Low immigrant mortality in England and Wales: a data artefact?

Matthew Wallace and Hill Kulu*

School of Environmental Sciences, University of Liverpool, Roxby Building,

Liverpool, L69 7ZT, United Kingdom

** Corresponding author. E-mail: m.wallace@liverpool.ac.uk*

Abstract

Previous research shows low mortality for most immigrants compared to natives in host countries. This advantage is often attributed to health selection processes in migration and to protective health behaviours. Little research has examined the role of data quality, especially the registration of moves. Registration errors relating to moves between origin and host countries can mismatch deaths and risk populations, leading to denominator bias and under-estimation of migrant mortality (data artefact). The paper investigates the mortality of immigrants in England and Wales from 1971-2001 using the Office for National Statistics Longitudinal Study (ONS LS), a 1% sample of the population of England and Wales. We apply parametric survival models to study the mortality of 450,000 individuals. We conduct sensitivity analysis to assess the impact of entry and exit uncertainty on immigrant mortality rates. The analysis shows that most international migrants have lower mortality than natives in England and Wales. Differences largely persist when we adjust models to entry and exit uncertainty and they become pronounced once we control for individual socioeconomic characteristics. This study supports low mortality among immigrants and shows that results are not a data artefact.

Keywords: mortality, immigrants, survival analysis, data artefact, England and Wales

Introduction

Low mortality rates for immigrants compared to natives in host countries has been found in New Zealand (Hajat et al., 2010), the U.S. (Abraido-Lanza et al., 1999; Palloni and Arias, 2004), Canada (McDonald and Kennedy, 2004), Germany (Razum et al., 1998; Ronellenfitsch et al., 2006), Belgium (Anson, 2004) and France (Wanner et al., 1994; Khlat and Courbage, 1996). However, intra-study findings can be heterogeneous and some Scandinavian studies have reported *high* relative immigrant mortality levels (Sundquist and Johansson, 1997; Sundquist and Li, 2006). This questions the low mortality among immigrants in host countries. Registration errors relating to moves between the origin and host country can mismatch deaths and risk populations, causing numerator and denominator error. This can create unintentional patterns within the data which artificially lower immigrant mortality.

The aims of this study are to investigate mortality of immigrants in England and Wales and to determine whether mortality patterns are a data artefact. We conduct sensitivity analysis to examine the influence of immigration and emigration date uncertainty on mortality rates of immigrants. To our knowledge, this is the first United Kingdom study to address entry uncertainty (a delayed immigration date) and exit uncertainty (failure to register an exit), and factor temporary exits from, and returns to the host country into analysis. Registration issues are intrinsic to register data; uncertainty control will allow us to determine whether low immigrant mortality is an artefact or an actuality, better explained by selection and health behaviours processes.

Background

Data artefact

Data artefact encompasses a broad range of potential error sources. These include the misreporting of age, misclassification of nationality or ethnicity, and registration errors relating to moves between the origin and host country which mismatch deaths and populations at risk and cause numerator and denominator error (Deboosere and Gadeyne, 2005). If emigrations are under-registered and deaths are undercounted (Kibele et al., 2008), the risk population is overestimated and immigrant mortality rates are depressed (Kibele et al., 2008). Immigrants may simply forget to register an exit or they may have an incentive to remain on host population registries (Weitoft et al., 1999). Those who remain on the host registry can become "statistically immortal" if they die elsewhere, as they continue to 'age' in the host country's official statistics (Kibele et al., 2008).

Evidence of the impact of registration errors on results varies. Studies by Kibele et al. (2008) and Kohls (2010), both reveal mortality underestimation in Germany; however, a counter study uses a German panel study (which avoids denominator bias) to demonstrate a similar mortality advantage to that found in German register studies (Razum et al., 2000). Lower immigrant mortality in Sweden is largely explained by denominator bias – though advantages persist for some groups (Weitoft et al., 1999). Howbeit, correction for substantial under-registration of Moroccans in France could not account for their relative high life expectancy. Further, a mortality advantage among the Portuguese in France persisted after controlling for registration bias and correction for undocumented emigration and late registration in Belgium was insignificant (Anson, 2004).

Return migration hypotheses are linked to registration issues (Deboosere and Gadeyne, 2005) and contribute to numerator and denominator error (Abraido-Lanza et al., 1999). The first, Salmon bias proposes that deteriorating health triggers return migration. This causes numerator bias as deaths among returnees are omitted from the numerator (Turra and Elo, 2008), denominator bias as individuals continue to age in host country databases if the departure is not registered and increasing health selectivity of the remaining host migrant sample. Partial evidence has been found for Mexicans in the U.S. (Palloni and Arias, 2004); a number of other studies support its existence but question its impact on mortality rates (Franzini et al., 2001; Turra and Elo, 2008; Arias et al., 2010). Salmon bias cannot explain lower mortality among Cubans and Puerto Ricans in the U.S. (Abraido-Lanza et al., 1999) or Turks in Germany (Razum et al., 1998).

The second, 'mobility bias' suggests that migrants may frequently return to their origin country for short or long periods (independent of health status) given the geographic proximity of many host and origin countries e.g. Southern Europe and North Africa to Germany and France (Khlat and Darmon, 2003). If these departures are unregistered, individuals will continue to contribute risk time even though they are not permanently resident in the host country. The third, the unhealthy remigration hypothesis is the return of immigrants who do not cope well economically or socially – these individuals may be prone to a future high mortality risk (Razum et al., 1998; Khlat and Darmon, 2003). The calculation implications are inflation of the denominator base and undercount of death at older ages.

Additionally, there may be problems with overstating of age, particularly at advanced ages (Palloni and Arias, 2004). It has been demonstrated that some populations aged 55+ in Latin America and some Hispanics in the US overstate their age (Dechter and Preston, 1991; Rosenwaike, 1991). This can depress mortality rates and affect the age distribution of deaths (Palloni and Arias, 2004). Misclassification of ethnicity on death certificates may also occur. In the US, this led to recommendations that Hispanic death rates be interpreted cautiously (Markides and Eschbach, 2005). An earlier study reported a 7% under-ascertainment of ethnicity on death certificates compared with self-classification (Rosenberg et al., 1999). This 7% correction was applied to demonstrate the persistence of low relative Hispanic mortality (Elo et al., 2004). In sum, data error may artificially lower migrant mortality but low mortality can persist after correction.

Selection

Beyond data artefact, selection theory posits the formation of a unique population with good health and low mortality. The selective effect is so strong that the health and mortality of the group is better than both origin and host populations, regardless of socioeconomic background (Deboosere and Gadeyne, 2005). Selection begins before migration and effects follow individuals to the host country (Franzini et al., 2001). This selection may encompass the ability to overcome the physical and psychological challenges of immigration (Gushulak, 2007) and selection for personality traits such as courage (Schiffauer, 1991), ambition, motivation (Uitenbroek and Verhoeff, 2002), social adeptness (Razum et al., 1998) and risk-taking (Lindstrom and Ramirez, 2010). Immigration into a new society is incompatible with health problems (Razum et al., 1998) and only those adequately healthy and capable of overcoming the difficulties of migration will succeed (Qi and Niu, 2013).

Links between health and wealth are apparent. The healthy and wealthy are able to migrate because they have the physical ability and financial resources to do so (Chiquiar and Hanson, 2002; McDonald and Kennedy, 2004). Yet, immigrants can have low mortality despite poor socioeconomic profiles (Razum and Twardella, 2002). This is known as the Hispanic Mortality Paradox (Abraido-Lanza et al., 1999). A low socioeconomic status is linked with poor health and adverse mortality outcomes; so it is paradoxical that Hispanics could have lower mortality than natives who have a better socioeconomic status (Palloni and Arias, 2004) – but low mortality among Hispanics is evident (Wei et al., 1996; Abraido-Lanza et al., 1999 and 2005; Palloni and Arias, 2004; Turra and Elo, 2008). This paradox has been observed for Mediterranean migrants in Germany (Razum et al., 1998), France (Khlat and Courbage, 1996), and Belgium (Anson, 2004).

Health Behaviour

The health behaviour hypothesis proposes that migrants have more favourable health behaviours which result in a relative health and mortality advantage to natives (Scribner, 1996). Evidence finds the practice of both positive and negative behaviours. In their respective studies, nutritional habits are more favourable among Moroccans in France (Khlat and Courbage, 1996), Turks in Germany (Bilgin et al., 1994; Razum et al., 1998) and Greeks in Australia (Powles, 1990) but all have comparable tobacco consumption to natives. Male and female Latinos are likely to drink less and (women) smoke less, but migrants are less likely to use preventative services (Abraido-Lanza et al., 1999). Health behaviours can be gender-specific. Smoking prevalence in Moroccan, Turkish and Chinese males is higher than in females (Uitewaal et al., 2004; Li, 2011). Mexican, Cuban and Puerto Rican men are more than twice as likely to consume alcohol as women (Marks et al., 1990).

Despite this heterogeneity in health behaviours, the practice of certain positive behaviours may offset negative effects from less favourable habits (Powles, 1990). For example, while tobacco consumption among Moroccans is comparable to French natives, low alcohol consumption may provide some protection from lung cancer (Bandera et al., 2001 in Khlat and Darmon, 2003). Further, the impact of continuing high rates of cigarette smoking, obesity, diabetes and sedentary lifestyles among Greeks in Australia is offset by the protective effects of the Mediterranean diet (Powles, 1990) – the group continues to display lower overall mortality and CVD mortality than Australians (Kouris-Blazos, 2002).

Health behaviours closely link with acculturation theory – the deterioration of health over time through the adoption of native behaviours (Abraido-Lanza et al., 2005). Evidence indicates that health behaviours worsen with acculturation (Scribner, 1996). At the point of migration a cultural buffer exists which differentiates migrants and natives; as migrants spend time in the host country, the buffer disappears (Jasso et al., 2004). In a comprehensive review of U.S acculturation literature, Lara et al. (2005) claim that although not absolute, evidence points towards a negative effect of acculturation on health (substance abuse and diet) among Latinos in the US; though healthcare access improved.

Mortality of migrants in the United Kingdom

Previous research in the UK is less conclusive. Low mortality has been found among Polish, Italian, South Asian, Vietnamese, Chinese and Caribbean migrants (Marmot et al., 1983; Swerdlow, 1991; Scott and Timaeus, 2013). Other studies have supported low mortality among young immigrants but high mortality for older immigrants (Wild et al. 2007). Extensive variation cause-specific mortality by country of birth has also been observed (Wild et al., 2006; 2007). High mortality among the Irish (Wild et al., 2007) persists into the second and third generations (Harding and Balajaran, 1996; Harding and Balajaran, 2001); mortality is also relatively high among Scots (Wild et al., 2007). Proxy studies (using limiting long-term illness) also show variation with low mortality among the Chinese only (Rees et al., 2009) and low mortality for Scots compared to the origin country but not host (Wallace and Kulu, 2013).

Given findings from current literature, the low mortality of immigrants in host countries may be a data artefact, the result of an inflated denominator base and an undercount of deaths. Simultaneously, low immigrant mortality may be an actuality, explained by a combination of selection and the continued practice of protective health behaviours. Howbeit, it is rare for studies on data artefact to find that registration error accounts wholly for the differential mortality of migrants and natives. Our hypotheses are therefore as follows:

First, we expect international migrants to have lower mortality levels than natives in England and Wales.

Second, we expect controlling for registration error to reduce mortality differences between immigrants and natives; though we anticipate differences will persist after control.

Third, we expect mortality advantages for immigrants (if any) to become more pronounced once we have controlled for socioeconomic characteristics of individuals.

Methods

The Office for National Statistics Longitudinal Study (ONS LS)

The Office for National Statistics Longitudinal Study is a record linkage study that links anonymised Census and vital event data for a one percent sample of England and Wales. The ONS LS sample was originally drawn from the 1971 Census by taking all individuals born on one of four selected dates. The same dates were used to supplement the sample (by approx. 500, 000 individuals) in 1981, 1991 and 2001. More than half a million study members have been identified at each Census and the study now includes information on more than one million different individuals (Goldring and Newman, 2010).

Information from Censuses has been linked with information on entry events (births and entries) and exit events (deaths and exits) from the National Health Service Central Register (NHSCR). The NHSCR compiles and maintains a record of NHS patients (those registered with a doctor in England and Wales). The database is routinely updated with information on births, deaths and migrations. The data is attractive because of its size, length and ability to allow users to separate age, period and cohort effects in analysis (Goldring and Newman, 2010). The ONS LS over-samples immigrants and under-samples emigrants (Hattersley, 1999).

Entry into the ONS LS

Entry into the ONS LS is recorded when an immigrant registers with a doctor and joins the NHS or when an individual completes a census form. A healthy individual may not register with a doctor until their services are required. Although the date of entry into a country is asked for on the doctor's application list, it is not cross-checked against other sources and can be inaccurate (Hattersley, 1999). The ONS LS may also miss those who have private healthcare, short-term immigrants who emigrate after at least one year who have not registered with a doctor during their stay, and European workers whose country of origin have a reciprocal arrangement with the National Health Service (Hattersley, 1999).

Exit from the ONS LS

Exit from the ONS LS can occur one of two ways; through death or embarkation. Death certificates are a legal requirement and virtually all deaths occurring in England and Wales are registered.

However, the NHSCR will only register an exit if they are notified by the Department for Social Security (DSS) that an individual paying National Insurance is known to be leaving the country for over three months. This also has to be confirmed by the Health Authority. These notifications may only be received up to ten years after the event has taken place and those who go abroad for a short period may not inform the DSS at all (Hattersley, 1999). This method of notification is supplemented by medical card returns to doctors and immigration officials at airports. This is not a legal requirement (Hattersley, 1999). Approximately 8, 500 individuals embarked from the ONS LS between 1971 and 2001.

If individuals meet neither of these criteria and are not enumerated at census they are lost to follow-up. We assume that these individuals are unrecorded embarkations from England and Wales though individuals can also be lost when incorrect information is recorded. Others are lost if they are not counted at every census. Ultimately, we cannot provide conclusive answers as to how specific individuals are lost to follow-up (Blackwell et al, 2003). Those who are lost to follow-up are more likely to be young and male, born outside of the UK and belong to an ethnic minority (ONS, 2013). They account for 12% of the dataset. While it is not possible to pinpoint an exact exit date, we can identify a decade of exit based upon final appearance at census and non-appearance thereafter e.g. enumeration in 1981 and non-enumeration in 1991 and 2001 censuses suggests an exit between 1981 and 1990.

Temporary exits and re-entries in the ONS LS

The ONS LS also records temporary exits and returns. For these events, there are two types of residence trajectory. Those with consistent cases where individuals can be continually resident (there are no recorded exits or re-entries) and non-continually resident (there are chronological exits and re-entries) and inconsistent cases where there is a missing value or unchronological sequence (Robards et al., 2011). Those with consistent, continually resident cases are 'at risk' of death until they experience the final event or are right-censored. Sample members with consistent, non-continually resident cases have both at risk and out of risk periods. These are taken into account to ensure out of risk periods do not inflate the denominator. (Please refer to diagrams of residence trajectories in Robards et al., 2011).

Individuals with inconsistent cases have either (i) an unchronological event sequence e.g. an exit date is later than its partnered re-entry date or (ii) information is missing. Those with an unchronological event sequence are dropped. If a case is inconsistent because of a missing value, we impute a value of the partnered event – 12 months. This is conditional upon the timing of any event before the missing value being at least 13 months so as not to create further inconsistency. We do this because immigrants are more likely to record exits and re-entries and we do not want to reduce our sample size. We drop 700 individuals and impute values for 6,000. Nearly all missing values occur where there is a value for re-entry 1 but not exit 1.

Modelling exit and entry uncertainty in the ONS LS

Given the uncertainty around defining the correct denominators required for calculating accurate immigrant mortality rates, we implement the following scenarios to assess the impact of denominator bias. Under exit control we project three scenarios based on the empirical distribution of known exits from the dataset (approximately 9, 000 individuals see Table 1). Exits of known individuals are measured as number of years after final census appearance. We take the median, and upper and lower quartiles to define our scenarios. Exit scenario A projects an early exit (2-years after census), scenario B a middle exit (4-years) and scenario C a late exit (7-years). We allow intercensal entries for immigrants.

Under entry control we do not allow intercensal entry and limit onset of risk to first census appearance. We project the middle exit scenario for those lost to follow-up. While adjusting entry provides a high certainty of presence, it reduces risk time and leads to mortality overestimation, particularly when there are few (if any) deaths between intercensal entry and first census appearance. Most immigrants experience a delay in registration, suggesting that risk time has already been reduced. In the conservative model we limit entry to first census appearance and project an early exit scenario of two years after census.

Figure 1 presents these scenarios. Unadjusted, the immigrant enters in 1985 and last appears at the 1991 census (the immigrant is then lost to follow-up), contributing a risk period of 6-years to the denominator. Under the three exit scenarios we project exit dates of 1993 (2-years), 1995 (4-years) and 1998 (7-years) for the immigrant. This contributes risk periods of 8, 10 and 13-years respectively. Under entry control, we limit the immigrant's entry date to 1991 (the date of the census) and project an exit date of 1995, contributing a risk period of 4-years. Finally, under the conservative scenario the immigrant enters in 1991 and exits in 1993, contributing a risk period of 2-years. Across models we see a minimum contribution to the denominator for this case of 2-years and a maximum contribution of 13-years. Across scenarios the native contributes an unchanged risk period (unless the individual does not record an emigration; in which case they are also lost to follow-up and subject to the same exit scenarios).

Defining first generation immigrants

Migrant status is defined by country of birth. Country of birth is a question asked at each census from 1971-2001. A definitive country is assigned by taking the modal answer across censuses at which individuals were present. An individual present across four censuses will be assigned a definitive country if they have selected the same country at least three times; an individual present across two or three censuses requires two of the same answers. An individual present at one census is assigned the country selected at that census. Approximately 6,000 individuals (<1% of the sample) had multiple modes. We use assumptions to reduce this value.

Individuals whose modes are tied between a UK and foreign country are assigned the latter as a country of birth; especially as in many of these instances this is the country specified first. Individuals who are tied as a result of non-definitive answers e.g. Pakistan/Bangladesh (in 1971) and Ireland Part Not Stated (1971 and 1981) are assigned their later answer when individuals were *able to* or *chose to* specify a more detailed answer. Making these assumptions reduced the multiple mode category to less than 2,000 individuals. Remaining individuals are included in models under the category unresolvable. It should be noted that a small number of British citizens born abroad may be included within the sample of migrants.

Sample size

The original LS sample was 851,416 individuals. 18,356 individuals were removed from the dataset because they were “untraced”. LS members are “untraced” when their records are not found within the NHSCR. We cannot match any census information they have with any events they may have experienced; we cannot study these individuals longitudinally. 623 sample members were dropped because they had inconsistent exit and re-entry dates; 169 sample members had discrepant entry, death or date of birth values; these were either missing or conflicting. The comparison of all excluded cases (2.2%) with the sample by socio-demographic characteristics corresponds with previous research which shows that untraced LS members are more likely to be younger and come from a country of birth other than England and Wales (ONS, 2010).

We compared mortality rates in England and Wales from the ONS LS with mortality rates in the UK from the Human Mortality Database (HMD) for decades 1970, 1980 and 1990. The comparison shows that the age-specific death rates are slightly higher for the ONS LS data than for the HMD particularly for ages younger than 60 (Table 2). However, for most cases the differences lie within 95% confidence intervals around estimates obtained from the LS data and in all cases within 90% confidence intervals. As expected, confidence intervals are wide for younger ages and narrow for older ages.

Statistical Methods

We use survival analysis to study mortality rates of immigrants relative to those of natives in England and Wales. The basic model is as follows:

$$\mu_i(t) = \mu_0(t) \times \exp\left\{\sum_j \beta_j x_{ij}(t)\right\}, \qquad (1)$$

where $\mu_i(t)$ denotes the hazard (or the 'force') of mortality for individual i at age t and $\mu_0(t)$ denotes the baseline hazard, i.e. the mortality risk by age, which we assume to follow Gompertz distribution (the hazard of mortality increases exponentially by age)[1]; individuals are under the risk at entry (age 20 or the age at immigration if older) and are followed until the event of death, emigration or right-censoring at April 2001 (the date of the 2001 census), whichever comes first. $x_{ij}(t)$ represents the values of a variable measuring an individual's socio-demographic background; β_j is the parameter estimate for the variable.

Model 1 investigates mortality differences between immigrants and natives using the exit scenarios for those lost to follow-up. Model controls for sex (male and female), period (1971-80, 1981-90 and 1991-00) and country of birth. Model 1A projects an early exit (2-year), 1B a middle exit (4-year) and 1C a late exit (7-year). Model 2 fits entry uncertainty (limiting entry to first census appearance) and controls for sex, period and country of birth. Model 3 controls for sex, period, country of birth and socioeconomic characteristics to explore where the latter can explain differential immigrant and native mortality. Model 4 stratifies by sex. Model 3 and 4 allow intercensal entry and project a 4-year exit for lost to follow-up.

Socioeconomic characteristics are education level (high, middle, low or missing) and social class (upper, middle, lower or missing). Social class is defined as upper (professional, managerial and technical), middle (skilled manual and non-manual and partly-skilled), lower (unskilled and armed forces) and missing and education level as (degree and above), middle (A-level or 16+ qualifications), low (GCSE and below) and missing. Education level and social class are time-varying covariates, measured at population census. Table 3 shows distribution of risk time and death events.

Model 5 specifies migrant status as an interaction term to show whether mortality by age follows different patterns for immigrants and natives. This acts as a proxy for time in the host country. To fit the model we have to aggregate country of birth to neighbouring (Scotland, Irish Republic and Northern Ireland), South Asian (India, Pakistan and Bangladesh), African and Caribbean (Jamaica, Other Caribbean, East and Southern and West and Central Africa), China and Other Asia and Other (Eastern and Western Europe and Other) due to the limit on interaction models. The interaction term is defined by the binary 0 native = England, Wales, Scotland, Irish Republic, Northern Ireland; 1

[1] We also fitted a Cox and a piecewise-constant exponential hazard model to investigate mortality differences between immigrants and the native-born population. The results (available upon request) were very similar to those obtained by a Gompertz model.

migrant = international migrants. We use a likelihood ratio test to compare the fit of the two nested models (3 and 5).

The lower age limit in the study is set to age 20-years. Due to low cell counts across all migrant groups above middle age in the early years of the ONS LS, we set the upper age limit to 45 years in 1971. We increase this value by an age versus year interval of 1 x 1 until the end of the observation window (2001 Census) whereby the limit is 75-years. This ensures comparability between natives and the immigrant population under investigation. Our final sample consists of 453,352 individuals.

Results

Models 1A-C (Table 4) control for sex, period and country of birth and project exit scenarios of 2, 4 and 7-years after census for those lost to follow-up. Mortality rates for immigrants relative to natives are highest in 1A and lowest in 1C as we increase risk time and inflate the denominator. We observe persistent, low mortality levels for Pakistan, Western Europe and Other Asia. Mortality is relatively high for Scotland, the Irish Republic and Northern Ireland. For Jamaica, we observe high mortality rates but the difference to natives is significant in 1A only.

Model 2 (Table 4) controls for sex, period and country of birth and controls entry, limiting entry to first census appearance. For those lost to follow-up the model projects the 4-year exit scenario. Mortality levels are higher for immigrants compared to 1B as we deflate the denominator by limiting entry to first census appearance. Again we find high mortality for Scotland, the Irish Republic and Northern Ireland and low mortality for Western Europe and Other Asia. Estimated mortality levels are also lower for Pakistan and Bangladesh, but the difference to natives become insignificant when adjusting entry time for immigrants.

Model 3 (Table 4) controls for sex, period, country of birth, education level and social class. Given results from models 1 and 2, model 3 does not control entry and projects the 4-year exit scenario for those lost to follow-up. As expected mortality levels are lower for females and individuals with higher educational level and social class; mortality rates have declined over time. Once we control education and social class, the advantage of immigrants becomes pronounced; most immigrants now have lower mortality than natives. Lower mortality levels are observed for India, Pakistan, Bangladesh, Other Caribbean, East and Southern Africa, Western Europe, China and Other Asia[2]. Mortality levels for individuals who were born in Jamaica, Eastern Europe or West and Central Africa do not differ from

[2] We also fitted a survival model in which the entry date for immigrants was restricted to first appearance at census and the 'early exit' (2-year) was assumed for those with a missing return migration date. The lower mortality for several immigrant groups (individuals from Pakistan, Bangladesh and Western Europe) persisted even for such a conservative model (results available upon request).

natives. A small decrease in relative mortality rates can be observed for Northern Ireland and the Irish Republic.

Model 4 (table 5) stratifies by sex and controls for period, country of birth, education level and social class. Model 4 does not control entry and projects the 4-year exit scenario for those lost to follow-up. We find consistent, low mortality among males and females from India, Pakistan, Bangladesh, Western Europe and Other Asia. Males from Other Caribbean and East and Southern Africa record low relative mortality; female counterparts reflect the native baseline. Females from China record very low relative mortality; Chinese males have a low relative value which is not significant. We see consistent high mortality levels for males and females from Scotland, Northern Ireland and the Irish Republic. When stratified by sex, Jamaican males have lower mortality than natives; Jamaican females have higher relative mortality.

Model 5 (Figure 2) show results from the age interactions (the model fit improved significantly: LR = 5.7, with d.f. = 1, with a $p < 0.05$). (For the sake of simplicity, we fit a sex-adjusted rather than sex-stratified model.) We see differences between immigrants and natives at age 20-years for all groups; China and Other Asia and South Asia have particularly marked advantages. These differences converge towards native mortality over time (signified as 1 on the Y axis). At older ages mortality of African and Caribbean migrants and group Other converges to native levels. The mortality of South Asian and Chinese and Other Asians is still converging but even by age 80-years both groups still have low relative mortality.

Discussion

Our analysis shows that *most* international migrants have lower mortality than natives in England and Wales; though we do see some heterogeneity. Mortality differences between immigrants and natives largely persist when we adjust for entry and exit uncertainty and they become pronounced upon control for individual socioeconomic characteristics. Sex-stratified estimates mainly show consistency between men and women by country of birth, and interactions show declining mortality differences between natives and immigrants as age increases; most immigrants retain lower relative mortality in all ages. Importantly, our study supports low mortality among most immigrants is not a data artefact. Findings are largely consistent with previous studies. We consider selection and health behaviour as explanations for low mortality.

Selection theory proposes that migrants comprise a self-selected population with good health status and low mortality risk. Given the year the ONS LS was founded, it is likely that many of the migrants in the initial 1971 sample are pioneer migrants from the post-war Commonwealth labour movement (1945-1962). The most selective of international migrants are the first to leave for destinations. Pioneer migrants do not benefit from the information and support provided by pre-established migrant networks that facilitate reaching a destination, gaining employment and finding accommodation (Lindstrom and Ramirez, 2010). Individuals have to be socially-adept, resilient and embracers of risk in order to succeed in the establishment of new migrant communities and networks in the host country.

Following the establishment of new migrant communities, continuing self-selection by individuals from origin countries is likely to contribute to the persistent low mortality of migrants. While communities and networks are now established, individuals still have to travel long-distances and integrate into a new host society. This initial selection may then be accentuated by the return migration of individuals who are already unwell, or alternatively of those are likely to experience ill-health and a higher future mortality risk. This can be seen as a method of indirect selection for factors innately linked to both socio-occupational skills and health (Khlat and Darmon, 2003). Low mortality found in Western Europeans may be a result of this selection in return migration, given its geographical proximity to England and Wales – though evidence for health-motivated return migration is mixed (Razum et al., 1998; Franzini et al., 2001; Palloni and Arias, 2004; Turra and Elo, 2008; Arias et al., 2010)

Sex-stratified estimates also provide support for selection. Given that there are good reasons to expect male and female immigrants to have differential mortality; we find consistency by sex across most countries: India, Pakistan, Bangladesh, Western Europe, Eastern Europe, Other Asia and the Rest of the World. This consistency persists despite potential different reasons for migration. Traditionally, literature suggests that women migrate mostly for family reunification (Sotelo and Cranford, 2006) playing a secondary, supportive role to males in the migration process (Shauman and Noonan, 2007). If this is the case, it would stand to reason that women would not select for good health and low mortality upon migration. This is not reflected in our results.

The sex-stratified results for Jamaica show low relative mortality among men and high relative mortality among women. If we discount gendered migration and assume that men and women select into immigration, differences may be a result of differential health behaviours. Women drink and smoke less than men, but are much more likely to be obese, and have bigger waist circumferences and waist-to-hip ratios (Wilks et al., 2008; NOO, 2011). These measures are associated with increased cardiovascular disease risk. Analysis of cause-specific mortality (to determine if CVD mortality is high relative to natives and Jamaican males) would improve our understanding of differential mortality by sex in Jamaicans in England and Wales.

Health behaviours may too explain low mortality of immigrant groups. Indians (women), Pakistanis, Bangladeshis are least likely to drink above government guidelines (ONS, 2005). While general drinking rates remain low for Pakistanis and Bangladeshis, Black Africans and Black Caribbeans consume more alcohol than South Asians and the Chinese, but still less than the general population

(Hurcombe et al., 2010). The countries comprising Western and Eastern Europe have comparable to high relative drinking rates (WHO, 2014).

Cigarette consumption varies by country and sex, with low rates among Indian, Pakistani, Bangladeshi and Chinese women and higher rates (but still below native levels) for men (ONS, 2005). Bangladeshi and Black Caribbean men both have a higher smoking rate than natives and women from their respective countries (ONS, 2005). Many of the countries comprising groups Western and Eastern Europe have comparable to higher smoking rates than England and Wales (Zatoński et al., 2012) with less variation by sex. Substance use is also lower among ethnic minorities, particularly those from South Asia (UKDPC, 2010).

For nutrition, the protective effect of a Mediterranean diet is emphasised (Powles, 1990; Kouris-Blazos, 2002; Knoops et al., 2004); South Asian diets can have harmful dietary fat content due to use of oils, ghee and butter (Bhopal & Rafnsson, 2009). For Eastern Europeans, intake of saturated fat, sugar and complex carbohydrates are cited as causes for concern (Boylan et al., 2009). Obesity varies by background with low relative levels among Bangladeshi and Indian men and the Chinese, and higher relative levels among Black Caribbean, Black African and Pakistani women (Higgins and Dale, 2009). Chinese, Pakistani, Bangladeshi and Indians (latter men only) all report low relative levels of physical activity.

We see variation in immigrant health profiles; immigrants practice healthy *and* unhealthy behaviours. We can characterise South Asians by low levels of drinking and drug use, with high-fat diets and physical inactivity. Similarly, we can characterise Western Europeans by comparable smoking and drinking rates with a low-fat, protective Mediterranean diet. For Indians, Pakistanis and Bangladeshis, low alcohol and cigarette use may be key to their low mortality. For Western Europeans, diet may play a key role. Cause-specific analysis, alongside analysis of group-specific health behaviours would provide definitive conclusions. Unhealthy behaviours among Eastern Europeans, combined with their high relative mortality risk from the origin may explain why this group does not have low relative mortality, even if they are origin-selective.

Health profiles can change over time as immigrants adopt a native lifestyle and discontinue the practice of protective origin-learned behaviours (e.g. the consumption of a British high-fat diet can become common in South Asians (Bhopal and Rafnsson, 2009)). This acculturation may explain the interaction models. All groups are converging to native levels but South Asian and Chinese and Other Asian groups still have low relative mortality in old ages. Alternatively, we may observe a selection effect whereby selection is much greater for younger immigrants. However, given the dominant immigration pattern to England and Wales (migration of young individuals between 20 and 30 years old) combined with the unchanging age profile of immigrant groups over time in our sample, this is unlikely. Results could be a salmon bias effect. If older individuals are more likely to return home through illness but do not record an exit, correcting for denominator bias may diminish the mortality advantage among older immigrants. However, the age distribution for lost to follow-up across our groups is not negatively skewed.

We find immigrants from Scotland, Northern Ireland and the Irish Republic have higher mortality than natives. Results are consistent with previous literature. Similar patterns have also been noted for Finns migrating to neighbouring Sweden. The culmination of proximity, pre-existing extensive social networks, a shared language, and cultural similarities may significantly ease the migration process and reduce the level of selectivity required to migrate. While immigrants from these countries may have higher mortality than natives, previous research has shown that these groups may still select from the origin country (Wallace and Kulu 2013).

Our results are consistent with Scott and Timaeus' (2013) recent study on mortality differentials by ethnicity in England and Wales. We both find low mortality among Indian, Pakistani, Bangladeshi, Chinese and Other Asian immigrants. Findings on all-cause mortality for Scottish and Irish migrants are also consistent with Wild et al's (2008) census study. However, results for international migrants are only comparable with early age SMRs (age 20-44); with the study documenting the deterioration of most migrant mortality advantages after age 45. Our analysis showed declining mortality differences between natives and migrants as age increases, but most migrants had lower mortality in all ages.

The study has several limitations. First, we compare immigrant mortality only to natives in the host country (not the origin). Second, we do not study the health and selectivity of individuals before immigration (Rubalcava, 2008). Nevertheless, the mortality of immigrants in host countries is a public health concern (Jayaweera, 2011). The increasing size and diversity of the proportion of the UK population has important implications for meeting health needs and for planning and delivering health services (Jayaweera, 2010). The study's strength lies in its comprehensive control of entry and exit uncertainty. Findings from this study provide further support to low mortality among immigrants in host countries and, importantly, show that this is not a data artefact. Future research should look beyond all-cause mortality.

Bibliography

Abraído-Lanza, A. F., Dohrenwend, B. P., Ng-Mak, D. S., & Turner, J. B. (1999). The Latino mortality paradox: a test of the" salmon bias" and healthy migrant hypotheses. *American Journal of Public Health*, 89(10), 1543-1548.

Abraído-Lanza, A. F., Chao, M. T., & Flórez, K. R. (2005). Do healthy behaviors decline with greater acculturation? Implications for the Latino mortality paradox. *Social science & medicine*, 61(6), 1243-1255.

Anson, J. (2004). The migrant mortality advantage: a 70 month follow-up of the Brussels population. *European Journal of Population*, 20(3), 191-218.

Arias, E., Eschbach, K., Schauman, W. S., Backlund, E. L., & Sorlie, P. D. (2010). The Hispanic mortality advantage and ethnic misclassification on US death certificates. *American Journal of Public Health*, 100(1), 171–177.

Bandera, E. V., Freudenheim, J. L., & Vena, J. E. (2001). Alcohol Consumption and Lung Cancer A Review of the Epidemiologic Evidence. *Cancer Epidemiology Biomarkers & Prevention*, 10(8), 813-821.

Bhopal, R. S., & Rafnsson, S. B. (2009). Could mitochondrial efficiency explain the susceptibility to adiposity, metabolic syndrome, diabetes and cardiovascular diseases in South Asian populations?. *International journal of epidemiology*, *38*(4), 1072-1081.

Bilgin, Y., Arat, A., & Karatay, E. 1994. Risikofaktorprofil bei Patienten mit koronarer Herzerkrankung. *Die Medizinische Welt*, 45, 136–139.

Blackwell, L., Lynch, K., Smith, J., & Goldblatt, P. (2003). Longitudinal Study 1971-2001: Completeness of Census Linkage, Series LS no. 10. Office for National Statistics, London.

Boylan, S., Welch, A., Pikhart, H., Malyutina, S., Pajak, A., Kubinova, R., ... & Bobak, M. (2009). Dietary habits in three Central and Eastern European countries: the HAPIEE study. *BMC Public Health*, *9*(1), 439.

Chiquiar, D., & Hanson, G. H. (2002). International migration, self-selection, and the distribution of wages: Evidence from Mexico and the United States (No. w9242). National Bureau of Economic Research.

Deboosere, P., & Gadeyne, S. (2005). Adult migrant mortality advantage in Belgium: evidence using census and register data. *Population (English edition)*, 60(5), 655-698.

Dechter, A. R., & Preston, S. H. (1990). Age misreporting and its effects on adult mortality estimates in Latin America. *Population Bulletin of the United Nations*, (31-32), 1-16.

Franzini, L., Ribble, J. C., & Keddie, A. M. (2000). Understanding the Hispanic paradox. *Ethnicity & disease*, 11(3), 496-518.

Goldring, S., & Newman, J. (2010). The ONS Longitudinal Study – a prestigious past and a bright future. *Population Trends*, 139, 4-11.

Gushulak, B. (2007). Healthier on arrival? Further insight into the "healthy immigrant effect". *Canadian Medical Association Journal*, 176(10), 1439-1440.

Hajat, A., Blakely, T., Dayal, S., & Jatrana, S. (2010). Do New Zealand's immigrants have a mortality advantage? evidence from the New Zealand census-mortality study. *Ethnicity & health*, 15(5), 531-547.

Harding, S., Balarajan, R., & Balarajan, R. (1996). Patterns of mortality in second generation Irish living in England and Wales: longitudinal study. *Bmj*, 312(7043), 1389-1392.

Harding, S., & Balarajan, R. (2001). Mortality of third generation Irish people living in England and Wales: longitudinal study. *Bmj*, 322(7284), 466-467.

Hattersley, L. (1999). LS User Guide 18 – International migration data in the Longitudinal Study, Office for National Statistics, LS Unit, London.

Higgins, V., & Dale, A. (2010). Ethnic differences in physical activity and obesity. In *Ethnicity and Integration* (pp. 203-224). Springer Netherlands.

Hurcombe, R., Bayley, M., & Goodman, A. (2010). Ethnicity and alcohol: a review of the UK literature.

Jasso, G., Massey, D. S., Rosenzweig, M. R., & Smith, J. P. (2004). Immigrant health: selectivity and acculturation. *Critical perspectives on racial and ethnic differences in health in late life*, 227-266.

Jayaweera, H., & Quigley, M. A. (2010). Health status, health behaviour and healthcare use among migrants in the UK: evidence from mothers in the Millennium Cohort Study. *Social Science & Medicine*, 71(5), 1002-1010.

Jayaweera, H. (2011). Health of migrants in the UK: what do we know. The Migration Observatory, University of Oxford.

Khlat, M., & Darmon, N. (2003). Is there a Mediterranean migrants mortality paradox in Europe?. *International Journal of Epidemiology*, 32(6), 1115-1118.

Khlat, M., & Courbage, Y. (1996). Mortality and causes of death of Moroccans in France, 1979-91. *Population*, 59-94.

Kibele, E., Scholz, R., & Shkolnikov, V. M. (2008). Low migrant mortality in Germany for men aged 65 and older: fact or artifact? *European Journal of Epidemiology*, 23(6), 389-393.

Knoops, K. T., de Groot, L. C., Kromhout, D., Perrin, A. E., Moreiras-Varela, O., Menotti, A., & Van Staveren, W. A. (2004). Mediterranean diet, lifestyle factors, and 10-year mortality in elderly European men and women: the HALE project. *Jama*, *292*(12), 1433-1439.

Kohls, M. (2010). Selection, Social Status or Data Artefact – What Determines the Mortality of Migrants in Germany? In: Salzmann, T., Edmonston, B., & Raymer, J. *Demographic Aspects of Migration*. New York: Springer. 153-177.

Kouris-Blazos, A. (2002). Morbidity mortality paradox of 1st generation Greek Australians. *Asia Pacific journal of clinical nutrition*, 11(3), 569-575.

Lara, M., Gamboa, C., Kahramanian, M. I., Morales, L. S., & Hayes Bautista, D. E. (2005). Acculturation and Latino health in the United States: a review of the literature and its sociopolitical context. *Annu. Rev. Public Health*, 26, 367-397.

Lindstrom, D. P., & Ramírez, A. L. (2010). Pioneers and followers: Migrant selectivity and the development of US migration streams in Latin America. *The Annals of the American Academy of Political and Social Science*, 630(1), 53-77.

Marks, G., Garcia, M., & Solis, J. M. (1990). Health risk behaviors of Hispanics in the United States: findings from HHANES, 1982-84. *American Journal of Public Health*, 80(Suppl), 20-26.

Markides, K. S., & Eschbach, K. (2005). Aging, migration, and mortality: current status of research on the Hispanic paradox. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 60(Special Issue 2), 68-75.

Marmot, M. G., Adelstein, A. M., & Bulusu, L. (1983). Immigrant mortality in England and Wales 1970-78. *Population Trends*, (33), 14-7.

McDonald, J. T., & Kennedy, S. (2004). Insights into the 'healthy immigrant effect': health status and health service use of immigrants to Canada. *Social science & medicine*, 59(8), 1613-1627.

National Obesity Observatory. (2011). Obesity and Ethnicity. Retrieved from: http://www.noo.org.uk/uploads/doc/vid_9851_Obesity_ethnicity.pdf.

Office for National Statistics. (2005). Ethnicity and Identity. Retrieved from: http://www.ons.gov.uk/ons/rel/ethnicity/focus-on-ethnicity-and-identity/focus-on-ethnicity-and-identity-summary-report/focus-on---ethnicity-and-identity-summary-report.pdf.

Palloni, A., & Arias, E. (2004). Paradox lost: explaining the Hispanic adult mortality advantage. *Demography*, 41(3), 385-415.

Powles, J. (1990). The best of both worlds: attempting to explain the persisting low mortality of Greek migrants to Australia. What we know about Health Transition: the Cultural. *Social and Behavioural Determinants of Health*, 584-594.

Qi, Y., & Niu, J. (2013). Health Selection Effects in China's Internal Migration. *Asian Population Studies*, 9(2), 142-155.

Razum, O., Zeeb, H., Akgün, H. S., & Yilmaz, S. (1998). Low overall mortality of Turkish residents in Germany persists and extends into a second generation: merely a healthy migrant effect?. *Tropical Medicine & International Health*, 3(4), 297-303.

Razum, O., Zeeb, H., & Rohrmann, S. (2000). The "healthy immigrant effect" – not merely a fallacy of inaccurate denominator figures (letter to the editor). *International Journal of Epidemiology*, 29, 191–192.

Razum, O., & Twardella, D. (2002). Towards an explanation for paradoxically low mortality among recent immigrants. *Tropical Medicine & International Health*, 7(1), 4–10.

Rees, P. H., Wohland, P. N., & Norman, P. D. (2009). The estimation of mortality for ethnic groups at local scale within the United Kingdom. *Social science & medicine*, 69(11), 1592-1607.

Robards, J., Berrington, A., & Hinde, A. (2011). Estimating fertility rates using the ONS Longitudinal Study-what difference does the inclusion of non-continually resident members make? *Population trends*, 144(1), 33-47.

Ronellenfitsch, U., Kyobutungi, C., Becher, H., & Razum, O. (2006). All-cause and cardiovascular mortality among ethnic German immigrants from the Former Soviet Union: a cohort study. *BMC Public Health*, 6(1), 16.

Rosenberg, H. M., Maurer, J. D., Sorlie, P. D., Johnson, N. J., MacDorman, M. F., Hoyert, D. L., ... & Scott, C. (1999). Quality of death rates by race and Hispanic origin: a summary of current research, 1999. *Vital and health statistics*. Series 2, Data evaluation and methods research, (128), 1-13.

Rosenwaike, I. (1991). Mortality of Hispanic populations: Mexicans, Puerto Ricans, and Cubans in the United States and in the home countries. Studies in Population and Urban Demography, 6, 221.

Rubalcava, L. N., Teruel, G. M., Thomas, D., & Goldman, N. (2008). The healthy migrant effect: new findings from the Mexican Family Life Survey. *American Journal of Public Health*, 98(1), 78-84.

Schiffauer, W. (1991). Die Migranten aus Subay. Türken in Deutschland: Eine Ethnographie. Stuttgart: Klett-Cotta.

Scott, A. P., & Timæus, I. M. (2013). Mortality differentials 1991− 2005 by self-reported ethnicity: findings from the ONS Longitudinal Study. *Journal of epidemiology and community health*, 67(9), 743-750.

Scribner, R. (1996). Paradox as paradigm--the health outcomes of Mexican Americans. *American Journal of Public Health*, 86(3), 303-305.

Shauman, K. A., & Noonan, M. C. (2007). Family migration and labor force outcomes: sex differences in occupational context. *Social Forces*, *85*(4), 1735-1764.

Hondagneu-Sotelo, P., & Cranford, C. (2006). Gender and migration. In *Handbook of the Sociology of Gender* (pp. 105-126). Springer US.

Sundquist, J., & Johansson, S. E. (1997). Self-reported poor health and low educational level predictors for mortality: a population based follow up study of 39,156 people in Sweden. *Journal of Epidemiology and Community Health*, 51(1), 35-40.

Sundquist, K., & Li, X. (2006). Coronary heart disease risks in first-and second-generation immigrants in Sweden: a follow-up study. *Journal of internal medicine*, *259*(4), 418-427. Swerdlow, A. J. (1991). Mortality and cancer incidence in Vietnamese refugees in England and Wales: a follow-up study. *International journal of epidemiology*,*20*(1), 13-19.

Turra, C. M., & Elo, I. T. (2008). The impact of salmon bias on the Hispanic mortality advantage: New evidence from social security data. *Population Research and Policy Review*, *27*(5), 515-530.

Uitenbroek, D. G., & Verhoeff, A. P. (2002). Life expectancy and mortality differences between migrant groups living in Amsterdam, the Netherlands.*Social Science & Medicine*, *54*(9), 1379-1388.

Uitewaal, P. J. M., Manna, D. R., Bruijnzeels, M. A., Hoes, A. W., & Thomas, S. (2004). Prevalence of type 2 diabetes mellitus, other cardiovascular risk factors, and cardiovascular disease in Turkish and Moroccan immigrants in North West Europe: a systematic review. *Preventive medicine*, *39*(6), 1068-1076.

UK Drugs Policy Comission. (2010). Drugs and Diversity: Ethnic minority groups. Learning from the evidence. Retrievedfrom: http://www.ukdpc.org.uk/wp-content/uploads/Policy%20report%20-%20Drugs%20and%20diversity_%20ethnic%20minority%20groups%20(policy%20briefing).pdf.

Wallace, M., & Kulu, H. (2013). Migration and Health in England and Scotland: a Study of Migrant Selectivity and Salmon Bias. *Population, Space and Place*.

Wanner, P., Bouchardy, C., & Parkin, D. M. (1994). [Cancer mortality among Swiss migrants in France]. *Revue d'epidemiologie et de sante publique*, *43*(1), 26-36.

Wei, M., Valdez, R. A., Mitchell, B. D., Haffner, S. M., Stern, M. P., & Hazuda, H. P. (1996). Migration status, socioeconomic status, and mortality rates in Mexican Americans and non-Hispanic whites: the San Antonio Heart Study. *Annals of epidemiology*, *6*(4), 307-313.

Weitoft, G. R., Gullberg, A., Hjern, A., & Rosen, M. (1999). Mortality statistics in immigrant research: method for adjusting underestimation of mortality. *International Journal of Epidemiology*, *28*(4), 756-763.

World Health Organisation. (2014). Global status report on alcohol and health. Retrieved from: http://www.who.int/substance_abuse/publications/global_alcohol_report/msb_gsr_2014_3.pdf.

Wild, S. H., Fischbacher, C. M., Brock, A., Griffiths, C., & Bhopal, R. (2006). Mortality from all cancers and lung, colorectal, breast and prostate cancer by country of birth in England and Wales, 2001–2003. *British journal of cancer*, *94*(7), 1079-1085.

Wild, S. H., Fischbacher, C., Brock, A., Griffiths, C., & Bhopal, R. (2007). Mortality from all causes and circulatory disease by country of birth in England and Wales 2001–2003. *Journal of public health*, *29*(2), 191-198.

Wilks, R., Younger, N., Tulloch-Reid, M., McFarlane, S., & Francis, D. (2008). Jamaica health and lifestyle survey 2007-8. *Kingston: Tropical Medicine Research Institute, University of the West Indies, Mona*.

Zatoński, W., Przewoźniak, K., Sulkowska, U., West, R., & Wojtyła, A. (2012). Tobacco smoking in countries of the European Union. *Ann Agric Environ Med*,*19*(2), 181-192.

Table 1. Recorded exits per year from the ONS LS by Census decade.

Years after Census	1971		1981		1991		Total	
	Exits	%	Exits	%	Exits	%	Exits	%
1	574	15	470	19	320	13	1364	16
2	557	30	382	35	340	27	1279	30
3	602	45	248	45	274	38	1124	43
4	575	60	177	52	276	49	1028	55
5	366	70	153	58	204	58	723	63
6	261	77	143	64	202	66	606	70
7	244	83	204	72	186	73	634	77
8	244	89	207	81	219	82	670	85
9	200	95	235	90	208	91	643	92
10	208	100	234	100	227	100	669	100
Total	**3831**	**.**	**2453**	**.**	**2456**	**.**	**8740**	**.**

[3]

[3] >Source: Authors' calculations based on the ONS LS.
>Table shows recorded exits from the ONS LS by decade. This is measured as years after final census appearance. This distribution informs our exit scenarios for individuals lost to follow-up. The value of quartiles are measured as Q1 = 1.83; Q2 = 3.91; Q3 = 6.96 (i.e. 2-, 4- and 7-years after census).

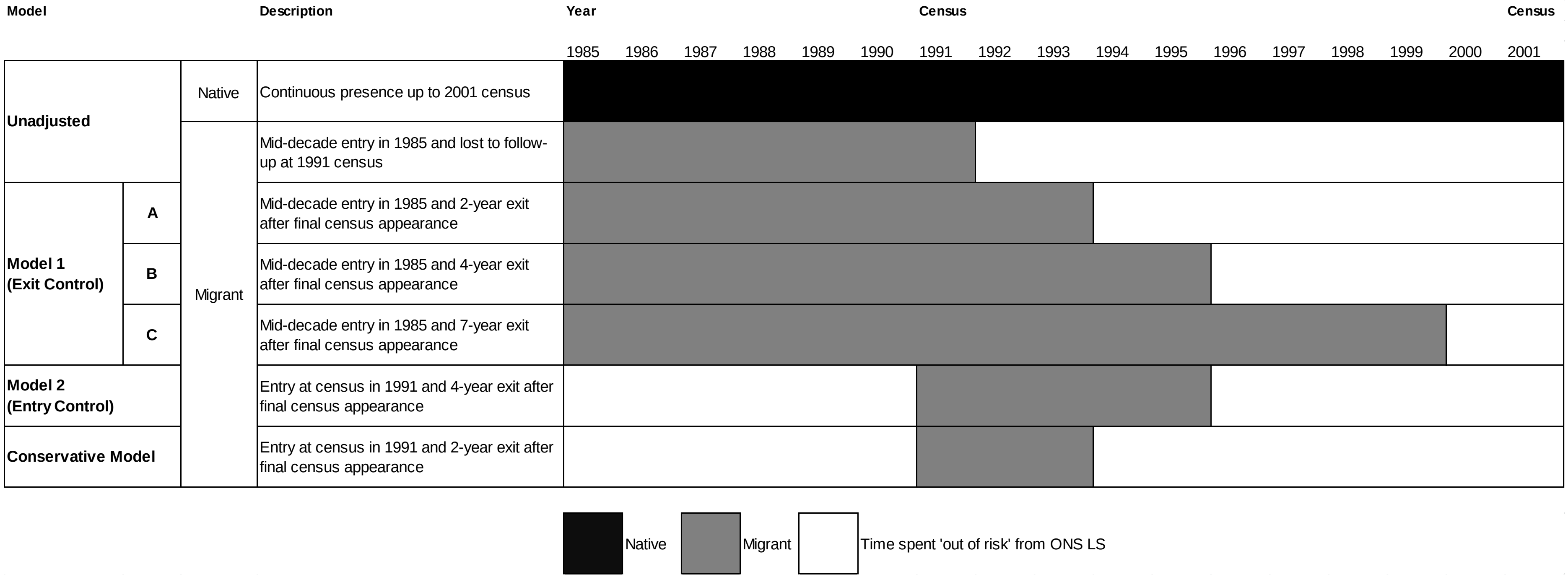


Figure 1. Scenarios for addressing exit and entry uncertainty in the ONS LS.

Table 2. Relative ratio Human Mortality Database and ONS Longitudinal Study.

Age (Years)	Human Mortality Database	Office for National Statistics Longitudinal Study					
		1971-80	95% CI	1981-90	95% CI	1991-00	95% CI
20	1.00	1.25	(1.10 to 1.42)	0.98	(0.87 to 1.10)	0.97	(0.84 to 1.12)
25	1.00	1.12	(0.99 to 1.27)	0.94	(0.84 to 1.05)	1.05	(0.92 to 1.21)
30	1.00	1.00	(0.90 to 1.11)	0.95	(0.86 to 1.06)	1.07	(0.95 to 1.21)
35	1.00	1.13	(1.02 to 1.24)	1.06	(0.97 to 1.17)	1.08	(0.97 to 1.21)
40	1.00	1.11	(1.03 to 1.20)	1.06	(0.98 to 1.14)	1.04	(0.96 to 1.14)
45	1.00	1.08	(1.02 to 1.14)	1.11	(1.04 to 1.18)	1.09	(1.02 to 1.17)
50	1.00	1.05	(1.01 to 1.10)	1.12	(1.07 to 1.17)	1.11	(1.05 to 1.18)
55	1.00	1.02	(0.98 to 1.05)	1.08	(1.05 to 1.12)	1.08	(1.03 to 1.13)
60	1.00	1.01	(0.99 to 1.04)	1.04	(1.01 to 1.07)	1.10	(1.06 to 1.14)
65	1.00	1.01	(0.99 to 1.03)	1.03	(1.01 to 1.05)	1.09	(1.06 to 1.12)
70	1.00	1.02	(1.00 to 1.04)	1.03	(1.01 to 1.05)	1.05	(1.03 to 1.08)
75	1.00	1.02	(1.00 to 1.04)	1.02	(1.00 to 1.04)	1.03	(1.01 to 1.05)
80	1.00	1.03	(1.01 to 1.05)	1.02	(1.00 to 1.04)	1.05	(1.03 to 1.07)
85	1.00	1.02	(1.00 to 1.05)	1.03	(1.01 to 1.06)	1.02	(1.00 to 1.04)
90	1.00	0.98	(0.95 to 1.01)	0.95	(0.93 to 0.98)	0.93	(0.91 to 0.95)

Source: Authors' calculations based on the HMD and the ONS LS.

Table 3. Person-years at risk and number of events by covariates.

Covariate	Years at risk	%	Events	Covariate	Years at risk	%	Events	Covariate	Years at risk	%	Events
Sex				**Country of birth**				**Education**			
Male	50,440,288	50	16,467	England	87,617,074	87	22,843	High	5,748,367	6	896
Female	50,564,447	50	10,233	Scotland	1,814,278	2	678	Middle	6,916,052	7	1,121
Period				Northern Ireland	537,772	1	210	Low	80,873,985	80	22,407
1971-80	24,192,900	24	3,084	Irish Republic	1,513,422	1	663	Unspecified	1,402,382	1	140
1981-90	34,984,630	35	7,452	India	1,879,303	2	513	Missing	6,063,949	6	2,136
1991-00	41,827,205	41	16,164	Pakistan	990,901	1	177	**Social Class**			
Age				Bangladesh	360,518	0	71	Upper	19,352,876	19	4,331
20-24	13,738,972	14	695	Jamaica	538,880	1	217	Middle	47,242,431	47	11,843
25-29	14,160,002	14	753	Other Caribbean	406,388	0	111	Lower	5,030,607	5	1,736
30-34	13,808,115	14	944	E&S Africa	765,898	1	113	Unspecified	23,314,872	23	6,654
35-39	13,096,548	13	1,195	W&C Africa	291,717	0	51	Missing	6,063,949	6	2,136
40-44	12,419,201	12	1,905	W Europe	1,225,456	1	231				
45-49	11,142,316	11	2,804	E Europe	368,337	0	198				
50-54	8,795,236	9	3,554	China	235,928	0	47				
55-59	6,369,754	6	4,281	Other Asia	520,028	1	69				
60-64	4,291,723	4	4,608	Rest of World	1,704,563	2	385				
65-69	2,415,792	2	3,974	Unresolvable	234,272	0	123				
70+	767,076	1	1,987					**Total**	**101,004,735**	**100**	**26,700**

Source: Authors' calculations based on the ONS LS.

Table 4. Hazard ratios of mortality of immigrants compared with natives in England and Wales. Control for exit uncertainty.

	Model 1									Model 2			Model 3		
	[A]			[B]			[C]								
Covariates	Haz Ratio	95% CI	Sig	Hazard Ratio	95% CI	Sig	Hazard Ratio	95% CI	Sig	Hazard Ratio	95% CI	Sig	Hazard Ratio	95% CI	Sig
Sex															
Male	1.00			1.00			1.00			1.00			1.00		
Female	0.61	(0.59 to 0.62)	***	0.61	(0.59 to 0.62)	***	0.61	(0.59 to 0.62)	***	0.61	(0.59 to 0.62)	***	0.49	(0.48 to 0.50)	***
Period															
1971-1980	1.00			1.00			1.00			1.00			1.00		
1981-1990	0.91	(0.87 to 0.95)	***	0.91	(0.87 to 0.95)	***	0.90	(0.86 to 0.94)	***	0.90	(0.86 to 0.94)	***	0.92	(0.89 to 0.97)	***
1991-2000	0.87	(0.83 to 0.91)	***	0.86	(0.82 to 0.90)	***	0.84	(0.80 to 0.88)	***	0.85	(0.82 to 0.89)	***	0.88	(0.85 to 0.93)	***
Country of birth															
England and Wales	1.00			1.00			1.00			1.00			1.00		
Scotland	1.30	(1.20 to 1.40)	***	1.28	(1.19 to 1.38)	***	1.26	(1.16 to 1.36)	***	1.29	(1.20 to 1.40)	***	1.28	(1.19 to 1.39)	***
Northern Ireland	1.28	(1.12 to 1.47)	***	1.27	(1.11 to 1.46)	***	1.25	(1.09 to 1.43)	***	1.31	(1.14 to 1.50)	***	1.22	(1.06 to 1.39)	***
Irish Republic	1.24	(1.14 to 1.33)	***	1.22	(1.13 to 1.31)	***	1.18	(1.09 to 1.28)	***	1.24	(1.15 to 1.34)	***	1.11	(1.02 to 1.20)	***
India	1.00	(0.91 to 1.09)		0.98	(0.90 to 1.07)		0.95	(0.87 to 1.04)		1.04	(0.95 to 1.13)		0.89	(0.81 to 0.97)	***
Pakistan	0.87	(0.75 to 1.01)	*	0.85	(0.73 to 0.99)	**	0.81	(0.70 to 0.94)	***	0.92	(0.79 to 1.06)		0.69	(0.59 to 0.79)	***
Bangladesh	0.85	(0.68 to 1.08)		0.83	(0.66 to 1.05)		0.79	(0.62 to 0.99)	**	0.94	(0.75 to 1.19)		0.62	(0.49 to 0.78)	***
Jamaica	1.13	(0.98 to 1.29)	*	1.09	(0.96 to 1.25)		1.04	(0.91 to 1.19)		1.11	(0.97 to 1.26)		0.97	(0.84 to 1.10)	
Other Caribbean	0.93	(0.77 to 1.13)		0.90	(0.75 to 1.09)		0.86	(0.71 to 1.03)		0.93	(0.77 to 1.12)		0.85	(0.70 to 1.02)	*
E&S Africa	0.90	(0.75 to 1.08)		0.89	(0.74 to 1.07)		0.87	(0.72 to 1.04)		1.00	(0.83 to 1.20)		0.82	(0.68 to 0.98)	**
W&C Africa	0.99	(0.75 to 1.30)		0.95	(0.72 to 1.25)		0.88	(0.67 to 1.16)		1.10	(0.84 to 1.45)		0.84	(0.64 to 1.10)	
W Europe	0.72	(0.63 to 0.82)	***	0.70	(0.62 to 0.80)	***	0.68	(0.60 to 0.78)	***	0.73	(0.64 to 0.83)	***	0.68	(0.60 to 0.78)	***
E Europe	1.05	(0.91 to 1.20)		1.03	(0.90 to 1.19)		1.01	(0.88 to 1.17)		1.07	(0.93 to 1.23)		0.96	(0.84 to 1.11)	
China	0.86	(0.64 to 1.14)		0.83	(0.63 to 1.11)		0.80	(0.60 to 1.06)		0.92	(0.69 to 1.22)		0.75	(0.56 to 0.99)	**
Other Asia	0.74	(0.58 to 0.94)	**	0.72	(0.57 to 0.91)	***	0.69	(0.55 to 0.88)	***	0.82	(0.65 to 1.04)		0.68	(0.54 to 0.86)	***
Rest of World	0.98	(0.89 to 1.09)		0.96	(0.87 to 1.06)		0.91	(0.83 to 1.01)	*	1.04	(0.94 to 1.15)		0.89	(0.81 to 0.99)	**
Unresolvable	2.06	(1.72 to 2.45)	***	1.99	(1.66 to 2.37)	***	1.87	(1.56 to 2.23)	***	2.06	(1.73 to 2.46)	***	1.61	(1.35 to 1.93)	***
Education															
High	.			.			.			.			1.00		
Middle	.			.			.			.			1.19	(1.09 to 1.31)	***
Low	.			.			.			.			1.57	(1.46 to 1.68)	***
Unspecified	.			.			.			.			1.81	(1.50 to 2.17)	***
Missing	.			.			.			.			3.13	(2.90 to 3.39)	***
Social Class															
Upper	.			.			.			.			1.00		
Middle	.			.			.			.			1.21	(1.17 to 1.26)	***
Lower	.			.			.			.			1.52	(1.43 to 1.61)	***
Unspecified	.			.			.			.			2.20	(2.11 to 2.30)	***
Missing	.			.			.			.					

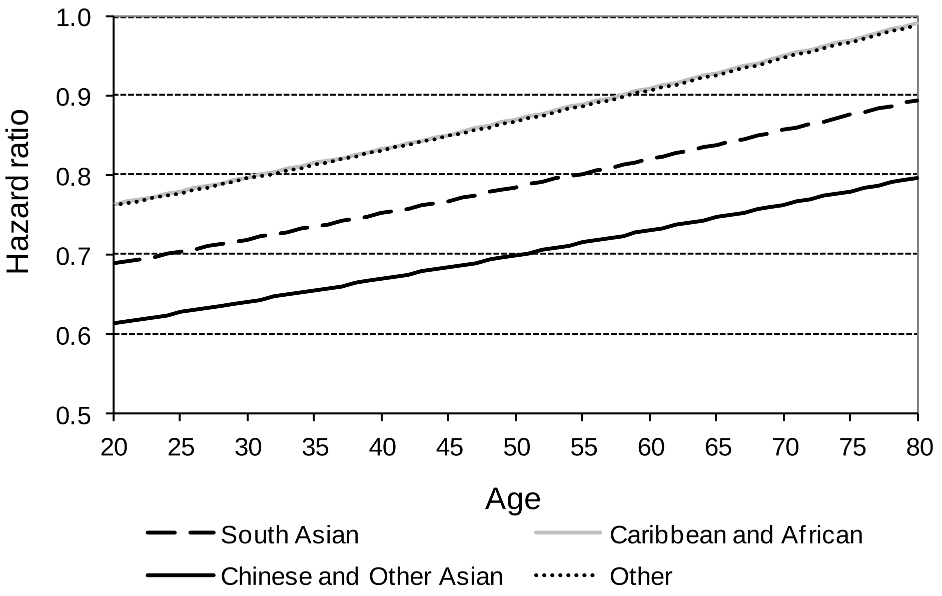
[4]

[4] >*Source:* Authors' calculations based on the ONS LS.
>Significance levels at 1% (***) 5% (**) and 10% (*).
>Model 1 controls for exit uncertainty. We project three different scenarios for individuals who are lost to follow-up. The scenarios are based on the empirical distribution of known exits of individuals from the data. Model 1A projects an exit for 2-years after final census appearance; Model 1B 4-years and Model 1C 7-years. In these models we do not control for entry uncertainty.
>Model 2 controls for entry uncertainty. We limit the onset of risk to first appearance at census, even if a mid-decade entry has been recorded. This provides certainty of presence in England and Wales. Based on the results of model 1, we project an exit for those lost to follow-up of 4-years after final census appearance. The model to which results should be compared is Model 1B.
>Model 3 and Model 4 (below) control for individual socioeconomic characteristics. We continue to project an exit for those lost to follow-up of 4-years after census. Based on the results from Model 2 (entry uncertainty), we allow individuals to enter mid-decade and do not control their entry into the ONS LS. Model 3 should be compared to Model 1B.

Table 5. Hazard ratios of mortality of immigrants compared with natives in England and Wales by sex.

	Model 4					
	Males			Females		
Covariates	Hazard Ratio	95% CI	Sig	Hazard Ratio	95% CI	Sig
Period						
1971	1.00			1.00		
1981	0.91	(0.86 to 0.96)	***	0.91	(0.85 to 0.98)	**
1991	0.82	(0.78 to 0.87)	***	0.90	(0.84 to 0.97)	***
Country of birth						
England and Wales	1.00			1.00		
Scotland	1.25	(1.13 to 1.38)	***	1.35	(1.19 to 1.53)	***
Northern Ireland	1.21	(1.02 to 1.43)	**	1.20	(0.96 to 1.51)	
Irish Republic	1.06	(0.96 to 1.18)		1.14	(1.01 to 1.29)	**
India	0.90	(0.81 to 1.00)	**	0.84	(0.72 to 0.98)	**
Pakistan	0.68	(0.57 to 0.81)	***	0.66	(0.50 to 0.88)	***
Bangladesh	0.59	(0.45 to 0.77)	***	0.60	(0.36 to 0.97)	**
Jamaica	0.75	(0.62 to 0.90)	***	1.34	(1.10 to 1.62)	***
Other Caribbean	0.77	(0.61 to 0.97)	**	0.97	(0.72 to 1.32)	
E&S Africa	0.72	(0.56 to 0.91)	**	0.96	(0.72 to 1.27)	
W&C Africa	0.87	(0.64 to 1.19)		0.68	(0.37 to 1.22)	
W Europe	0.72	(0.60 to 0.87)	***	0.65	(0.54 to 0.78)	***
E Europe	0.97	(0.81 to 1.15)		0.92	(0.72 to 1.17)	
China	0.83	(0.61 to 1.15)		0.52	(0.27 to 0.99)	**
Other Asia	0.64	(0.46 to 0.87)	**	0.70	(0.49 to 1.01)	*
Rest of World	0.90	(0.80 to 1.03)		0.85	(0.72 to 1.00)	*
Unresolvable	1.35	(1.07 to 1.71)	**	2.03	(1.55 to 2.67)	***
Education						
High	1.00			1.00		
Middle	1.19	(1.07 to 1.33)	***	1.09	(0.92 to 1.29)	
Low	1.56	(1.44 to 1.70)	***	1.50	(1.29 to 1.74)	***
Unspecified	1.43	(1.13 to 1.82)	***	2.12	(1.57 to 2.86)	***
Missing	3.17	(2.90 to 3.48)	***	2.78	(2.36 to 3.27)	***
Social Class						
Upper	1.00			1.00		
Middle	1.24	(1.18 to 1.30)	***	1.10	(1.02 to 1.18)	**
Lower	1.60	(1.49 to 1.71)	***	1.27	(1.15 to 1.41)	***
Unspecified	2.92	(2.76 to 3.09)	***	1.67	(1.55 to 1.80)	***
Missing	Omitted					

Source: Authors' calculations based on the ONS LS.



Source: Authors' calculations based on the ONS LS.

Figure 2. Hazard ratios of mortality of immigrants compared with natives by age.

Acknowledgments:

"The permission of the Office for National Statistics to use the Longitudinal Study is gratefully acknowledged, as is the help provided by staff of the Centre for Longitudinal Study Information & User Support (CeLSIUS). CeLSIUS is supported by the ESRC Census of Population Programme (Award Ref: ES/K000365/1). The authors alone are responsible for the interpretation of the data."