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

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Abstract

Previous research shows low mortality for most immigrant groups compared to natives in the host country. This advantage is often attributed to beneficial health selection processes in immigration and return migration and to protective health behaviours. Little research has examined the role of data quality, especially the registration of moves. Under-registration of return migration artificially increases the risk population leading to 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 a series of sensitivity analyses to assess the impact of both entry and exit uncertainty on immigrant mortality rates. The analysis shows that most international migrants have lower mortality than England and Wales natives. 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 the results are not a data artefact.

Keywords: mortality, immigrants, survival analysis, UK

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; Kreft and Doblhammer, 2012), Belgium (Anson, 2004) and France (Wanner et al., 1995; Courbage and Khlat, 1996). However, findings can also show incongruity among results and the successful migration of individuals with a high mortality risk (such as in Scandinavia) (Sundquist and Johansson, 1997; Sundquist and Li, 2006). This calls into question the extent of the low mortality among immigrants in many 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 result in artificially low immigrant mortality (a data artefact) (Kohl, 2010).

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 or a reality. We conduct a series of sensitivity analyses to examine the impact of immigration and emigration date uncertainty on the mortality rates of immigrants. To our knowledge, this is the first study in the United Kingdom to explicitly address entry uncertainty (a delayed immigration date) and exit uncertainty (failure to register an exit) in the analysis of immigrant mortality. Further, this is one of the few studies in the United Kingdom to include temporary exits from, and returns to the host country in analysis. Registration issues are intrinsic to register data; uncertainty control will allow us to determine whether low immigrant mortality is a data artefact or attributable to selection and protective health behaviours.

Background

Data artefact

Data artefact encompasses a broad range of potential error sources. These include the misreporting of age (particularly at advanced ages), 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 (Kibele et al., 2008; Kohls, 2010) and deaths are undercounted (Neumann, 1991; Richter, 2006), the risk population is overestimated and immigrant mortality rates are depressed (Kibele et al., 2008). Immigrants may simply forget to register an exit. Alternatively, they may have an incentive to remain on host population registries after return to the origin country

(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).

Mortality re-estimation in Germany reveals a 25% underestimation of migrant mortality due to registration error (Kibele et al., 2008). Similarly, Kohls (2010) finds that low mortality of migrants in Germany is a result of poor data quality, especially at higher ages. A counter study uses the German Socio-Economic Panel (which avoids denominator bias) to demonstrate a similar-sized mortality advantage to that in German register studies (Razum et al., 2000). Lower mortality found in migrants in Sweden is largely explained by inaccurate denominators – though advantages persist for some groups (Weitoft et al., 1999). The under-registration of deaths of Moroccans in France has been estimated at 30%, yet after correction life expectancy remained higher than natives (Courbage and Khlat, 1996 in Darmon and Khlat, 2001). Mortality differences persist after correcting for Portuguese registration bias in France (Wanner et al., 1999 in Darmon and Khlat, 2001) and correction for undocumented emigration or late registration of migrants in Belgium has little impact upon migrant mortality patterns (Anson, 2004).

Return migration hypotheses are intrinsically linked to registration issues (Deboosere and Gadeyne, 2005) and contribute to numerator and denominator error (Abraido-Lanza et al., 1999). Salmon Bias proposes that deteriorating health triggers return migration. This results in artificially low mortality as deaths among returnees are omitted from the numerator (Turra and Elo, 2008). Further, individuals continue to ‘age’ in official statistics if the departure is not registered, inflating the denominator. Cautious support for a Salmon Bias has been found for Mexicans in the U.S. (Palloni and Arias, 2004); a number of other studies support its existence but state it cannot wholly explain the persistent low mortality of immigrants (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) and there is little evidence of the return migration of ill Turks from Germany (Razum et al., 1998).

In Europe, ‘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 the host country is unaware of these frequent departures, individuals will continue to contribute to denominators even though they are not permanently resident in the host country. 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.

Additionally, there may be problems with the 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 Hispanic subgroups in the United States overstate their age (Dechter and Preston, 1991; Rosenwaike, 1991). This can depress mortality rates at older ages and affect the age distribution of deaths (Palloni and Arias, 2004). The misclassification of ethnicity on death certificates may also occur. In America, this led to recommendations that death rates for Hispanics be interpreted with caution (Markides and Eschbach, 2005). An earlier study reported a 7% underascertainment of ethnicity on death certificates compared with self-classification (Rosenberg et al., 1999). This 7% correction was applied by Elo et al (2004) to demonstrate the persistence of low mortality among Hispanics in America.

In sum, while data issues may artificially lower migrant mortality, correcting for calculation error only appears to moderate mortality differences between immigrants and natives. Rarely do undercounts of deaths and inflations of the denominator account fully for any migrant mortality advantage.

Selection

Beyond data artefact, selection theory considers the formation of a unique population with good health and low mortality risk. 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 certain personality traits such as courage (Schiffauer, 1991 in Razum et al., 1998), 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 also apparent. The healthy and wealthy are able to migrate because they have both 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 innately linked with poor health and adverse mortality outcomes; so it is paradoxical that Hispanics could have more positive mortality profiles than non-Hispanic whites who have a more favourable socioeconomic status (Palloni and Arias, 2004). Nonetheless, low mortality among Hispanics is evident (if not a homogenous finding in all groups) (Wei et al., 1996; Abraido-Lanza et al., 1999 and 2005; Palloni and Arias, 2004; Turra and Elo, 2008). More widely, this paradox has been observed in Europe for Mediterranean migrants in Germany (Razum et al., 1998), France (Courbage and Khlat, 1996), and Belgium (Anson, 2004);

Governments can also health screen immigrants (McDonald and Kennedy, 2004; Kibele et al., 2008). However, the ultimate size of numbers denied entry to countries through ill health is questioned (Razum et al., 1998; Laroche, 2000; McDonald and Kennedy, 2004) as is the limited range of health outcomes that screening can assess (Lu, 2008).

Health Behaviour

The health behaviour hypothesis proposes that migrants have more favourable health behaviours which results in a relative health and mortality advantage to natives (Scribner, 1994 in Abraido-Lanza et al., 2005). 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 also be gender-specific. Smoking prevalence in Moroccan, Turkish and Chinese males is higher than in females (Uitewaal et al., 2001Li, 2011). Mexican, Cuban and Puerto Rican men are more than twice as likely to consume alcohol as women (Marks et al., 1990 in Lara et al., 2005).

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 in Abraido-Lanza et al., 1999). 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, the strongest evidence points towards a negative effect of acculturation on health behaviours (substance abuse and diet) among Latinos in the United States; though migrants were more likely to use preventative services.

Mortality of migrants in the United Kingdom

Previous research in the UK is less conclusive. Several studies have identified health and mortality advantages for Polish, Italian, South Asian, Vietnamese, Chinese and Caribbean migrants (Marmot et al., 1984; Swerdlow, 1991; Scott and Timaeus, 2013). However, other studies have supported lower mortality among immigrants at younger ages but shown significantly higher mortality for most immigrant groups at older ages (Wild et al. 2007). Extensive variation in the causes of 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 (Raftery et al., 1990; Harding and Balajaran, 1996; Harding and Balajaran, 2001); mortality is also relatively high among Scots (Wild et al., 2007).

Given findings from current literature, the low mortality of immigrants in host countries may be explained by a combination of selection processes at work before and upon entry, and the conservation of this selectivity through the practice of protective health behaviours. Simultaneously, mortality differences between immigrants and natives may be a data artefact, the result of an inflated denominator base and an undercount of deaths. Howbeit, studies on the latter rarely find mortality differences between immigrants and natives wholly attributable to data error. Our hypotheses are therefore as follows:

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

Second, we expect controlling for exit and entry uncertainty to reduce mortality differences between immigrants and natives.

Third, in line with previous research, though we expect to see a reduction, we anticipate differences will persist after controlling for exit and entry uncertainty.

Fourth, 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 representative 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 birth dates. The same four dates were used to supplement the sample (by around 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).

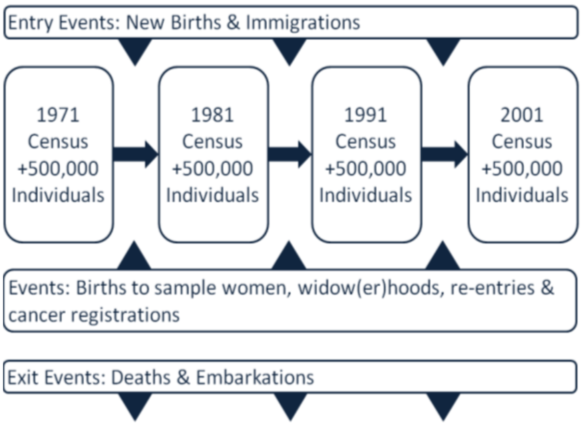

Figure 1. Structure of the ONS LS.

Information from Censuses has been linked with information on entry events (births and immigrations) and exit events (deaths and emigrations). Event data is accessed from patient registration data on the National Health Service Central Register (NHSCR). The NHSCR compiles and maintains a computerised record of NHS patients (those who are registered with a doctor in England and Wales). The database is routinely updated with information on births, deaths and migratory events (ONS, 2014). The ONS LS is attractive because of its large sample size, length and ability to allow users to separate age, period and cohort effects in their analysis (Goldring and Newman, 2010). The ONS LS is known to over-sample immigrants and under-sample emigrants (Hattersley, 1999).

Entry into the ONS LS

Entry into the ONS LS is dependent on how soon after entry an immigrant registers with a doctor and joins the National Health Service (Hattersley, 1999), assuming that said individual has not already completed 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 embarkation 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 relevant 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 (exited) from the ONS LS between 1971 and 2001.

If individuals meets neither of these criteria and are not enumerated at census they are classified as 'lost to follow-up'. We make the assumption that these individuals are unrecorded embarkations from England and Wales though individuals can also be lost when an inconsistent date of birth or corroborating information is recorded. Others are lost if they are not counted at every census. Ultimately, the ONS LS 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 United Kingdom 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 their decade of exit based on final appearance at census and non-appearance thereafter e.g. enumeration at the 1981 census and non-enumeration at the 1991 and 2001 censuses suggests an exit between 1981 and 1990.

Embarkations and re-entries in the ONS LS

For mid-decade embarkations and re-entries (individuals who leave and return to England and Wales), there are two types of residence trajectory. Those with *consistent* cases where individuals can be *continually* resident (there are no recorded embarkations or re-entries) and *non-continually* resident (there are recorded embarkations and re-entries which are chronological) and *inconsistent* cases whereby there is a missing value or an unchronological event sequence (Robards et al., 2011). Those with *consistent, continually resident* cases can be considered 'at risk' of death until they experience the final event (death) or reach the end of the observation window. Sample members with *consistent, non-continually* resident cases have both 'at risk' and 'out of risk' periods. These are factored into the study 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 sequence of events e.g. an embarkation date is later than its partnered re-entry date or (ii) a piece of event information is missing. Those ONS LS members who have an unchronological sequence of events are dropped from the dataset. If however a case is made *inconsistent* by a missing value, we impute an arbitrary 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 prior so as not to create any further inconsistency within the data. We do this because those foreign-born individuals are more likely to record embarkations and re-entries in the ONS LS and we do not want to lose these individuals from the dataset. We drop 700 individuals and impute values for 6,000. Most missing values occur where there is a value for re-entry 1 but not embarkation 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 potential denominator bias. Under exit control we project three scenarios based on the empirical distribution of known exits from the dataset (approximately 13, 000 individuals). Exits of known individuals are measured from final appearance at census. We take the median, and upper and lower quartiles to inform our scenarios. Exit scenario A projects an early exit of two years after census, scenario B a middle exit of four years after census and scenario C a late exit of seven years after census. The exit scenarios do not control for entry and allow immigrants to be at risk when entering between censuses.

Under entry control we limit the onset of risk to first appearance at census; we also project the middle exit scenario for those 'lost to follow-up'. However, we must stress that this model may not represent reality. Although adjusting entry provides a high level of certainty of presence, it reduces the risk time and leads to mortality overestimation, particularly when there are few (if any) deaths between intercensal entry and first appearance at census. Most immigrants also experience a delay in registration, suggesting that risk time has already been reduced. Lastly, in the conservative model we limit entry to first appearance at census and project an early exit scenario of just two years after census.

Figure 1 presents these scenarios. Unadjusted, the immigrant enters in 1985 and last appears at the 1991 census (before being 'lost to follow-up), contributing a risk period of at least 6-years to the denominator. Under the three exit scenarios we project exit dates of 1993, 1995 and 1998 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 to the denominator. Across models we see a minimum contribution to the denominator for this immigrant of 2-years and a maximum contribution of 13-years. Across all scenarios the native individual contributes an unchanged risk period.

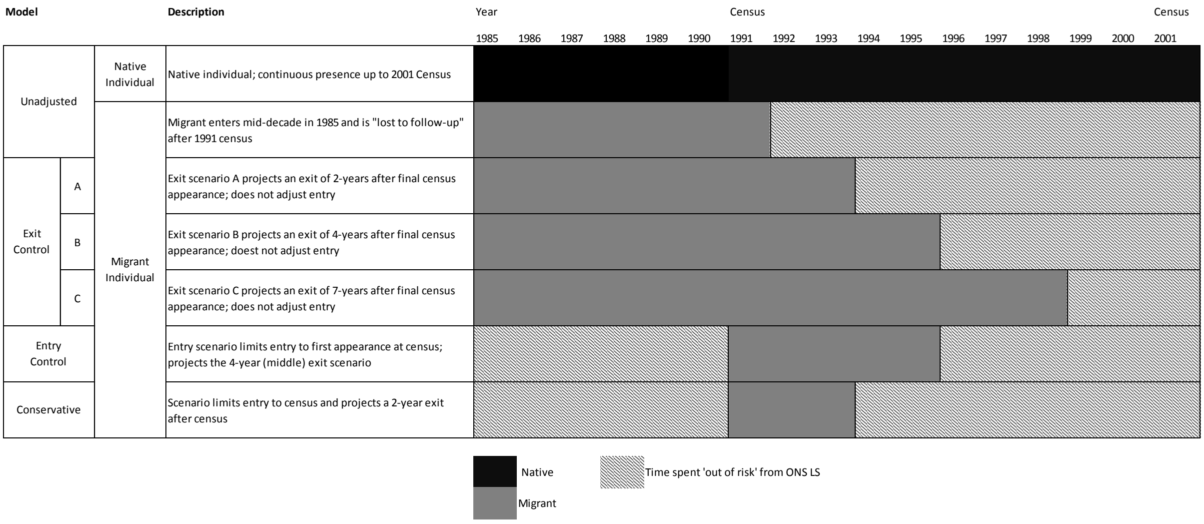

Figure 1. Scenarios for addressing exit and entry uncertainty in the ONS LS.

Defining first generation immigrants

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

Individuals whose modes are tied between a U.K 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 (in 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 are unable to study these individuals longitudinally. 623 sample members were dropped because they had inconsistent embarkation 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%) 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 an ethnic minority and country of birth other than England and Wales (ONS, 2014).

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 age interval by year interval is 5 x 10 and death rates in the ONS LS are presented relative to those from the HMD. The comparison shows that the age-specific death rates are slightly higher for the 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 three different exit scenarios for "lost to follow-up"; we control for *sex* (male and female) and *period* (1971-80, 1981-90 and 1991-2000). We refer to the model using the early (2-year) exit scenario as Model 1A, the model using the middle (4-year) exit scenario as Model 1B, and the model using the late (7-year) exit scenario as Model 1C. Model 2 fits hazard models with entry uncertainty to examine the effect of delayed registration of immigration on results. Model 3 controls for individual socioeconomic characteristics to explore whether these characteristics explain mortality differences between immigrants and natives. We include in the models as time-varying covariates *education level* (high, middle, low, unspecified or missing) and *social class* (upper, middle, lower, unspecified or missing). The distribution of risk time and death events by the categories of variables is provided in Table 3. Model 4 separates Model 3 by sex to detect any gender differences in mortality levels between immigrants and natives.

Education level is defined as high (degree and above), middle (A-level or 16+ qualifications), low (GCSE and below) and missing. 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 (the 2001 Census) whereby the limit is 75 years (Figure 1). This

[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.

ensures comparability between natives and the immigrant population under investigation. Our final research population consists of 453,352 individuals.

Results

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

Model 2 (Table 5) controls for sex, period and country of birth and controls entry, limiting onset of risk to first appearance at census. For those "lost to follow-up" the model projects the middle (4-year) exit scenario. Mortality levels are slightly higher for immigrants compared to model 1B as we deflate the denominator by limiting entry to first appearance at census. Again we find higher mortality levels for Scotland, the Irish Republic and Northern Ireland and lower mortality rates 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 the entry time for immigrants.

Model 3 (Table 6) 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 also declined over time. Once we control for the individual education and social class the advantage of immigrants becomes pronounced; most immigrants now have lower mortality rates than natives. Lower mortality levels are observed for immigrants from 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 those of the native-born population. A small decrease in relative mortality rates can be observed for Northern Ireland and the Irish Republic.

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[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).

Model 4 (Table 7) controls for period, country of birth, education level and social class. The model does not control entry, projects the 4-year exit scenario for those "lost to follow-up" and runs separate analysis by sex. We see low mortality levels for both males and females from India, Pakistan, Bangladesh, Western Europe and Other Asia. We also observe significantly lower mortality rates for Other Caribbean men, East and South African men and Chinese women. For Jamaicans we find marked differences by sex. While Jamaican males have significantly lower mortality rates than natives, females show significantly higher mortality levels. Both males and females from Scotland, Northern Ireland and Ireland show higher mortality levels than the native-born population though some differences are not significant.

Discussion

Our analysis shows that most international migrants have lower mortality than England and Wales natives; though we do see some heterogeneity. Mortality differences between natives and migrants largely persist when we adjust models to entry and exit uncertainty and they become pronounced once we control for socioeconomic characteristics of population. Our further analysis showed declining mortality differences between natives and migrants by increasing age, but most migrants had lower mortality than natives in all ages. Our study supports low mortality among most immigrants and shows that the results are not data artefact. The findings are largely consistent with previous studies and lend further weight to explanations of selection effects and protective health behaviours.

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 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, 2009). Individuals have to be socially-adept, resilient and embrace risk in order to succeed in the establishment of new migrant communities and networks in the host country.

Following the successful establishment of new migrant communities, continuing self-selection among individuals from the origin countries is likely to contribute to the persistent low mortality of migrants in England and Wales. Migrants' self-select for both good health (and future mortality risk) and appropriate personality traits (the resolve, determination and capacity to successfully migrate). Initial self-selection may then be accentuated by the return migration of individuals who are already unwell, or alternatively of those who do not cope well economically or socially and 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).

Health behaviours of migrants can also account for variation in mortality patterns. The protective effect of diet is often emphasised (particularly Mediterranean and Chinese), especially those which consist chiefly of fruit, vegetables and fibre. Obesity prevalence is lower among men from India, Pakistan, Bangladesh, Africa and men and women from China (NOO, 2011). Natives in England and Wales also have one of the highest alcohol consumption rates per capita in the world while India, Pakistan, and Bangladesh have some of the lowest. Additionally, cigarette consumption per capita in England and Wales is higher than in many of the countries under study. These variations reflect distinct cultural attitudes and lifestyle choices. While these behaviours can change over time through acculturation to host society norms, there is evidence of cultural pluralism. As long as a cultural buffer is maintained and assuming origin habits promote good health, migrants will benefit doubly from favourable origin country habits and the efficiency of the health care system in the host country (Khlat and Darmon, 2003). Individuals will retain better health status and a low future mortality risk.

We find consistent similarities by sex across countries of birth. Despite the different reasons for migration (e.g. employment versus family), both males and females are a select group for many of the countries under study. However, some differences do exist. We see comparatively lower mortality among females from India, Western Europe and China, and males from Jamaica, Other Caribbean and East and Southern Africa; though rates for all sexes in these groups fall below the native baseline. However, mortality among Jamaican females is actually higher than that for natives. We attribute this to diet and obesity. Black Caribbean women have greater obesity prevalence than Black Caribbean males *and* natives (NOO, 2011). Greater obesity may lead to excess female mortality from weight-related diseases. This is an issue that needs to be further investigated. The analysis of cause-specific mortality could significantly improve our understanding of gender differences in mortality for Jamaican immigrants in England and Wales.

We find immigrants from neighbouring countries (Scotland, Northern Ireland and the Irish Republic) have higher mortality than the England and Wales population. This high mortality persists across sensitivity models and after socioeconomic control. Results are consistent with previous mortality literature which documents raised mortality for first-generation, neighbouring migrants from Scotland, Northern Ireland and the Irish Republic. Similar patterns have also been noted for Finns migrating to neighbouring Sweden (Sundquist and Johansson, 1997). 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 other parts of the British Isles have higher mortality than natives in England and Wales, they may still have better health than the population of origin and are thus a select group (Wallace and Kulu 2013).

Our results are consistent with Scott and Timaeus' (2013) recent study on mortality differentials by ethnicity in England and Wales. Though there are differences in the scope and design of the two studies, we see notable similarities in results. We, like Scott and Timaeus, 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-based study. However, results for international migrants are only comparable with Wild et al's early age SMRs (age 20-44); with the study documenting the deterioration of most migrant mortality advantages after age 45. Our further analysis showed declining mortality differences between natives and migrants by increasing age, but most migrants had lower mortality in all ages. More generally, findings from this study provide further support to low mortality among immigrants in the United Kingdom and, most importantly, show that this is not a data artefact.

The study is limited to comparisons between immigrants and the native-born; arguably a more suitable reference group is non-migrants from the origin country (Rubalcava et al., 2008). Second, while we can study mortality of immigrants after arrival in the host country we do not study the health and selectivity of immigrants prior to migration (Rubalcava et al., 2008). Despite these limitations, determining the mortality of immigrant groups in the host country is of public health concern (Jayaweera, 2011). The increasing size and diversity of the proportion of the UK population who were born overseas have important implications for meeting health needs and for planning and delivering health services (Jayaweera, 2010). Moreover, this is one of the few studies in the estimation of migrant mortality which can conclusively state that low mortality remains for most international immigrants in England and Wales after comprehensive control for entry uncertainty, exit uncertainty and (documented) embarkations and re-entries into the host country. Future research could look beyond all-cause mortality to cause-specific mortality and utilise data on duration of residence in the ONS Longitudinal Study to test theories of acculturation.

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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]

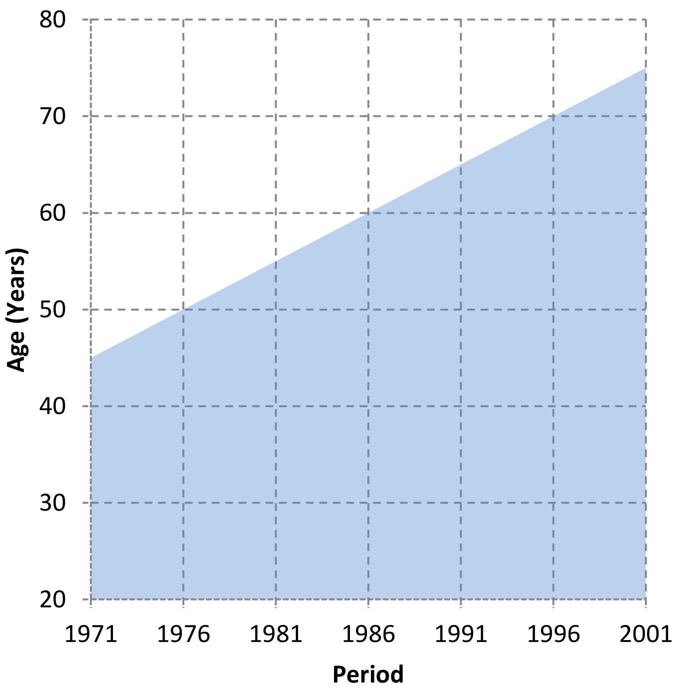

Figure 1. Research population by age and period.

[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).

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

	1971-80				1981-90				1991-00			
Age	HMD	<	LS	>	HMD	<	LS	>	HMD	<	LS	>
20	1.00	1.10	1.25	1.42	1.00	0.87	0.98	1.10	1.00	0.84	0.97	1.12
25	1.00	0.99	1.12	1.27	1.00	0.84	0.94	1.05	1.00	0.92	1.05	1.21
30	1.00	0.90	1.00	1.11	1.00	0.86	0.95	1.06	1.00	0.95	1.07	1.21
35	1.00	1.02	1.13	1.24	1.00	0.97	1.06	1.17	1.00	0.97	1.08	1.21
40	1.00	1.03	1.11	1.20	1.00	0.98	1.06	1.14	1.00	0.96	1.04	1.14
45	1.00	1.02	1.08	1.14	1.00	1.04	1.11	1.18	1.00	1.02	1.09	1.17
50	1.00	1.01	1.05	1.10	1.00	1.07	1.12	1.17	1.00	1.05	1.11	1.18
55	1.00	0.98	1.02	1.05	1.00	1.05	1.08	1.12	1.00	1.03	1.08	1.13
60	1.00	0.99	1.01	1.04	1.00	1.01	1.04	1.07	1.00	1.06	1.10	1.14
65	1.00	0.99	1.01	1.03	1.00	1.01	1.03	1.05	1.00	1.06	1.09	1.12
70	1.00	1.00	1.02	1.04	1.00	1.01	1.03	1.05	1.00	1.03	1.05	1.08
75	1.00	1.00	1.02	1.04	1.00	1.00	1.02	1.04	1.00	1.01	1.03	1.05
80	1.00	1.01	1.03	1.05	1.00	1.00	1.02	1.04	1.00	1.03	1.05	1.07
85	1.00	1.00	1.02	1.05	1.00	1.01	1.03	1.06	1.00	1.00	1.02	1.04
90	1.00	0.95	0.98	1.01	1.00	0.93	0.95	0.98	1.00	0.91	0.93	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
Age				**Sex**			
20-4	13,738,972	14	695	Male	50,440,288	50	16,467
25-9	14,160,002	14	753	Female	50,564,447	50	10,233
30-4	13,808,115	14	944	**Period**			
35-9	13,096,548	13	1,195	1971-80	24,192,900	24	3,084
40-4	12,419,201	12	1,905	1981-90	34,984,630	35	7,452
45-9	11,142,316	11	2,804	1991-00	41,827,205	41	16,164
50-4	8,795,236	9	3,554	**Country of birth**			
55-9	6,369,754	6	4,281	England	87,617,074	87	22,843
60-4	4,291,723	4	4,608	Scotland	1,814,278	2	678
65-9	2,415,792	2	3,974	Northern Ireland	537,772	1	210
70+	767,076	1	1,987	Irish Republic	1,513,422	1	663
Education				India	1,879,303	2	513
High	5,748,367	6	896	Pakistan	990,901	1	177
Middle	6,916,052	7	1,121	Bangladesh	360,518	0	71
Low	80,873,985	80	22,407	Jamaica	538,880	1	217
Unspecified	1,402,382	1	140	Other Caribbean	406,388	0	111
Missing	6,063,949	6	2,136	E&S Africa	765,898	1	113
Social Class				W&C Africa	291,717	0	51
Upper	19,352,876	19	4,331	W Europe	1,225,456	1	231
Middle	47,242,431	47	11,843	E Europe	368,337	0	198
Lower	5,030,607	5	1,736	China	235,928	0	47
Unspecified	23,314,872	23	6,654	Other Asia	520,028	1	69
Missing	6,063,949	6	2,136	Rest of World	1,704,563	2	385
				Unresolvable	234,272	0	123
Total	101,004,735	100	26,700	**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								
	[A]			[B]			[C]		
Covariates	Hazard Ratio	95% CI	Sig	Hazard Ratio	95% CI	Sig	Hazard Ratio	95% CI	Sig
Sex									
Male	1.00			1.00			1.00		
Female	0.61	0.59 - 0.62	***	0.61	0.59 - 0.62	***	0.61	0.59 - 0.62	***
Period									
1971	1.00			1.00			1.00		
1981	0.91	0.87 - 0.95	***	0.91	0.87 - 0.95	***	0.90	0.86 - 0.94	***
1991	0.87	0.83 - 0.91	***	0.86	0.82 - 0.90	***	0.84	0.80 - 0.88	***
Country of birth									
England and Wales	1.00			1.00			1.00		
Scotland	1.30	1.20 - 1.40	***	1.28	1.19 - 1.38	***	1.26	1.16 - 1.36	***
Northern Ireland	1.28	1.12 - 1.47	***	1.27	1.11 - 1.46	***	1.25	1.09 - 1.43	***
Irish Republic	1.24	1.14 - 1.33	***	1.22	1.13 - 1.31	***	1.18	1.09 - 1.28	***
India	1.00	0.91 - 1.09		0.98	0.90 - 1.07		0.95	0.87 - 1.04	
Pakistan	0.87	0.75 - 1.01	*	0.85	0.73 - 0.99	**	0.81	0.70 - 0.94	***
Bangladesh	0.85	0.68 - 1.08		0.83	0.66 - 1.05		0.79	0.62 - 0.99	**
Jamaica	1.13	0.98 - 1.29	*	1.09	0.96 - 1.25		1.04	0.91 - 1.19	
Other Caribbean	0.93	0.77 - 1.13		0.90	0.75 - 1.09		0.86	0.71 - 1.03	
E&S Africa	0.90	0.75 - 1.08		0.89	0.74 - 1.07		0.87	0.72 - 1.04	
W&C Africa	0.99	0.75 - 1.30		0.95	0.72 - 1.25		0.88	0.67 - 1.16	
W Europe	0.72	0.63 - 0.82	***	0.70	0.62 - 0.80	***	0.68	0.60 - 0.78	***
E Europe	1.05	0.91 - 1.20		1.03	0.90 - 1.19		1.01	0.88 - 1.17	
China	0.86	0.64 - 1.14		0.83	0.63 - 1.11		0.80	0.60 - 1.06	
Other Asia	0.74	0.58 - 0.94	**	0.72	0.57 - 0.91	***	0.69	0.55 - 0.88	***
Rest of World	0.98	0.89 - 1.09		0.96	0.87 - 1.06		0.91	0.83 - 1.01	*
Unresolvable	2.06	1.72 - 2.45	***	1.99	1.66 - 2.37	***	1.87	1.56 - 2.23	*** [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 (those who do not record an exit but do not appear at the next census(es)). The scenarios are based on the empirical distribution of known exits of individuals from the ONS LS. 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.

Table 5. Hazard ratios of mortality of immigrants compared with natives in England and Wales. Control for entry uncertainty.

Model 2			
Covariates	Hazard Ratio	95% CI	Sig
Sex			
Male	1.00		
Female	0.61	0.59 - 0.62	***
Period			
1971	1.00		
1981	0.90	0.86 - 0.94	***
1991	0.85	0.82 - 0.89	***
Country of birth			
England and Wales	1.00		
Scotland	1.29	1.20 - 1.40	***
Northern Ireland	1.31	1.14 - 1.50	***
Irish Republic	1.24	1.15 - 1.34	***
India	1.04	0.95 - 1.13	
Pakistan	0.92	0.79 - 1.06	
Bangladesh	0.94	0.75 - 1.19	
Jamaica	1.11	0.97 - 1.26	
Other Caribbean	0.93	0.77 - 1.12	
E&S Africa	1.00	0.83 - 1.20	
W&C Africa	1.10	0.84 - 1.45	
W Europe	0.73	0.64 - 0.83	***
E Europe	1.07	0.93 - 1.23	
China	0.92	0.69 - 1.22	
Other Asia	0.82	0.65 - 1.04	
Rest of World	1.04	0.94 - 1.15	
Unresolvable	2.06	1.73 - 2.46	***[5]

[5] >*Source:* Authors' calculations based on the ONS LS.
>Significance levels at 1% (***) 5% (**) and 10% (*).
>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. Resultantly, the model to which results should be compared is Model 1B.

Table 6. Hazard ratios of mortality of immigrants compared with natives in England and Wales. Control for socioeconomic characteristics.

Model 3			
Covariates	Hazard Ratio	95% CI	Sig
Sex			
Male	1.00		
Female	0.49	0.48 - 0.50	***
Period			
1971	1.00		
1981	0.92	0.89 - 0.97	***
1991	0.88	0.85 - 0.93	***
Country of birth			
England and Wales	1.00		
Scotland	1.28	1.19 - 1.39	***
Northern Ireland	1.22	1.06 - 1.39	***
Irish Republic	1.11	1.02 - 1.20	***
India	0.89	0.81 - 0.97	***
Pakistan	0.69	0.59 - 0.79	***
Bangladesh	0.62	0.49 - 0.78	***
Jamaica	0.97	0.84 - 1.10	
Other Caribbean	0.85	0.70 - 1.02	*
E&S Africa	0.82	0.68 - 0.98	**
W&C Africa	0.84	0.64 - 1.10	
W Europe	0.68	0.60 - 0.78	***
E Europe	0.96	0.84 - 1.11	
China	0.75	0.56 - 0.99	**
Other Asia	0.68	0.54 - 0.86	***
Rest of World	0.89	0.81 - 0.99	**
Unresolvable	1.61	1.35 - 1.93	***
Education			
High	1.00		
Middle	1.19	1.09 - 1.31	***
Low	1.57	1.46 - 1.68	***
Unspecified	1.81	1.50 - 2.17	***
Missing	3.13	2.90 - 3.39	***
Social Class			
High	1.00		
Middle	1.21	1.17 - 1.26	***
Lower	1.52	1.43 - 1.61	***
Unspecified	2.20	2.11 - 2.30	***
Missing	*Omitted*		[6]

[6] >*Source:* Authors' calculations based on the ONS LS.
>Significance levels at 1% (***) 5% (**) and 10% (*).
>Model 3 controls 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 should be compared to Model 1B.

Table 7. Relative hazard ratios of mortality of immigrants compared with natives in England and Wales. Control for socioeconomic characteristics.

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

[7]

[7] >*Source:* Authors' calculations based on the ONS LS.
>Reference categories: Period: 1971; Country of birth: England and Wales; Education level: high; Social Class: Upper.
>Significance levels at 1% (***) 5% (**) and 10% (*).
>Model 4 runs under the same controls as Model 3 (4-year exit for lost to follow-up and no entry control) but runs analysis separately by male and female.