypotheses may impact mortality outcomes at the aggregate level, i.e., how they produce variation over age in observed ratios of foreign-born vs. native-born mortality rates. This means that we need to address both (1) the individual-level effect of age on the mortality risk of foreign-born vs. native-born individuals, and (2) the effect of changes over age in the composition of migrants, resulting from the dynamics of entries and exists in and out of the migrant population over age. Our theoretical background addresses both phenomena.

In-migration selection effects

In-migration selection effects (also referred to as the “healthy migrant effect”) is one of the major explanations for the migrant mortality advantage.[7,11,24,30-35] According to this explanation, individuals who migrate may be more robust, on average, than members of the sending population, and this selection may be strong enough such that migrants end up being also more robust, on average, than members of the receiving population.

When examining how in-migration selection effects may impact age variations in the relative mortality of migrants, two dimensions need to be considered. First, not all migrants are self-selected, and this self-selection is likely to be highly age-specific. Individuals who migrated before age 20, in particular, are likely to have arrived through family reunification and are thus presumably less subject to positive health selection. Second, the direct effect of migrant selection on mortality is likely to be most important shortly after migrating and less important as duration of stay in the host country increases. Indeed, a migrant's level of robustness on the eve of his/her move out of sending country may not be so relevant for predicting his/her mortality in the receiving country 20 or 30 years later.

The combined effect of these two processes on the MMA can be hypothesized to operate as follows. First, the healthy migrant effect should be smaller at younger ages (say, below 20) at which foreign-born individuals are less likely to have been subject to health selection. Second, the healthy migrant effect should initially strengthen with age as large numbers of self-selected individuals arrive to the host country, for study or work. Finally, the effect of health selection should diminish with age as fewer self-selected migrants arrive and the average duration of residence of current migrants increases. As a result, when considering health selection alone, we expect the relative mortality of migrants to follow a U-shape pattern over age.

To illustrate how age-specific in-migration drastically changes the composition of the foreign-born population, we present in Figure 1 data from the 2007 French census showing how, among the foreign-born population, the proportion of recent migrants (arrived in the past 5 years) varies with age. The proportion of recent migrants is initially high (about 40% at ages 5-9), which is expected demographically since these migrants are too young to have spent much time in the host country. This proportion then decreases until 15-19, due to a decrease in arrivals at these ages. However, starting with ages 20-24, the proportion of recent migrants increases again, due to a spike in arrivals around age 20. Migrants who arrive at these young adult ages are likely to be of a different nature than the migrants who arrive as children, so we expect this rapid compositional change around age 20 to have a strong effect on mortality. The proportion of recent migrants then gradually decrease, reflecting a decline in arrivals.

Figure 2 illustrates how duration in the host country varies with age, again using French census data from 2007. As expected, average duration increases with age, but not in a linear fashion, because recent arrivals have a depressing effect on average duration for migrants of a given age. Nonetheless, this figure illustrates how a potential "wearing off" effect might play out for older vs. younger cohorts of migrants.

Return-migration selection effects

This explanation, also referred to as the "salmon bias" hypothesis, postulates that migrants who are in poor health in the host country may be more likely to return to their country of origin than healthier migrants, for reasons ranging from the willingness to seek better family support to the desire to die in one's birthplace.[18,20,30,34-37] As a result of this "unhealthy remigration," the proportion of healthy individuals among migrants who remain in the host country may be greater than expected given the conditions to which they have been exposed, and in turn mortality rates among them may be unexpectedly low. Return migration selection effects can also operate indirectly if migrants who leave the host country are more likely to be selected from categories associated with higher mortality (such as low SES) than comparable migrants who stayed, even if the motivation to return is not directly related to health.

The effect of return migration selection effects on age patterns of the MMA depends on two factors: (1) the age pattern of return migration; (2) variation with age in the strength of negative health selection among return migrants. Information is lacking about the second factor. It could be hypothesized that the willingness to seek better family support may be more relevant among middle-aged migrants who are more likely than older migrants to have retained ties in the country of origin, while the desire to die in one's birthplace may be more relevant at older ages where deaths are more likely to be the result of a degenerative process, allowing return plans to be made in time.

Whatever the variation with age in the strength of selection, the impact of unhealthy remigration on the MMA should occur primarily at the ages where rates of out-migration are large. Here also, little information is available, due to the difficulty of capturing exits in data sources. Nonetheless, data from France, shown in Figure 3, give us an example of how international out-migration may vary by age. This figure shows, among foreign born individuals of a given age in 1990, the proportion who had left the country by 1999 (estimated indirectly using censored cases in 1999). Outmigration is highest around age 25, which is expected given the high proportion of students in this age group, many of whom leave the host country upon completion of their studies. After a gradual decline, out-migration of foreign-born individuals increases at older ages, with a peak around retirement and another increase from age 70 onwards.

Given these age patterns of out-migration, unhealthy remigration (net of other factors) should generate a monotonic decline in the relative mortality of migrants throughout the life course, with accelerated declines at young adult ages and at post-retirement ages. If we further assume that the strength of the selection will be highest at older ages, then the predominant effect should be a gradual decline in the risk ratio starting around 60 when the rate of out-migration starts increasing quickly. Obviously, patterns of out migration may vary by a great amount depending on the host country and country of birth. The salmon bias, if present, should generate steeper declines in risk ratios with age for groups that have large rates of out-migration at older ages vs. groups that have little old-age out-migration.

Cultural effects

The cultural effects explanation for the MMA posits that migrants may have more favorable health behaviors (e.g., smoking, alcohol consumption, and diet) than the non-migrant population due to different norms in their country of origin.[34,38-40] These more favorable health behaviors may generate lower mortality among migrants.[25,35,41,42]

In order to hypothesize about how cultural effects may operate by age, the following mechanisms can be raised. First, cultural factors should have an effect on the migrant mortality advantage primarily at ages for which health behaviors such as smoking, alcohol and consumption are relevant for explaining mortality outcomes. This will largely exclude younger ages, say, below 20. Second, given the expectation that migrants will experience some degree of acculturation, we expect cultural effects to be most relevant among recent migrants, and attenuate over time as duration of residence in the host country increases.

In combination, these different processes can be expected to produce a U-shape pattern on the relative mortality of migrants, similar to what we hypothesized earlier about the healthy migrant effect. At younger ages, cultural effects should generate a decrease with age in the relative mortality of migrants, as health behaviors become increasingly relevant for mortality and the proportion of recent migrants increases following a peak in arrivals in the early 20’s. Cultural effects should then generate an increase with age in the relative mortality of migrants, as new arrivals decrease and the mean duration of residence in the host country increases.

Data artifacts

Data artifacts are often raised as an explanation for the MMA.[5,20,30,34,35] Indeed, the estimation of mortality among the foreign-born population is subject to a number of data problems that are inherent to the very nature of the migrant population: a population that is highly mobile and difficult to capture correctly in data sources.

We focus in this paper on data quality issues that are relevant for mortality estimates based on unlinked deaths and population (exposure) information, and where the origin of foreign-born individuals is based on country of birth information. Classic data problems in this literature, such as matching bias or censoring bias at the individual level, are not directly relevant when examining unlinked data. Numerator/denominator bias, which is a critical problem when using race/ethnicity to determine the origin of migrants, is not so relevant when the origin of migrants is determined on the basis of country of birth information, a basic demographic variable that is less subject to response bias. Therefore our discussion of data artifacts and their impact on the age pattern of the MMA focuses on the following remaining issues: (1) coverage of deaths; (2) coverage of the population; (3) age misreporting in either death or population information. We also focus our discussion on how these issues affect mortality estimates specifically for the foreign-born population. While mortality estimates for the native-born population are certainly not completely accurate, it seems reasonable to assume that age-specific variations in the MMA are not primarily explained by data quality issues among the native-born population.

In theory, age-specific mortality rates and resulting life tables are calculated for the resident ("de jure") population of country. This means that both deaths and exposure terms should pertain to the resident population, regardless of the "de facto" location of these deaths and person-years lived. In practice, however, counts of deaths used for numerators of death rates typically include deaths of non-residents occurring within the boundaries of a country and exclude deaths of residents occurring outside these boundaries.[43] While this may not generate important errors for the native-born population, this is potentially problematic for the foreign-born population, because this population is by nature a more internationally mobile population. Foreign-born residents of a country are more likely to spend a certain amount of time abroad, which increases the likelihood that their death will occur abroad and be missing from the numerator of mortality rates. (Deaths that occur abroad following a change of residence do not pose a data quality challenge per se since they are not supposed to be included in numerators of rates. However they may affect mortality rates via selection effects – see section above on selective return migration.)

Exposure terms for mortality rates, which typically come from census population counts, follow more accurately the “de jure” concept and will thus accurately exclude foreign-born non-residents. Foreign-born residents travelling abroad during the time of the census will still be accurately included in the denominator of rates if some household members are present in the country of residence at the time of census. This contrasts with death of residents occurring abroad which will be systematically excluded from numerators, regardless of the presence of household members in the country of residence.

This exclusion of all deaths occurring abroad from the numerator of mortality rates implies that an important factor for understanding the impact of data artifacts on the MMA is the amount of time spent abroad among the foreign-born resident population and how it may vary by age. Detailed quantitative information about how foreign-born residents divide their time between their host country and their country of birth is lacking. However, it could be hypothesized that as they age, foreign-born residents spend less time in their country of birth due to stronger family ties in the host country, loosened family ties in the country of origin, as well as declining health which makes back-and-forth travel more difficult. On the other hand, retirement opens up new opportunities for spending time in the country of origin, and some migrants may decide to spend a large part of their time in their country of birth (or another country) while still being counted in their host country as a regular resident. Keeping official residence in the host country while spending large periods of time abroad may also be advantageous, since in certain host countries benefits such as pensions and health care depend in part on maintaining residence.

If the dominant age pattern is one in which the amount of time actually spent abroad diminishes with age, we expect to observe an artifactual increase with age in the relative mortality risk of migrants. If, however, the amount of time spent abroad increases with age, this would produce a decrease in relative mortality with age.

For similar reasons, the coverage of the resident foreign-born population may also vary with age. Migrants who spend large amounts of time abroad are likely to be undercounted, especially if they are alone or travel with their household members. Undocumented migrants are also more likely to be undercounted in censuses. Overall, one might expect coverage of the foreign-born population to increase with age, as migrants secure their residence status and their mobility decreases with age. On the other hand, coverage may also decrease after retirement for those who spend increasing amounts of time abroad.

The net effect of these errors on age patterns of the MMA is difficult to assess without more information on the processes discussed above. Nonetheless international mobility is likely to affect death coverage more than population coverage, because as said earlier deaths occurring abroad are systematically excluded, while foreign-born residents travelling abroad may still be included in censuses. It can thus be hypothesized that groups with increased transnationality at older ages will exhibit a decline in their mortality ratio, while groups with decreased transnationality will experience an increase in their mortality ratio.

Age misreporting is another factor potentially affecting the relative risk of migrants and its age pattern. Migrants from less-developed countries often lack reliable documentation about their date of birth by the time of arrival in the host country. Older migrants may be particularly affected. While age misreporting can go in different directions, there is a large literature showing that overstatement of age may be more common than understatement. As a result, we expect age misreporting to generate a decrease with age in the relative mortality risk of migrants, particularly at older ages.

Summary of explanations and their effect on age patterns of the MMA

Processes generating a mortality advantage among migrants are complex and work in various directions over the life course. Nonetheless, some general conclusions can be drawn from the above discussion. We expect the healthy migrant effect and cultural effects to both generate a U-shape pattern on the relative mortality risk of migrants. "Unhealthy remigration," on the other hand, is expected to produce a decline in the relative risk of migrants over the life course, particularly at older ages. Data artifacts are likely to produce a decrease with age in the relative mortality of migrants among groups for whom retirement coincides with increased time spent in the country of origin, while they are likely to produce an increase with age among groups for whom ties with the country of origin loosen over age.

DATA AND METHODS

This paper relies on unlinked deaths and exposure information by age, sex and country of birth, in France, the UK and the US. In all three countries, exposure information is based on "de jure" census counts, while death information is based on "de facto" vital registration data, following common practice in mortality estimation.[43] As discussed earlier, this discrepancy may be inconsequential when examining mortality patterns for national populations, but it may cause important distortions when examining specific migrant groups.

For France, we combined death information for the period 2005-2009 with January 1 census estimates for 2006-2009. For the UK, we combined death information for the period 2010-11 with census information for 2011. For the US, we combined death information for 2008-2010 with exposure information derived from the American Community Survey (ACS) for the same period. In France and the UK, country-of-birth information was available by single country in both census and death information. In the US, however, country-of-birth information on death certificates was available only for the following countries of birth: Canada, Cuba, Mexico, and all other countries combined.

Combining death and exposure information, we calculated age-specific death rates (${}_{n}M_{x}$) by country of birth and sex. We then calculated age-specific mortality ratios for each migrant group by dividing the age-specific mortality rate for a given migrant group by the corresponding age-specific mortality rate for natives: $\frac{{}_{n}M_{x}^{Country\ of\ birth\ i}}{{}_{n}M_{x}^{Natives}}$. Mortality ratios were calculated for each 5-year age group, from 5-9 until 85+. (The age group 0-4 was excluded due to the small number of foreign-born individuals in that age group.) Confidence intervals were calculated using a Poisson model.

We also calculated age-adjusted risk ratios for various migrant groups using Poisson regression models with age controls. Such age-adjusted risk ratios make the implicit assumption that the relative risk is constant over age, similar to the “proportional hazard” assumption of a Cox regression model. Confidence intervals for these age-adjusted risk ratios were derived from the corresponding Poisson model.

RESULTS

Figure 4 shows age-specific mortality ratios for foreign-born vs. native born individuals in France, the UK and the US, by sex. The red curve shows age-specific risk ratios for all foreign-born individuals combined, with 95% confidence intervals. The red flat line shows the age-adjusted risk ratio for the foreign-born, here also with confidence intervals. The gray lines show age-specific risk ratios by individual country of origin (for the 20 most important countries of origin in terms of size of the migrant population in France and the UK).

These results confirm that for almost all country*sex combinations, there is a substantial amount of mortality advantage, summarized by an age-adjusted risk ratio that is less than one. (The only exception is foreign-born females in France, for whom the risk ratio is close to 1.) These age-adjusted risk ratios, however, hide a huge amount of age-specific variation, including ages at which there is actually excess mortality, and ages at which the advantage is far greater than what would be indicated by the age-adjusted risk ratio. Figure 4 also shows that in spite of a great amount of variability by country of origin, a systematic U-shape pattern appears in each country and for each sex when combining all foreign-born groups. Although not always statistically significant, the risk ratio starts above one, followed by a steep decline in the ratio until a minimum somewhere around age 45. Although the minimum value of the age-specific ratio varies in each host country, these values are sometimes in the neighborhood of .5, showing an advantage at these mid-adult ages that is far greater than typically documented in this literature. After reaching this minimum, the risk ratio increases towards one, and sometimes even goes above one like in the case of foreign-born females in France. This consistency is striking given the variety of situations among these three host countries in terms of origin of migrants, type of migration, and conditions in the host country. To our knowledge, this consistency has not been previously documented.

Obviously, this overall age pattern hides of great amount of heterogeneity by country of origin, as indicated by the gray lines in the background for Figure 4. Nonetheless, when focusing on individual countries, important regularities emerge. In Figure 5, we present individual countries with an age pattern of relative migrant mortality that is similar to what is observed for all migrants combined. Large countries of origin are represented in this figure, which is expected given the weight that these countries play in the overall pattern presented in in Figure 4. In France, migrants groups that follow this general pattern are males born in Algeria, Italy, Spain, Tunisia, Turkey and the UK, and females born in Italy, Portugal, Switzerland and the UK. In England & Wales, males born in India, Pakistan, France, Italy, South Africa, Sri Lanka, and females born in India, USA, China, Spain, Poland, Sri Lanka follow this pattern. In the US, all migrant groups for whom we have information except individuals born in Mexico present a general U-shape pattern. A detailed analysis of each country is beyond the scope of this paper, but it is quite remarkable that this age pattern apply to such diverse groups of migrants.

Figure 6 shows a number of individual migrant populations for whom the pattern of relative mortality deviates substantially from the general pattern presented in Figures 4 & 5. Specifically, these migrant populations experience a steep decline in their risk ratio at older ages, starting around age 60. In France, we find such patterns among males born in Morocco, Senegal, Mali and Ivory Coast, and females born in Morocco, Mali, Madagascar, Laos and Vietnam. In the UK, this pattern appears clearly among males born in Bangladesh, Nigeria and Zimbabwe, and females born in Bangladesh, Iraq and Pakistan. In the US, this pattern is visible among Mexican-born males, and, to a lesser extent, among Mexican-born females.

Note that there is also a number of migrant groups in France and the UK not shown in Figures 5 & 6 which exhibit a rather large amount of random variation around 1 in their mortality ratio due to their small population size, and for whom the specific shape of the age pattern is thus not well defined. It is interesting, nonetheless, that when merging migrant populations by region of origin, an overall U-shape pattern quickly emerges (results not shown). One exception are migrant groups from Eastern Europe which present excess mortality throughout the life course, especially at adult ages. These unusual groups obviously do not follow the general patterns shown in Figure 5 & 6.

DISCUSSION

This paper shows that far from being constant over age, relative migrant mortality presents large age variations that are often ignored in the migrant mortality literature. This age variation presents some striking similarities across heterogeneous migrant groups and host countries. The age pattern that is most systematic is a U-shape pattern, with a minimum reached among migrants aged 45. This systematicity suggests that similar, general mechanisms are at play for explaining the relative mortality of migrants across a variety of contexts.

Among the various explanations discussed earlier in the paper, the explanation that is most consistent with the observed patterns is the "healthy migrant effect" explanation. Indeed, the steep initial decline with age in the risk ratio (sometimes starting from a situation of excess mortality) corresponds to a transition from children who presumably arrive with their parents and may not be subject to strong selection forces, to young adults who arrive in large numbers starting at age 20 and profoundly modify the composition of the foreign-born population. As such, this decline reflects a compositional change of the migrant population rather than genuine age effects. The increase with age in the risk ratio after age 45 is consistent with a "wearing off" of the healthy migrant effect as mean duration of residence in the host country increases, unmitigated by new arrivals which become negligible after age 45.

This U-shape pattern could also be explained by acculturation and the progressive adoption of Western lifestyles, given that this mechanism is expected to produce a similar, U-shape pattern. Without additional information, it is difficult to tell which of these two explanations is most relevant. However, it is remarkable that the U-shape pattern is prevalent among migrant groups as diverse as Canadian-born vs. Mexican-born migrants in the US, or Tunisian-born vs. UK-born individuals in France, i.e., countries of origin which are probably just as different with one another in terms of health behaviors as they are with the host country. This suggests that the "healthy migrant effect" may be a more powerful force for explaining the patterns presented in this paper.

For countries that experience a decline in the risk ratio at older ages, it is difficult to tell if this is explained by the salmon bias effect, or data artifacts such as low coverage of resident deaths occurring abroad and age overstatement. Given the steepness of some of these declines, age overstatement seems unlikely an explanation, because we would expect age overstatement to have perhaps a smaller and more gradual impact. We are left with two explanations, i.e., low coverage of resident deaths occurring abroad and selective return migration. Without further information, the relative role of these explanations cannot be ascertained with certainty, but the steepness of the declines perhaps suggest a data quality issue with individuals declared in the census as "resident" by themselves or family members, but who as they age are in fact spending an increasing large portion of their time in their country of birth.

Overall, the "salmon bias" explanation is poorly supported by the patterns presented in this paper. For most countries, the risk ratio increases with age after age 45 or so, which is not consistent with what we would expect if the salmon bias was a dominant mechanism. Unhealthy remigration, if occurring, seems to be dwarfed by other processes such as wearing off of the healthy migrant effect or negative acculturation.

One limitation of this study is that while the mechanisms that we observe operate over the life course, age profiles of relative migrant mortality are examined in a cross-section. It is possible that earlier cohorts of migrants faced different conditions, explaining their higher relative mortality today, as they reach old ages, than later cohorts of migrants whom we observe at younger ages today. Nonetheless, the pervasiveness of the U-shape pattern across different migrant groups in different host countries suggests that cohort effects are not playing a dominant role. Cohort effects, if present, would be expected to vary greatly by migrant group and host country.

One issue to keep in mind when seeing risk ratios moving closer to one at older ages is that in the differential mortality literature, large differentials measured in relative terms are rarer at ages when mortality is high than when mortality is low. SES differentials in mortality, for example, tend to be lower at older ages than at younger ages. (The reverse would be true if mortality differentials where measured in absolute terms.) This make the decreases in relative mortality prior to age 45 all the more significant, because these decreases occur at ages where mortality rates are increasing with age. This also make the declines in risk ratios at older ages (Figure 6) particularly significant. For these countries, the mortality advantage increases both in relative and in absolute terms.

Overall, this paper shows the importance of documenting age variations in the relative mortality of migrants. Examining age-standardized or age-adjusted measures hides the scale of the advantage, which at mid-adult ages appears to be much larger than typically documented. It also hides a rather common pattern of excess mortality at younger ages, which is not apparent when all ages are combined. Finally, examining age patterns helps assess underlying explanations for the migrant mortality advantage. While an explanation may be consistent with an "average" advantage across ages, it may not resist the examination of age patterns. For example, the “salmon bias” hypothesis is expected to generate an overall mortality advantage, which is indeed observed for most countries, but it is also expected to produce a decrease in the risk ratio at older ages, which is not observed in most countries. On the other hand, the “healthy migrant effect” hypothesis gains support when examining age variations in risk ratios as opposed to age-adjusted risk ratios.

Lastly, this study suggests that individual-level analyses of the impact of duration of stay on mortality outcomes should probably exclude migrants who arrived, say, prior to age 20. As we show, these migrants experience excess mortality already when they are young, an excess which they are likely to retain throughout their life time. These migrants, when older, will carry with them long durations of stay and will play a large role in observed relationships between duration of stay and mortality. For them, however, a lack of positive selection may be a more important a mechanisms than duration effects per se.

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Figure 1: Proportion of newcomers (arrived in the past 5 years) among foreign−born, by age and sex, France, 2007 census

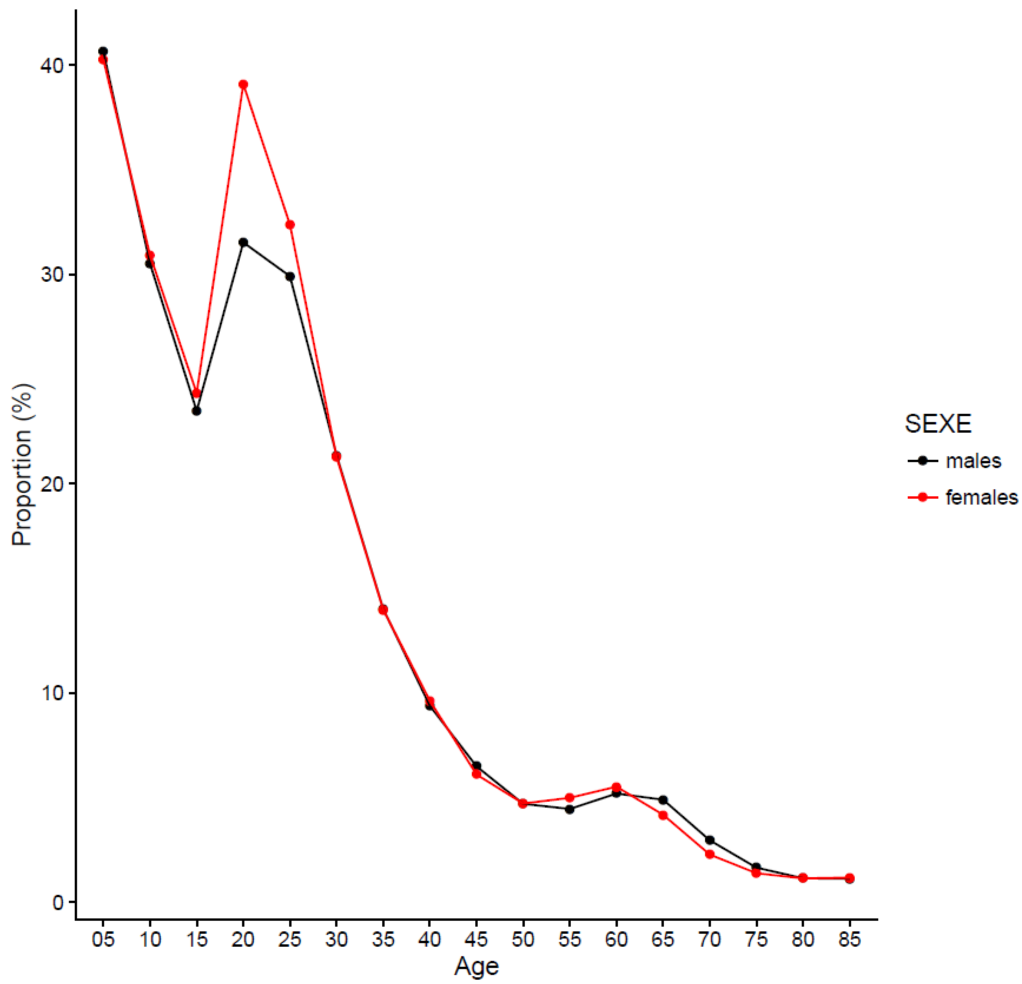

Figure 2: Median duration of stay among the foreign-born, by age and sex, France, 2007

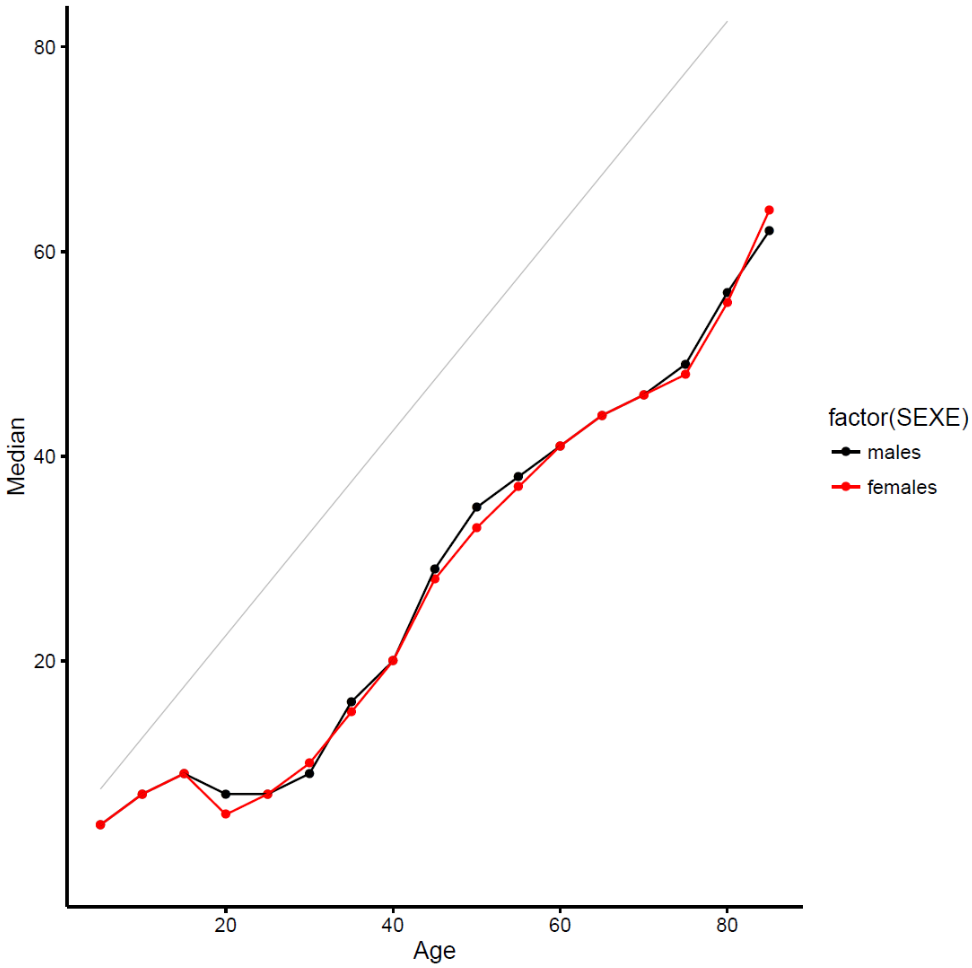

Figure 3: Proportion of individuals in 1990 who have left the country by 1999, by age in 1990, France, foreign-born individuals.

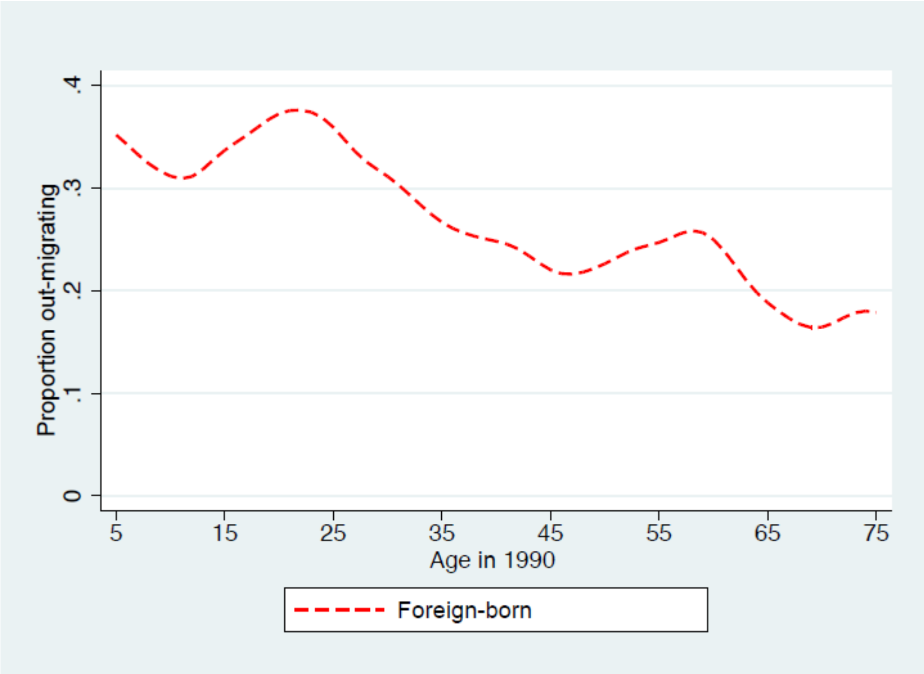

Figure 4: Age-specific mortality ratios (Foreign-born vs Native-Born) in France (2005-09), the UK (2010-11) and the US (2008-10), by sex

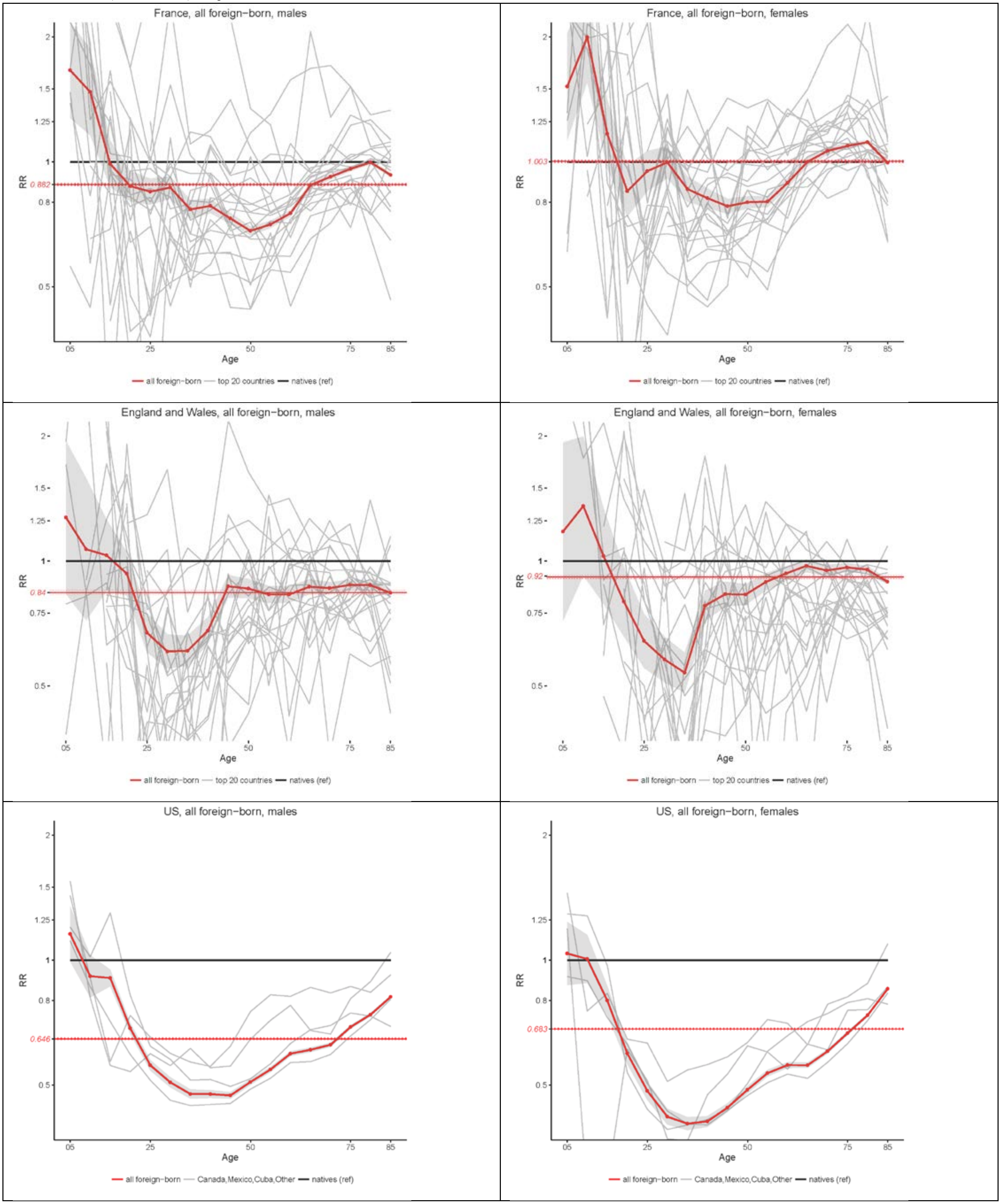

Figure 5: Age-specific mortality ratios (Foreign-born vs Native-Born) in France (2005-09), the UK (2010-11) and the US (2008-10), by sex, for countries of origin with general U-shape pattern

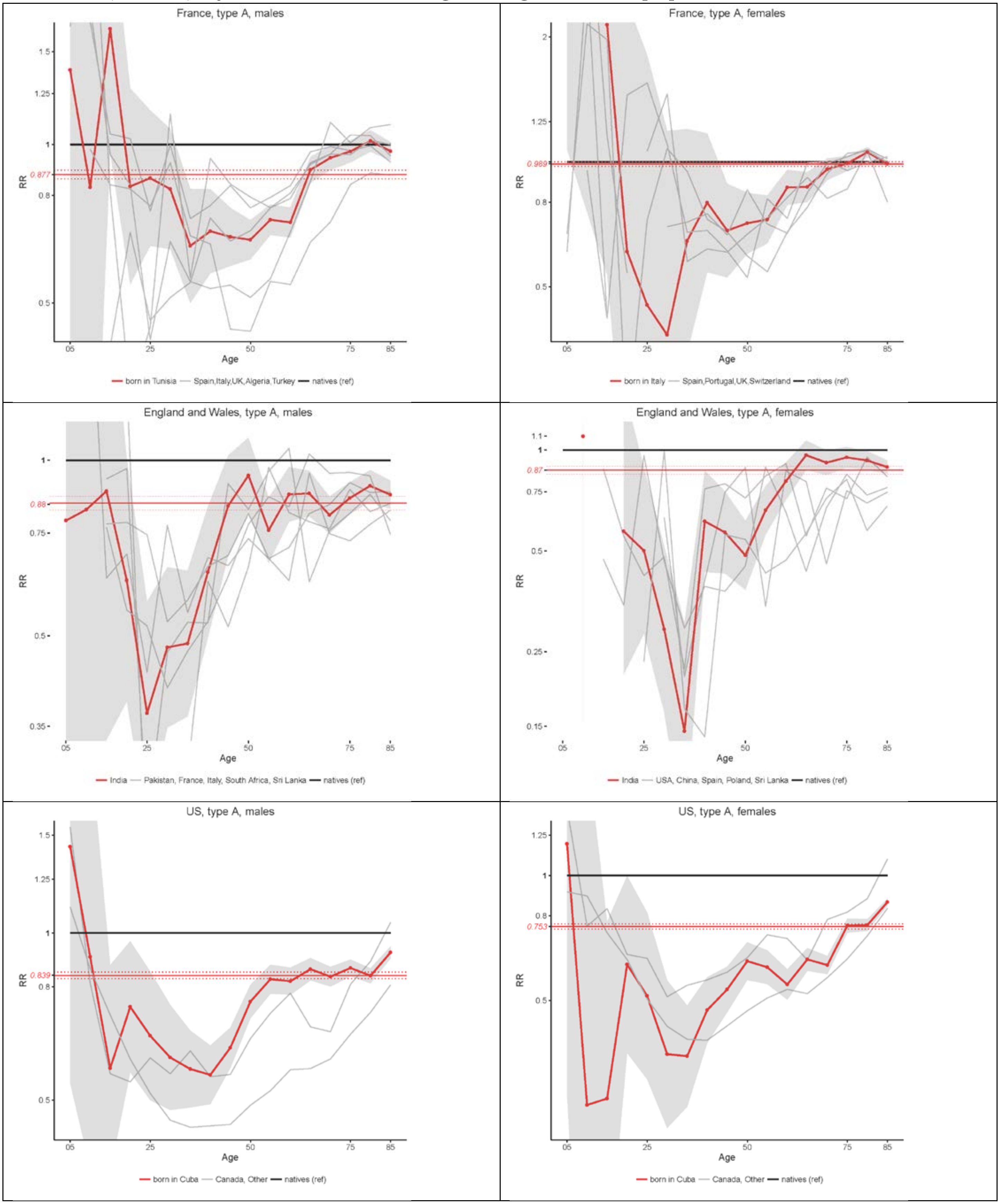

Figure 6: Age-specific mortality ratios (Foreign-born vs Native-Born) in France (2005-09), the UK (2010-11) and the US (2008-10), by sex, for countries of origin with a decline in relative mortality at older ages.