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Research Article

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Abstract

BACKGROUND
Differences in all-cause mortality between immigrants and host populations may provide insight into health inequities that could be reduced.

OBJECTIVE
Death risks of adult immigrants were compared to those of the host population to assess effects of country of origin, duration of residence, calendar period, and sociodemographic characteristics, i.e., sex, education, and marital and parental status.

METHODS
Registry data encompassing the entire Norwegian population age 25–79 in 1990–2012 were used to compare death risks in various immigrant groups and the host population, using discrete-time hazard regression models with time-varying covariates.

RESULTS
Over 451,000 deaths occurred in around 4.4 million individuals. After adjusting for sex, age, and calendar period, immigrants had an 8% survival advantage (odds ratio (OR) 0.92). Death-risk estimates for immigrants were lowered pronouncedly by further adjustment of sociodemographic factors (OR 0.81). The greatest survival advantage was observed among immigrants with a short duration of residence. With increasing lengths of stay, immigrants' risk of death became similar to that of the host population. The

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survival advantage was most pronounced for younger, unmarried, and childless immigrants. Although the survival of Central and Eastern European immigrants improved over time, none of the groups had a higher adjusted death risk than the host population.

CONCLUSIONS
Immigrants have a 20% survival advantage compared to the host population. The convergence in mortality with increasing duration of residence suggests that 'healthy migrant' and 'acculturation' effects counteract each other, and warrants further research on the health and welfare of long-term immigrants.

1. Introduction

Mortality is an indicator of health and disease risk (Razum et al. 1998). Studying differences in mortality between migrant and minority groups and the majority population might improve our understanding of the underlying mechanism. Mortality data from migrant groups in Norway could provide us with important insights, as there is a scarcity of data from Nordic countries. Secondly, in contrast to other Nordic welfare societies like Sweden, which has a longer period of immigration, Norway has seen a rapid rise in the migrant population, from negligible a few decades ago to a substantial part of the population being foreign-born today (14%). In an international context, Norway thus has a short immigration history and a comparatively late aging of the immigrant population. Furthermore, immigrant flows have been relatively fragmented, resulting in fluctuating stocks of immigrants, varying over time. This has resulted in large heterogeneity in the immigrant pool. In the past decade a large proportion of migrants have originated from low-income and/or Eastern European countries (Statistics Norway 2016). Given the origins of recent migrants, it might be assumed they are disadvantaged compared to the host population and therefore have poorer health or, on the contrary, that their health potential is better.

Besides being dynamic and heterogeneous, until recently the immigrant population has not been sufficiently numerous to warrant studies examining differences in Norwegian mortality. The Norwegian context is particularly interesting due to the country's egalitarian welfare policies, including freely available health care. Furthermore, social and gender equity policies have resulted in lower levels of inequality than elsewhere.

1.1 The Norwegian setting

The immigrant population in Norway, comprising immigrants and their descendants, has gradually increased from 1% in the early 1970s to 15% today (Statistics Norway 2016). It is expected to continue to increase quite substantially over the coming years (Cappelen, Skjerpen, and Tønnessen 2015). Norway's immigration policy was fairly liberal post-World War II. In the 1950s, immigrants comprised around 1% of the population and were mostly from Sweden, followed by refugees from Eastern Europe and thereafter by labor immigrants from other parts of the world. The post-1975 freeze on labor migrants meant that majority of migrants to Norway thereafter were refugees from Asia, Africa, South America, and Eastern Europe. However, with the expansion of the European Union (EU) in 2004 there was a marked increase in labor immigration from new EU countries, particularly Poland and Lithuania. The history of migration to Norway shows that the reasons for migration have varied over time, thereby influencing the composition of the immigrant population in Norway. For the study period 1990–2012, family reunification, employment, education, and refuge from conflict, political oppression, persecution, and natural disasters represented 39%, 31%, 6%, and 22% of the reasons for immigration, respectively.

Over the past five years the immigrant population in Norway has increased by almost 50%, from 552,000 to 804,000 (Statistics Norway 2016). Norway's immigrant population is heterogeneous and migrants originate from 221 different countries with the largest groups coming from Poland, Sweden, Somalia, Lithuania, Pakistan, and Iraq. In 2014 the largest groups arrived from Poland, Lithuania, and Eritrea.

Despite the dramatic rise in migration, Norway is not the first country of choice for many migrants. As was previously the case, most migrants prefer the UK, Germany, and/or Switzerland (IOM 2015). Norway has not been a colonial power and therefore has no migration from former colonies, as in the Netherlands and the UK. Furthermore, prior to finding oil in 1970 Norway was a relatively poor country, which, together with a cold, harsh climate, may have deterred migration. Lastly, Norway is not the first port of entry to Europe so migrants to the country must actively choose Norway as their destination. On the other hand, contrary to the situation in several other European countries, immigrants in Norway have generally the same legal rights as the host population. However, in many cases legal rights are not sufficient to ensure equitable provision of services such as health care and education. The Migrant Integration Policy Index (MIPEX) provides an overview of migrant opportunities to participate in societies cross-nationally. The recent MIPEX health strand (2015) ranks Norway in fourth place overall, suggesting that the country fares relatively well across many areas of welfare.

Using data from Norwegian administrative registers, we investigated adult death risks in various immigrant groups compared to the host population in the period 1990–2012.

2. Theoretical perspectives explaining mortality differences

The mortality of immigrants may differ from that of the host population due to: i) selection; ii) acculturation, social status, and social causation; and/or iii) data artefact. These mechanisms may contribute to a reduced or elevated mortality among immigrants, and may counteract one another, as outlined below.

2.1 Selection

Migrants are not usually representative of the general population in their country of origin, but represent selected groups. There are several types of selection. For instance, some studies suggest that resourceful people are most likely to migrate to other destinations (see e.g., Lindstrom and Ramirez 2010). Selection could also be based on health status, but there are arguments for both directions of its effect (Argeseanu, Ruben, and Narayan 2008; Choi 2012; Kibele, Scholz, and Shkolnikov 2008; Ng 2011). The 'healthy migrant' hypothesis prevails (Omariba, Ng, and Vissandjee 2014; Wallace and Kulu 2014), suggesting a lower mortality for migrants that may be the result of a positive health self-selection (Buckely, Hofman, and Minagawa 2011). Primarily healthy people decide to migrate, especially if the reasons for migration relate to education or work (skilled and unskilled labor). On the other hand, health self-selection might be negative, i.e., people with illness migrate hoping for better treatment in the destination country (Davies et al. 2011; McDonald and Kennedy 2004; Ronellenfitsch et al. 2006). This is also the case for involuntary migration (refugees), as their health may have been adversely affected prior to and/or after migration (DesMeules et al. 2005; Hollander 2013; Hollander et al. 2012; Norredam et al. 2012). Another theory suggests that as migrants age or fall ill they migrate back to their country of origin to die, and this phenomenon is commonly referred to as the 'salmon bias hypothesis' (Lu and Qin 2014).

2.2 Acculturation, social status, and social causation

Health behaviors and healthcare utilization vary considerably depending upon country of origin, duration of residence, and degree of acculturation in the host country. Many health behaviors that relate to mortality, such as smoking, alcohol use, nutritional intake, and physical activity, have been shown to vary between immigrants and the host population (see e.g., Bennett 1993; Blue and Fenelon 2011; Singh and Siahpush 2002; Wandel 1993). Immigrants may adopt some of the habits of the host population and this may increase or decrease mortality, depending on the prevalence of the behavior in question in the country of origin relative to that in the host population (i.e., whether migrants move from a low risk to a high risk country or vice versa). In general, immigrants to European countries tend to drink less alcohol than the host population, concurrent with earlier Norwegian findings (Kumar et al. 2008; Salas-Wright et al. 2014). On the other hand, some studies show that some immigrant groups are more likely to smoke, less physically active, and obese (Carlsson et al. 2014; Westerling and Rosen 2002), and this too concurs with a Norwegian Study (Kumar et al. 2008). However, research also shows that although immigrants' risk of adopting unhealthy behaviors increases with duration of residence, they remain below the national average (Blue and Fenelon 2011; Singh and Siahpush 2002).

When health entitlements are different in the country of origin and the host country, immigrants seem to delay seeking health care, as they are unfamiliar with how the services function (De Luca, Ponzo, and Andres 2013; Siddiqi, Zuberi, and Nguyen 2009). For instance, immigrants in Norway are less likely than the host population to seek somatic and/or mental primary care for both ordinary and emergency purposes, but substantial variation is observed according to country of origin, reason for immigration, and duration of residence (Diaz et al. 2014; Sandvik, Hunskaar, and Diaz 2012; Straiton, Reneflot, and Diaz 2014). Furthermore, some immigrants tend to use prescription medication incorrectly (Hakonsen, Lees, and Toverud 2014; Hakonsen and Toverud 2012). Under-utilization of health care services among immigrants has been observed in several countries, both where health care is universally available and where private insurance systems prevail (De Luca, Ponzo, and Andres 2013; Siddiqi, Zuberi, and Nguyen 2009).

Health behavior varies across sociodemographic groups. Literature documents that smoking is less common and recreational physical activity more common among highly educated individuals as compared to those with lower levels of education (Ross and Mirowsky 1999). Married individuals and parents lean towards healthier behavior and seek healthcare more readily, explained in part by selection and in part by social control (Kravdal 2001, 2003). However, such patterns may vary between host population and the various migrant groups. In our study, data on health behavior are unavailable, but

detailed longitudinal sociodemographic characteristics relating to migration and health status have been accounted for.

Social status or socioeconomic position is highly correlated with mortality, and the composition of immigrants and hosts across important dimensions such as education, income, marital status, and number of children differ considerably. However, as immigrants in Norway are a heterogeneous group with different and changing social status, the well-established links between mortality and education and marital status and parenthood might not play as important a role (see e.g., Dunn and Dyck 2000). On the other hand, taking sociodemographic characteristics into account might contribute to conceal differences between groups of immigrants, in particular related to the reason for migration (Klinthall and Lindstrom 2011).

Despite accounting for education, marital status, and the number of children, as we do in our study, some argue that the health of immigrants is negatively affected by the fact that they are immigrants and thus represent a disadvantaged group over and above the disadvantages experienced from conventionally measured socioeconomic factors such as education, income, and occupational class. This phenomenon is referred to as social causation (Marmot, Kogevinas, and Elston 1987). This is illustrated by the following example: highly educated immigrants who move to Norway tend to earn less than Norwegians with similar levels of education because they often end up in jobs not relevant to their education (Villund 2014).

2.3 Data artefact

Data artefacts are common in studies on immigrant populations, including registration errors resulting from inaccurate registration of movement between the country of origin and the host country. In particular, a lack of out-registration when immigrants emigrate is common. Immigrants may simply forget to register an exit or have an incentive to remain in host population registers (Weitoft et al. 1999). Immigrants who have left the country but remain in the host population register thus become statistically 'immortal' if they die elsewhere, and continue to age in the host country's official statistics (Kibele, Scholz, and Shkolnikov 2008). This kind of data artefact biases results towards lower mortality among immigrants, as out-migration is more common among immigrants than the host population. Other common errors include misreporting of age and/or misclassification of country of origin or education.

Although Norwegian population registers are of very high quality, incomplete or incorrect registration of information on immigrants, in particular emigration status and educational attainment, raises some concerns (see 'Strengths and limitations'). To account for possible variation in the registration of emigration, we assessed death risks

in various age groups and among immigrants of various lengths of residence. We also examined death risks of immigrants from different countries and/or country groups separately, as countries of origin largely correlate with the reason for immigration and the possibility of return migration.

2.4 Hypotheses and aim

The theories described above may influence mortality in different ways, although not in consistent directions. Whereas positive health selection and/or data artefacts could be associated with lower immigrant mortality, a negative acculturation process or negative social causation could be associated with higher immigrant mortality. As multiple mechanisms are likely to operate to varying degrees at different times and are likely to be specific for the host country and its population in particular, to hypothesize the overall impact of these mechanisms on immigrants' mortality is challenging.

As Norway was not a country of choice for migrants until recently (IOM 2015), the positive selection hypothesis may be less pronounced today compared to earlier. We thus expect to observe a convergence in mortality between hosts and recent immigrants, adjusted for duration of residence. We opted to include interaction terms for sociodemographic characteristics, as prior research has shown that these factors greatly influence mortality for both immigrants and non-immigrants. As we lack information on reasons for immigration, these variables may be used as proxies to help distinguish between, for instance, immigrants in Norway for educational purposes (often unmarried, childless, and highly educated) or family reunion (often married, with children and a lower education), especially within nativity groups where migrants have come to Norway for different reasons. Lastly, these characteristics are all linked to health behaviors, but perhaps differently across nativity groups. The aim of this study is to compare adult all-cause death risks in immigrants and the host population, by sex, age, and calendar period, taking important socioeconomic factors such as education and marital and parental status into account. A data set consisting of around 4.4 million individuals age 25–79 enables us to describe differences in risk for first- versus second-generation immigrants, and risks across nativity groups and duration of residence.

3. Existing research

Most previous research has shown immigrants to have lower all-cause mortality compared to host populations. In Europe this has been documented for England and Wales (Wallace and Kulu 2014), Germany (Razum et al. 1998; Ronellenfitsch et al.

2006), France (Boulogne et al. 2012; Courbage and Khlat 1996), Spain (Moncho et al. 2015), and Belgium (Anson 2004), among others. The predominant pattern of lower immigrant all-cause mortality is observed also in high-income countries outside of Europe, such as New Zealand (Hajat et al. 2010), Canada (McDonald and Kennedy 2004), and the U.S. (Argeseanu, Ruben, and Narayan 2008; Blue and Fenelon 2011; Choi 2012; Singh and Miller 2004; Singh and Siahpush 2002). With the exception of Singh and Miller (2004), the aforementioned studies suggest protective effects of a similar magnitude for male and female immigrants.

On the contrary, some research suggests that certain immigrant groups have poorer health and/or elevated mortality than that of their host populations (Albin et al. 2005; Bos et al. 2004). This has been attributed to stress, trauma, and other health-related exposures in the migration process, such as changes and (adjustment to) lower socioeconomic position (Bos et al. 2004; Boulogne et al. 2012).

The Nordic countries are all egalitarian welfare states, and have received immigrants from similar sending countries during the last decades. Lower all-cause mortality of immigrants has been documented in Sweden and Denmark (Gadd et al. 2006; Norredam et al. 2012). The specific risks, however, vary between different ethnic groups (Norredam et al. 2012), and some groups have been shown to have a higher or similar mortality (Albin et al. 2005; Norredam et al. 2012). A recent study on the impact of immigration on educational mortality in Norway found that the mortality of lower-educated immigrants was lower than that of similarly educated hosts (Elstad, Øverbye, and Dahl 2015).

The evidence from the theoretical background and an empirical review of existing studies is conflicting. In addition, there are notable gaps in the literature on immigrants' health and mortality, particularly in egalitarian welfare states with free public healthcare. Our study will contribute information on differences between various immigrant groups as well as the impact of duration of residence. We will describe the influence of sociodemographic characteristics such as sex, age, educational level, and family situation, and discuss the mechanisms most likely to play a role.

4. Data and methods

4.1 Data

The Norwegian Population Registry provides information on all Norwegian residents from 1960 onwards. Variables from this database include dates of birth, death, immigration, and emigration, sex and country of origin. Children of immigrants were assigned their mothers' country of origin. Data on yearly marital status and the number

of children was also extracted, and level of education was drawn from the National Education Database. The unique personal identification number assigned to all Norwegian citizens and immigrants with legal residence status enabled linkage of the registries. Approval to link data was granted after ethical review by the Norwegian Board of Medical Ethics.

4.2 Variables and categorizations

Immigrant status was our primary independent variable of interest. Five different specifications were used: overall immigrant status (specification *1*); first- (foreign-born) versus second-generation immigrants (Norwegian-born with two immigrant parents) (specification *2*); country group of origin (specification *3*); select countries of origin (specification *4*); and duration of residence (specification *5*). For specification *3*, Statistics Norway's standard of classification was applied to categorize immigrants into nine groups based on country group of origin. For specification *4*, we selected the largest groups of immigrants from individual countries. The remaining population was defined as the host population, and primarily comprises residents born in Norway with two Norwegian-born parents.[6]

Potential confounding was addressed by including time-varying categorical covariates on observation period (1990–1994, 1995–1999, 2000–2004, and 2005–2012), age group (25–39, 40–49, 50–59, 60–69, and 70–79), marital status (never-married, married, and previously married, i.e., widowed, divorced, or separated) and parental status (children vs. no children), as these variables have been shown to vary across immigration groups and to impact on mortality. Persons' highest registered level of education was used, as our data has been updated with recent survey data to minimize underreporting of immigrants' education, which could lead to differential misclassification (Pedersen and Falnes-Dalheim 2012), and categorized as limited to primary education, secondary education, lower tertiary education, or higher tertiary education.

4.3 Methods

Discrete-time hazard regression models for death among more than 4.4 million persons age 25–79 and residing in Norway at some point during 1990–2012 were estimated

[6] Also included in the host population are foreign-born residents with two Norwegian-born parents, foreign-born residents with one Norwegian-born parent, and Norwegian-born residents with one foreign-born parent.

(Allison 1995). From our data, 451,379 deaths in around 67.7 million person-years of exposure were analyzed.

For each individual, a series of one-year observations was created, starting in 1990 or at time of immigration to Norway if later, or age 25 and ending at the end of 2012 or when the person died, reached age 79, or emigrated, whichever came first. We chose one-year observations for practical purposes, but three-month intervals gave similar results (not shown). Each observation included a number of variables that referred to the situation at the beginning of the year, and the outcome variable was death from any cause within the year in question. Due to observations of greater mobility among immigrants, only those registered as residents at the beginning of each observation period in question were included.

Logistic regression models were estimated, using the Proc Logistic procedure in SAS. Average marginal effects and adjusted predicted probabilities of death at representative values were computed for all immigrants and for a 10% random subsample of the hosts, using the margins command in Stata (Mood 2010; Williams 2012). The statistical significance level was set at 5%.

4.4 Model specifications

For specifications *1–3*, we ran models *a–d*. Model *a* is the basic model and includes age group and calendar period (as well as sex in joint models of men and women). Model *b* includes basic controls, but also marital and parental status. Model *c* includes basic controls and educational level. Model *d* is the fully adjusted model and includes basic controls, education, and marital and parental status. As the theoretical perspectives and empirical studies suggest, the association between various immigration characteristics and all-cause mortality may vary across age, time period, educational level, and/or family characteristics. Interaction terms between immigrant characteristics and these variables were included in additional models to assess possible effect modification. When the interaction term suggested statistical significance, a fully adjusted model (i.e., model *d*) was set up, but stratified on the variable in question. To further assess possible sociodemographic effects, adjusted predictions at representative values were calculated and plotted for a subsample, interacting age and calendar period with immigrant status.[7]

[7] To facilitate comparisons, average marginal effects for all specifications are shown in the Appendix (Table A6).

5. Results

5.1 Descriptive results

A total of 274,371 deaths occurred within 33.9 million person-years of observation for men. Corresponding figures for women were 177,008 deaths within 33.8 million person-years. First- and second-generation immigrants comprised 13.7% of the male population (N=310 883) and 16.6% of the female population (N=367 399). The average follow-up time was 15.1 years: 8.4 years for immigrants and 16.3 years for the host population. Second-generation immigrants comprise a relatively small and young part of the Norwegian population, and only 113 deaths were observed among the 12,569 registered individuals. Appendix (Table A1) shows detailed information regarding the distributions.

5.2 Overall results for immigrants versus hosts

Overall, the odds ratio (OR) of death for all immigrants compared to the host population was 0.92 (95% confidence interval (CI) 0.90–0.93), with basic adjustments (i.e., sex, age, and calendar period). Compared to the host population, the OR for male immigrants was 0.92 (CI 0.90–0.94), whereas the OR for female immigrants was 0.91 (CI 0.89–0.93). After adjustments for parental status, marital status, and educational level, hereafter referred to as sociodemographic factors, the survival advantage of immigrants as a group compared to hosts became more pronounced (OR 0.81, CI 0.79–0.82), but, relative to hosts, the effect appeared similar for male (OR 0.81, CI 0.79–0.83) and female (OR 0.82, CI 0.80–0.84) immigrants. In line with this, the interaction term between immigrant status (specification *1*) and sex was not statistically significant ($p_{interaction}$ 0.67). Compared to hosts, the point estimate of second-generation immigrants was somewhat lower than that of first-generation immigrants, but these differences were not statistically significant: the OR for first generation immigrants was 0.81 (CI 0.80–0.82), whereas the respective OR for second generation immigrants was 0.70 (CI 0.58–0.84). Compared to hosts, the relative death risk of second-generation immigrants appeared fairly similar across genders: Female second-generation immigrants had an OR of 0.60 (CI 0.42–0.86), whereas for males it was 0.74 (CI 0.60–0.92).

5.3 Results by country (group) of origin

Figure 1 compares odds ratios for death with basic controls (model *a*) and fully adjusted, i.e., with controls also for sociodemographic information (model *d*), and illustrates the impact of the covariate adjustments on the risk estimates for each country group of origin.[8] From Figure 1 it seems evident that regardless of migrant group, male migrants had a lower death risk than hosts. Among these groups, men from Nordic countries and North America/Oceania had the highest death risk, whereas men from the Middle East and Asia had the lowest. Among immigrant women, the lowest death risk was observed for those from the Middle East and Asia. The death risk for women from the Nordic, North American, and Oceanic countries was similar to that of the hosts.[9]

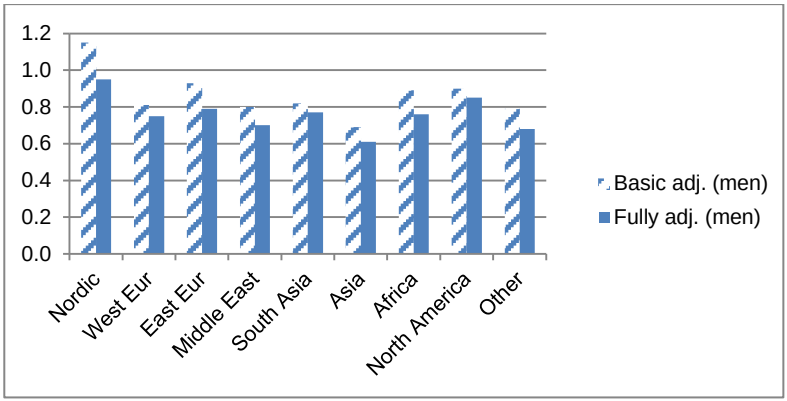
Similarly, Figure 2 and Table A4 portray death risk estimates from models *a* and *d* for immigrants from countries with the largest number of immigrants in Norway. It shows that with only basic controls, immigrants from Pakistan and Thailand had a similar death risk as the hosts (OR 1.06 and 1.00, respectively). When we also controlled for marital status, parenthood, and educational level, the estimate for Pakistanis remained similar to that of the host population (OR 0.96), whereas the estimate for Thais fell below that of the hosts (OR 0.78). Immigrants from Iran, Iraq, and Vietnam had the lowest risk.

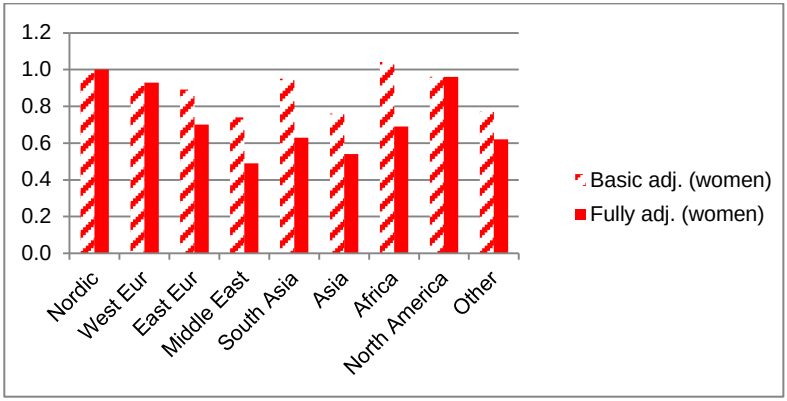
When we examined men and women separately (Table A4) the pattern remained fairly similar: Both men and women from Pakistan had a similar death risk to that of the hosts, as was the case for men from Thailand. Polish migrants constitute the largest group in the study, and their death risk is lower than that of the host population. In comparison to the other individual countries shown in Figure 2 and Table A4, the death risk of Polish men ranked low whereas that of Polish women ranked in the middle.

[8] Tables A2 and A3 in the Appendix provide the specific estimates from models *a–d*, and show that control for parental status, marital status, and educational level lowered the death risk estimates markedly, most pronouncedly for immigrants from Africa. Furthermore, the effects of the sociodemographic covariates were in line with previous research: Relative to those never-married, married individuals had a survival advantage, whereas previously married individuals had a survival disadvantage. Parenthood was associated with a survival advantage, net of the effect of marital status. Estimates for educational level showed that death risks decreased almost linearly with increasing education.

[9] In all analyses of country (group) and duration of residence, first- and second-generation immigrants are modeled jointly. However, as second-generation immigrants constitute such a small part of the immigrant population in Norway, robustness checks showed that all estimates were virtually identical when we restricted the analyses to include only first-generation immigrants (not shown, available upon request).

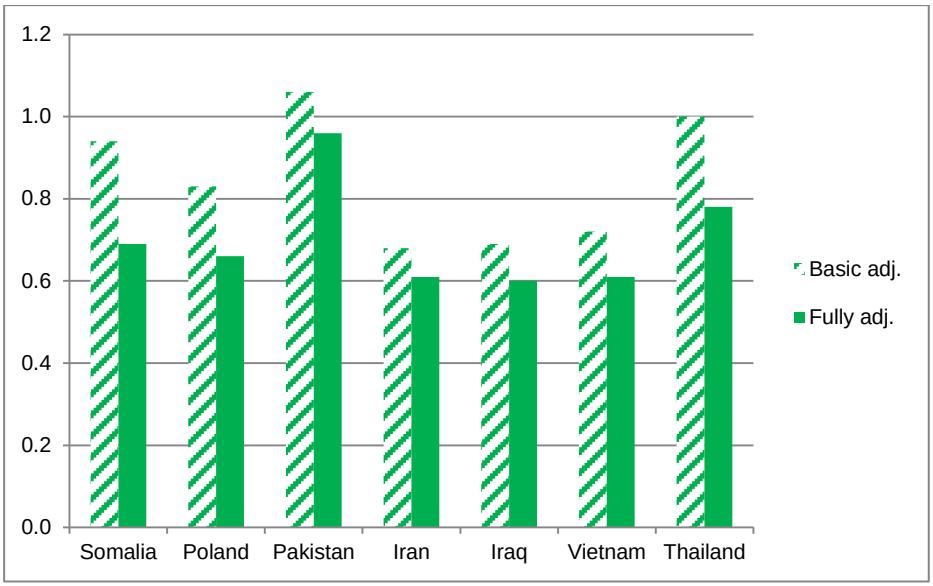
Figure 1: Death risks (ORs) for men and women by country group of origin





Note: The host population is the reference category (OR=1). Age group and calendar period represent basic adjustment, whereas full adjustment also includes education, marital and parental status.

Figure 2: Death risks (ORs) for men and women combined, by the largest individual countries of origin

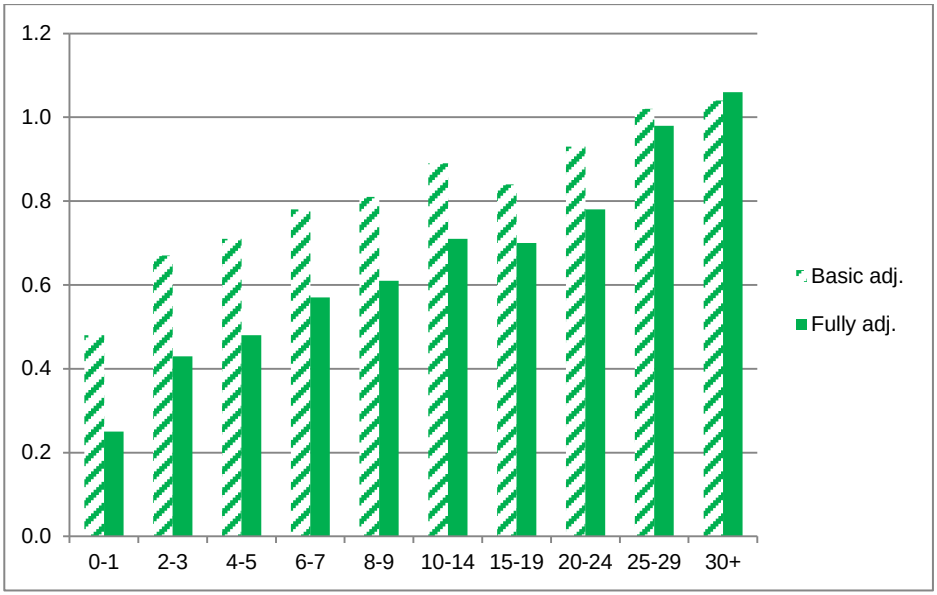


Note: The host population is the reference category (OR=1). Sex, age group and calendar period represent basic adjustment, whereas full adjustment also includes education, marital and parental status.

5.4 Duration of residence

Figure 3 and Table A5 portray risk estimates by duration of residence in Norway, and show that the comparative risk of dying increased with increasing length of residence. Newly arrived immigrants (0–1 year) had a very low death risk compared to the hosts, whereas the death risk of immigrants who had lived in Norway for 25–29 years was similar to that of the host population, and those who had lived here 30 or more years had a slightly higher death risk. Robustness checks revealed that the pattern was fairly consistent across sex, age (above and below age 60), and calendar period (Table A5). In other words, the risk of dying increased with length of residence in a similar manner for men and women and for older and younger immigrants, and the pattern was similar for the calendar periods 1990–1999 and 2000–2012.

Figure 3: Death risks (ORs) for immigrants by years of residence in Norway



Note: The host population is the reference category (OR=1). Sex, age group and calendar period represent basic adjustment, whereas full adjustment also includes education, marital and parental status.

5.5 The impact of sociodemographic factors

5.5.1 Age and calendar period

Table 1 shows the different death risks for immigrants relative to hosts by age group (25–59 years vs. 60–79 years) and calendar period (1990–1999 vs. 2000–2012). The death risk of older immigrants was more similar to that of older hosts (OR 0.85) than that of younger immigrants to younger hosts (OR 0.43), as indicated by a statistically significant interaction term between immigrant status and age group (specification *1*, model *d*, $p_{interaction} < 0.001$).

Table 1: Death risks stratified by age group and calendar period[a]

	Age < 60 years		Age ≥ 60 years		1990–1999		2000–2012	
	OR[b]	95% CI[c]	OR	95% CI	OR	95% CI	OR	95% CI
Host population	1	ref	1	ref	1	ref	1	ref
All immigrants[d]	0.43	0.42–0.44	0.85	0.83–0.86	0.82	0.80–0.84	0.78	0.77–0.80
Country group of origin[e]								
Nordic countries	0.63	0.60–0.66	0.96	0.93–0.98	0.91	0.87–0.94	0.98	0.95–1.01
West Europe	0.47	0.43–0.49	0.86	0.82–0.89	0.78	0.74–0.82	0.83	0.79–0.86
East Europe	0.34	0.32–0.35	0.87	0.83–0.90	0.86	0.80–0.91	0.68	0.65–0.71
Middle East	0.35	0.33–0.38	0.56	0.51–0.61	0.70	0.62–0.78	0.59	0.55–0.63
South Asia	0.44	0.41–0.47	0.63	0.59–0.68	0.74	0.67–0.82	0.70	0.65–0.74
Asia	0.37	0.34–0.39	0.52	0.47–0.56	0.60	0.54–0.67	0.58	0.53–0.61
Africa	0.37	0.34–0.39	0.62	0.55–0.71	0.84	0.72–0.97	0.68	0.62–0.73
North America & Oceania	0.43	0.37–0.50	1.05	0.99–1.11	0.87	0.80–0.93	0.95	0.88–1.03
Other countries	0.38	0.34–0.43	0.63	0.56–0.71	0.65	0.55–0.75	0.65	0.59–0.72

Notes: [a]This table presents stratified analyses from two fully adjusted models (model *d*, i.e., sex, age group, calendar period, educational level, marital and parental status) by age group and calendar period. The stratifying variable itself was not included in the respective model. [b]Odds ratio. '1' denotes the reference category. [c]Confidence interval. 'ref' denotes the reference category. [d]Specification *1*. [e]Specification *3*.

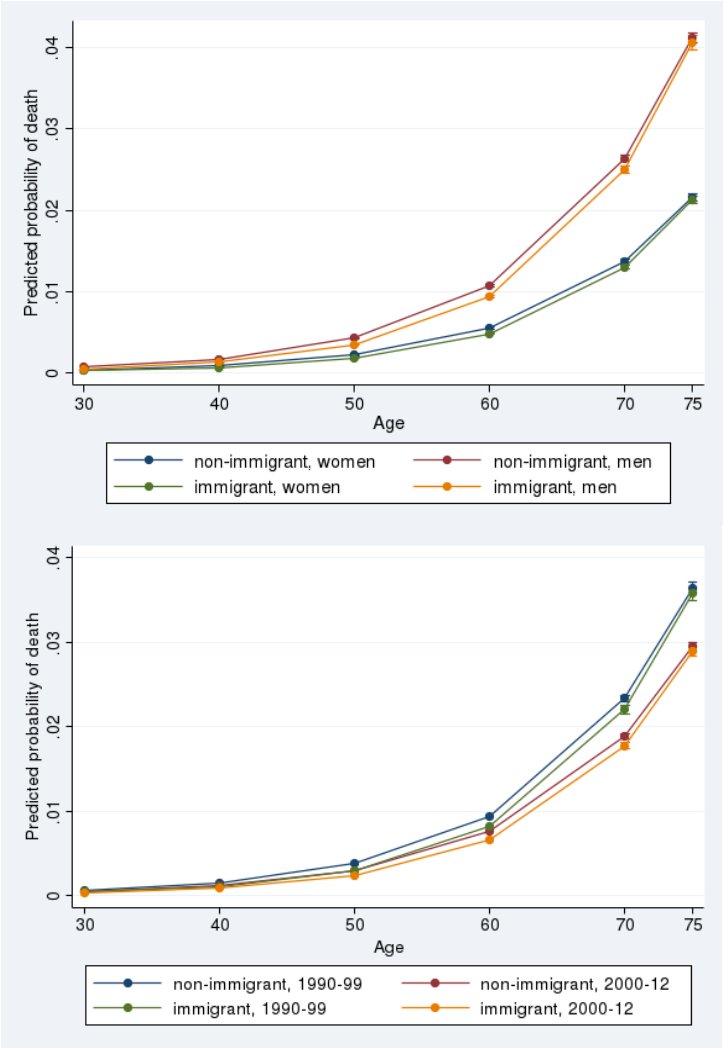
Figure 4 shows that the predicted probability of death by age is consistent across sex and calendar period, increasing with age and decreasing over time.

When we examined the impact of age by country groups, we found that the most pronounced differences in death risks between younger and older individuals were observed for immigrants from North America and Oceania (OR 0.43 for younger vs. 1.05 for older individuals) and Central and Eastern Europe (OR 0.34 for younger vs. 0.87 for older individuals). The difference between age groups was lowest among immigrants from Asia.

The interaction term between immigrant status and calendar period was not statistically significant (specification *1*, model *d*, $p_{interaction}$ 0.99). As such, the overall death risk of immigrants versus hosts was similar across the two calendar periods examined (OR 0.82 vs 0.78). This was also true across sex and age, in absolute terms, as portrayed in Figure 5.

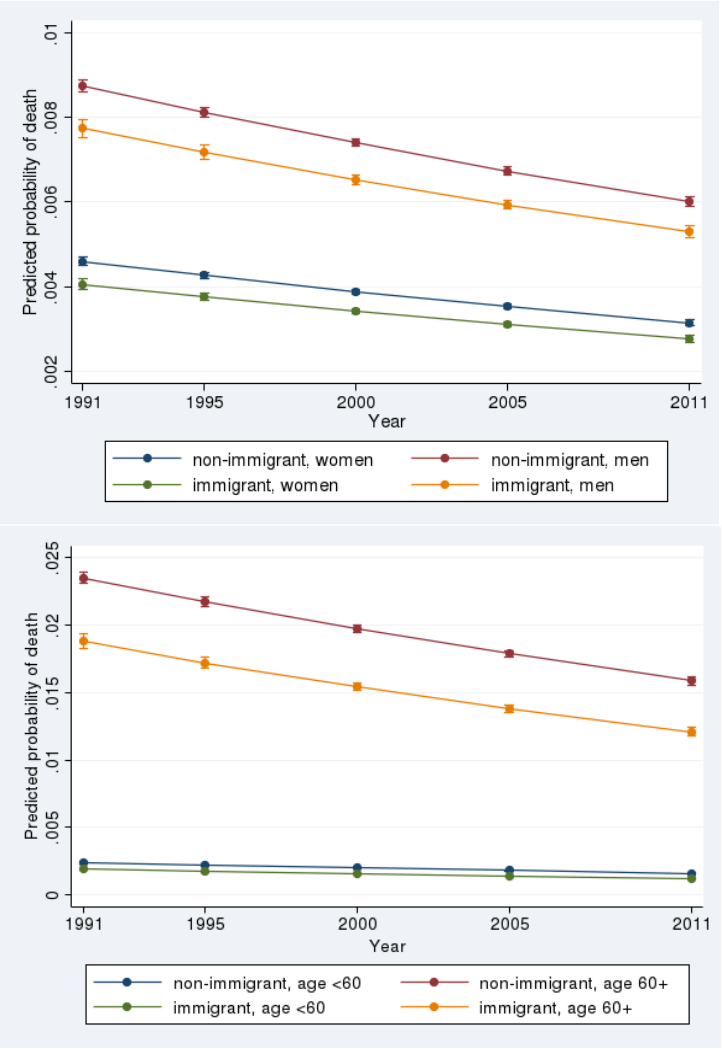
Only Central and Eastern European immigrants appear to have had better survival in the last decade compared to the previous period. The death risk of immigrants from the other Nordic countries has deteriorated over time, as shown by the latter time period where they no longer have a survival advantage compared to the host population. A similar pattern was observed for immigrants from North America and Oceania.

Figure 4: Adjusted predicted probabilities of death by age, for men and women (top) and early and late calendar periods (bottom)



Note: The adjusted predictive margins were calculated by including an interaction term between immigrant status and linear age in the fully adjusted model *d*. As such, the portrayed effects are net of covariates. 95% CIs are shown at the predicted values.

Figure 5: Adjusted predicted probabilities of death by calendar period, for men and women (top) and younger and older age (bottom)



Note: The adjusted predictive margins were calculated by including an interaction term between immigrant status and linear calendar year in the fully adjusted model *d*. As such, the portrayed effects are net of covariates. 95% CIs are shown at the predicted values.

5.5.2 Marital status, parental status, and educational level

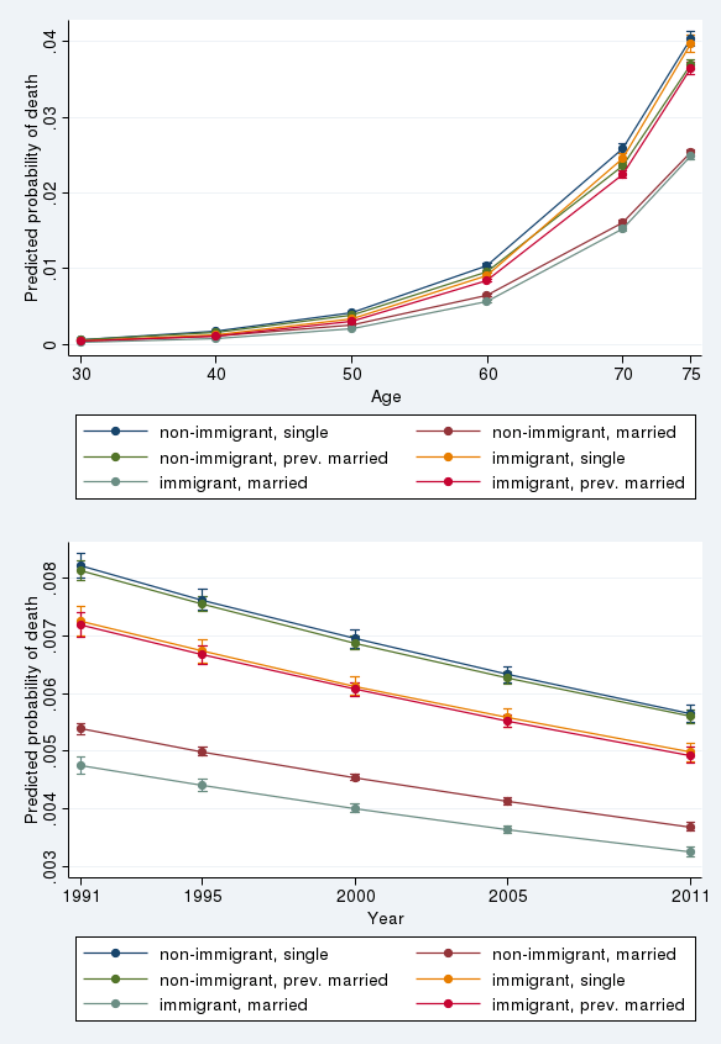
The inclusion of interaction terms between immigrant status (specification *1*) and marital status ($p_{interaction}$ <0.001), parental status ($p_{interaction}$ <0.001) and educational level ($p_{interaction}$ <0.001), respectively, in model *d*, revealed a pronounced effect modification. Table 2 shows the stratified analyses. There is a pronounced survival advantage for unmarried and childless immigrants. Relative to hosts, the overall OR of married immigrants was 0.95, whereas it was 0.73 for unmarried immigrants. The direction of effect was similar for all immigrant groups. Of all married individuals, only married immigrants from Western European, Middle Eastern, and Asian countries had a significantly lower death risk than the host population. In absolute terms, however, married individuals (both immigrants and hosts) have a survival advantage relative to previously married or single individuals (Figure 6).

Table 2: Death risks stratified by marital status, parenthood, and educational level[a]

	Married		Not married[b]		Parents		Childless		High education[c]		Low education[d]	
	OR[e]	95% CI[f]	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Host population	1	ref	1	ref	1	ref	1	ref	1	ref	1	ref
All immigrants[g]	0.95	0.93–0.97	0.73	0.71–0.74	0.93	0.91–0.95	0.59	0.57–0.61	0.86	0.84–0.88	0.80	0.78–0.81
Country group of origin[h]												
Nordic countries	1.04	0.99–1.07	0.89	0.86–0.92	1.05	1.01–1.08	0.77	0.74–0.80	0.94	0.90–0.98	0.96	0.92–0.99
West Europe	0.90	0.85–0.94	0.76	0.72–0.79	0.92	0.89–0.96	0.58	0.54–0.61	0.81	0.77–0.85	0.84	0.80–0.88
East Europe	0.97	0.92–1.01	0.63	0.60–0.66	0.98	0.93–1.02	0.50	0.47–0.52	0.84	0.79–0.89	0.79	0.75–0.84
Middle East	0.77	0.71–0.83	0.57	0.53–0.62	0.70	0.66–0.75	0.48	0.43–0.53	0.75	0.67–0.83	0.54	0.50–0.59
South Asia	0.94	0.87–1.00	0.58	0.53–0.64	0.88	0.82–0.93	0.45	0.40–0.50	0.82	0.73–0.92	0.66	0.60–0.71
Asia	0.78	0.72–0.84	0.48	0.43–0.52	0.67	0.62–0.72	0.43	0.38–0.48	0.76	0.67–0.84	0.59	0.54–0.63
Africa	0.95	0.84–1.06	0.64	0.58–0.70	0.82	0.75–0.90	0.55	0.48–0.61	1.03	0.90–1.17	0.53	0.47–0.60
North America & Oceania	1.04	0.97–1.13	0.79	0.73–0.85	1.01	0.92–1.07	0.66	0.59–0.72	0.91	0.83–1.00	1.02	0.94–1.10
Other countries	0.94	0.83–1.06	0.52	0.46–0.59	0.73	0.66–0.81	0.52	0.45–0.60	0.79	0.68–0.91	0.56	0.48–0.64

Notes: [a]This table presents stratified analyses from two fully adjusted models (model *d*, i.e., sex, age group, calendar period, educational level, marital and parental status) by marital status (married vs not married), parental status (parents vs childless) and education (primary or secondary education vs tertiary education). The stratifying variable itself was not included in the respective model. [b]The 'Not married' category includes both never married and previously married individuals. [c]High education is defined as any tertiary education. [d]Low education is defined as primary and secondary education. [e]Odds ratio. '1' denotes the reference category. [f]Confidence interval. 'ref' denotes the reference catefory. [g]Specification *1*. [h]Specification *3*.

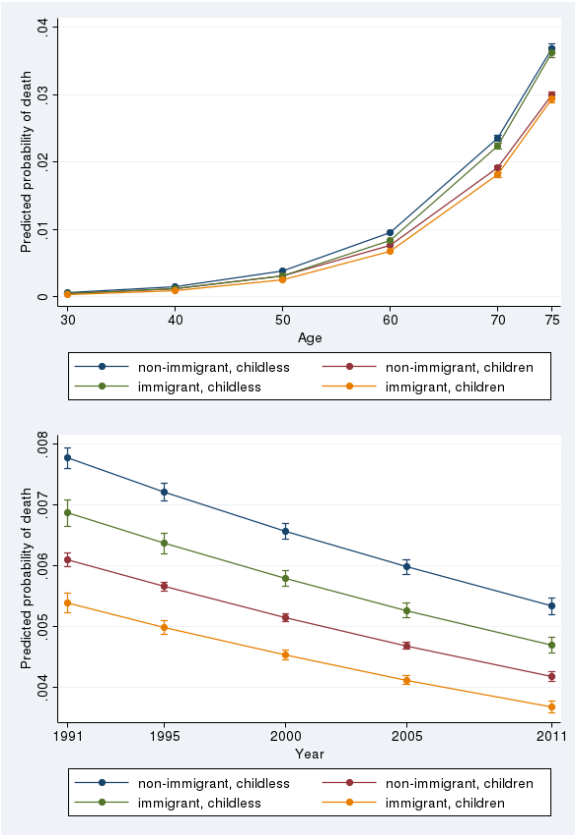
Figure 6: Adjusted predicted probabilities of death by marital status, by age (top) and calendar period (bottom)



Note: The adjusted predictive margins were calculated by including an interaction term between immigrant status and linear age or calendar year in the fully adjusted model *d*. As such, the portrayed effects are net of covariates. 95% CIs are shown at the predicted values.

In comparison to the hosts, childless immigrants had a survival advantage compared to immigrants with children (OR 0.59 vs 0.93) and the direction of effect was similar for all immigrant groups. Immigrants from Western European, Middle Eastern, Asian, and African countries with children had a survival advantage when compared to the host population. Nevertheless, in absolute terms, parents (both immigrants and hosts) have a survival advantage relative to childless individuals, across age and calendar period (Figure 7).

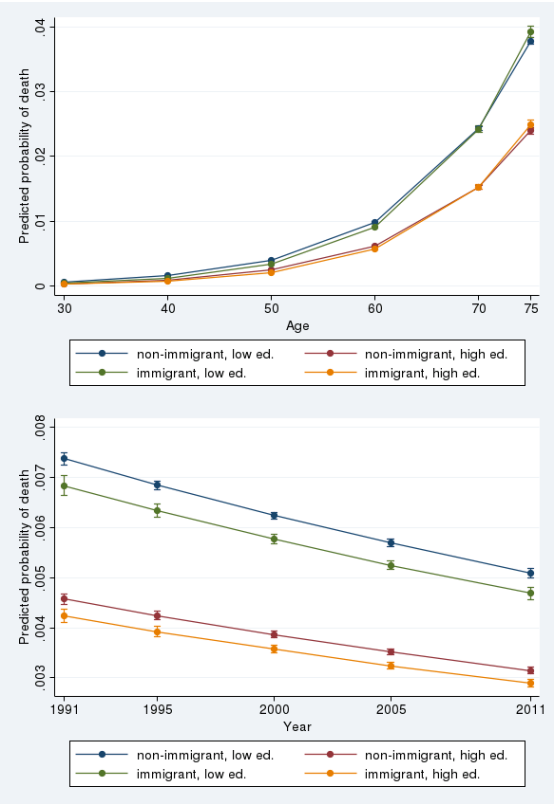
Figure 7: Adjusted predicted probabilities of death by parental status, by age (top) and calendar period (bottom)



Note: The adjusted predictive margins were calculated by including an interaction term between immigrant status and linear age or calendar year in the fully adjusted model *d*. As such, the portrayed effects are net of covariates. 95% CIs are shown at the predicted values.

Although the interaction term between immigrant status and educational level was statistically significant, the overall difference between higher- and lower-educated immigrants was relatively small compared to the host population (OR 0.86 vs 0.80). In absolute terms, highly educated individuals have a survival advantage over lower-educated individuals. Differences across age between immigrants and hosts are minor or non-existent. Low-educated immigrants have a survival advantage compared to hosts across calendar time (Figure 8).

Figure 8: Adjusted predicted probabilities of death by educational level, by age (top) and calendar period (bottom)



Note: The adjusted predictive margins were calculated by including an interaction term between immigrant status and linear age or calendar year in the fully adjusted model *d*. As such, the portrayed effects are net of covariates. 95% CIs are shown at the predicted values.

Educational effects differed between immigrants from various country groups. Immigrants from the Middle East, Asia, and Africa with low education had a significant survival advantage compared to similarly educated hosts. However, immigrants from Africa with high education had a death risk similar to that of hosts with high education. Compared to hosts, immigrants with low education and short duration of residence had a greater survival advantage than those with a high education (Table A6).

6. Discussion and conclusion

Concurrent with the findings of many others (see e.g., Hajat et al. 2010; McDonald and Kennedy 2004; Wallace and Kulu 2014) and the 'healthy selection' hypothesis, immigrants across most country groups have a survival advantage compared to the Norwegian host population. While this advantage is relatively stable over time, a pronounced increase in death risks is observed with increasing duration of residence, contrary to other reports (Bos et al. 2007; Omariba, Ng, and Vissandjee 2014) but in line with the 'negative acculturation' hypothesis. In Norway the survival advantage of immigrants is most pronounced for younger, unmarried, and childless individuals. This is in contrast to findings by Bos et al. (2004) and Bos et al. (2007), but consistent with the known compositional structure of education and labor migrants. Contrary to findings from the US (Singh and Miller 2004), immigrants' survival advantage does not vary by sex.

6.1 Possible mechanisms

We should have observed a convergence in the death risk of newcomers compared to that of the host population, had the early migrants been healthier. We observe, however, the opposite. The death risk of immigrants with long duration of residence mirrors that of hosts. The likely protective selection effects of the pioneer migrants may be counteracted by prolonged exposure to Norwegian societal structures, habits, and risk factors (Diaz and Kumar 2014). Furthermore, contrary to other studies, despite adjustments for residential duration a survival convergence over calendar time was not observed (Moncho et al. 2015). Positive selection is likely to play a role in immigrants' survival advantage, as observed for refugees' mortality, which falls between that of hosts and other immigrants (Norredam et al. (2012). This also concurs with recent findings suggesting that the survival advantage of immigrants may be attributed to the 'healthy migrant' effect and is less likely to result from the remigration of less healthy individuals (Norredam et al. 2015; Omariba, Ng, and Vissandjee 2014).

As the duration of exposure to conditions in the host country increases, immigrants' risk of death rises and resembles that of the hosts. This is in line with the acculturation, social causation, and social status hypotheses. The risk of dying increased with length of residence in a similar manner for older and younger immigrants. This pattern of mortality convergence concurs with studies by Nasseri and Moulton (2011) and Ng (2011), but differs from the results of Bos et al. (2007) and Omariba, Ng, and Vissandjee (2014). Other studies have found age at migration to be an important factor (Angel et al. 2010), thus suggesting that selection plays a more important role than acculturation. In line with this, we find the death risk of second-generation immigrants to be lower than that of the first generation, albeit not statistically significant. The second-generation immigrant population is too young to study this in more detail. Our results differ from other research that shows that the mortality of second-generation immigrants tends to fall in between that of first generation and the hosts (Raftery, Jones, and Rosato 1990; Razum et al. 1998). Our findings thus support the social causation hypothesis, as second-generation immigrants might be less adversely affected by 'being immigrants'.

Lastly, data artefacts may influence our results (see below). While a bias of lower death risks of immigrants due to incorrect emigration data cannot be ruled out, it is unlikely to be the sole reason for the marked survival advantage. We thus conclude that the survival advantage of immigrants in Norway is real, in line with recent findings from England and Wales (Wallace and Kulu 2014), but contrary to older Swedish studies (Albin et al. 2005; Weitoft et al. 1999).

6.2 The influence of sociodemographic features

The inclusion of sociodemographic characteristics lowered estimates of immigrants' death risk, in concordance with existing literature (Bos et al. 2004; Klinthall and Lindstrom 2011; Norredam et al. 2012; Omariba, Ng, and Vissandjee 2014; Wallace and Kulu 2014). In stepwise models the inclusion of education mattered most, followed by marital and parental status. Taken together with the increase in death risk by time since migration, this might be consistent with a social causation interpretation, i.e., migration status may act jointly with socioeconomic disadvantage measured by conventional measures to heighten death risks in the long run. According to Smith (2000), migrants' socioeconomic position may be problematic to assess, and as migration status and socioeconomic position are closely interlinked we need to be cautious when attempting to assess the effect of migration 'independent' of socioeconomic factors. As an example, some groups of immigrants with low education had a more pronounced survival advantage relative to the hosts, compared to that of

immigrants with a high education. Migrants with lower education are often characterized as 'resourceful', as they have had the resources to migrate in the first place (Lindstrom and Ramirez 2010). Our register data are, however, unable to assess this further. On the other hand, highly educated immigrants with a short duration of residence had significantly lower death risks than those with a low education, although both groups had significantly lower death risks than the host population. Only less-educated immigrants that had lived for a very long time in Norway had a survival disadvantage relative to the host population.

The marked survival advantage among unmarried, childless immigrants was unexpected. Such immigrants are likely to be labor or student migrants. The proportion of labor migrants to students is two to three (Statistics Norway 2016). Besides adjusting for education, we cannot further explain these differences from the available data. The survival disadvantage of married compared to unmarried individuals across all country groups differs from Bos et al., who also confirmed the well-established protective nature of marriage for mortality for subgroups of immigrants (2004). The adverse effect of parenthood was pronounced and consistent, and is contrary to reports for ill health (Dunn and Dyck 2000).

6.3 Strengths and limitations

Our high quality data encompassing the entire Norwegian population enabled us to minimize selection and information bias. Furthermore, availability of sociodemographic characteristics made it possible to adjust for possible effects of differences in family behavior or educational attainment between (subgroups of) immigrants and the host population. Several limitations should, however, be noted. First, the adult immigrant population in Norway is relatively young and comprises a relatively small proportion of the entire population and an even smaller proportion of deaths. Therefore, we opted to focus on all-cause mortality. Analyses of specific causes of death would have provided more insight into the likely differences in health status and health behaviors between various groups of immigrants (Bos et al. 2004; Singh and Siahpush 2001, 2002).

Second, individuals' level of education in Norway is registered based on information provided directly to Statistics Norway by the respective educational institutions. Hence data on education obtained in Norway is almost complete, whereas information on education obtained abroad might be incomplete. In 2011–2012, a large survey undertaken among immigrants to assess their education prior to migration showed that the proportion of immigrants with missing educational data was reduced from 43% to about 20% in the national registers (Steinkellner and Holseter 2013). In our sample, education was missing for 16% of immigrants, and primarily for those with

short durations of residence. Further analyses are required in order to confirm our findings for education, in particular for short-stay immigrants.

Third, the extent to which missing or incorrect emigration data may have influenced our results could not be examined in detail. Some persons fail to notify the authorities when they emigrate, and remain 'immortal' in vital statistics. Immigrants in Norway have high emigration rates, as observed in 2011 when 70% of the registered emigrations were attributed to immigrants (Pettersen 2013).[10] However, refugees are less likely to emigrate than labor immigrants. In Norway the likelihood of emigrating is greatest the first year after immigration, and decreases substantially with time. After ten years of residence, very few leave (Pettersen 2013). Similarly, circular and/or repeated migration is relatively rare. To account for possible differential out-migration registration and/or censoring, we ran robustness checks of death risks in smaller subgroups of immigrants.[11] No consistent patterns emerged, and we found little evidence for systematic selection in registration or censoring. The increased death risk observed for longer duration of residence further suggests that any bias is likely to be minor.

Fourth, immigration patterns to Norway have shifted considerably over time, and several of the examined characteristics are thus intrinsically linked. Older and younger immigrants originate from different countries. This makes it difficult to disentangle effects of age, calendar period, and country of origin. Also, as we adjust for age and length of residence, age at immigration is a linear combination of these two variables and may thus not be assessed independently. To the extent permitted by our numbers, we included relevant variables to examine possible confounding and effect modification. However, this study is observational, as are most studies in this area today. Future studies would benefit from more stringent design to evaluate the possible causal nature of the observed associations.

[10] The Directorate of Taxes 'removes' individuals for whom there are no indicators of presence in Norway (e.g., no financial activity). The percentage of administrative out-registrations 1990–2012 has risen markedly. In 2010, around 25% of all emigrations was administrative, and immigrants accounted for the majority (Pettersen 2013).

[11] We have left censoring at age 25, in 1990, or at later ages or arrival times in Norway, and right censoring at age 79 or emigration. Censoring applies more frequently to immigrants than hosts, resulting in shorter observation times on average for immigrants. This is handled relatively well in discrete-time models, including only residents of a particular year.

6.4 Conclusion

Immigrants in Norway have a lower mortality than the host population and this has been stable over time. Sociodemographic factors play an important role in immigrants' survival advantage. Although mortality varies substantially between groups of origin, no group has a higher death risk than the host population after adjusting for sociodemographic factors.

The convergence in mortality for hosts and immigrants with increasing duration of residence suggests that 'healthy migration' and negative acculturation effects may counteract each another. However, due to the observational design of our study and the lack of data on specific mechanisms, we cannot draw causal conclusions. Future research should examine health status and health behavior differences as potential precursors of subsequent mortality. As the immigrant population continues to grow and age, more research on the mechanisms influencing death risk, health, and welfare of long-term immigrants is warranted.

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Appendix

Table A1: Number of deaths and risk time for the main country groups of origin across covariates[a]

	Host population	Nordic countries	West Europe	East Europe	Middle East	South Asia	Asia	Africa	North America & Oceania
Deaths/pyrs in total[b]	433 036/61.97 mill	6 049/1.08 mill	3 288/796 433	2 964/1.15 mill	1 163/653 454	1 309/594 023	1 059/607 123	694/386 676	1 313/200 317
Female	169 844/31.04 mill	2 380/551 526	1 441/346 143	1 030/538 562	296/247 943	455/266 415	530/403 642	235/167 893	599/105 026
Male	263 192/30.93 mill	3 669/524 410	1 847/450 290	1 934/607 593	867/405 511	854/327 608	529/203 481	459/218 783	714/95 291
Age 25–39	16 635/20.31 mill	258/419 605	110/289 825	298/624 804	220/377 754	175/332 628	179/337 629	205/251 010	35/70 829
Age 40–49	24 391/13.61 mill	435/240 515	253/206 066	341/277 749	232/170 146	215/142 330	186/151 740	161/88 553	46/46 001
Age 50–59	51 916/11.66 mill	943/194 960	530/153 906	505/149 064	241/70 691	303/76 131	204/74 396	99/31 221	101/30 999
Age 60–69	107 306/9.18 mill	1 765/139 538	1 008/96 379	750/61 881	258/25 942	376/32 748	217/30 337	137/11 414	265/26 250
Age 70–79	232 788/7.21 mill	2 648/81 318	1 387/50 257	1 070/32 657	212/8 921	240/10 186	273/13 021	92/4 478	866/26 238
1990–1994	112 516/13.00 mill	1 126/182 508	587/134 304	346/73 042	122/66 605	152/77 754	130/68 188	62/33 381	386/44 231
1995–1999	103 421/13.40 mill	1 245/217 348	652/142 738	547/121 848	181/90 626	207/94 739	183/88 979	107/45 446	293/42 057
2000–2004	89 359/13.58 mill	1 381/244 700	717/159 342	669/175 348	278/148 022	293/125 458	233/120 048	162/75 476	287/40 898
2005–2012	127 740/21.99 mill	2 297/431 380	1 332/360 049	1 402/775 917	582/348 201	657/296 072	513/329 908	363/232 373	347/73 131
Childless[c]	104 474/9.88 mill	2 200/332 303	1 032/240 591	1 284/442 747	335/126 649	295/94 246	324/157 636	268/107 158	384/56 567
1+ child(ren)	328 562/52.09 mill	3 849/743 634	2 256/555 842	1 680/703 408	828/526 805	1 014/499 777	735/449 487	426/279 518	929/143 750
Never married[c]	74 721/17.05 mill	1 627/427 788	759/256761	599/376 372	280/148 703	161/106 776	169/148 579	204/131 304	251/53 419
Married	220 579/34.42 mill	2 538/478 255	1 521/417 405	1 506/638 293	603/402 676	862/439 036	632/375 135	302/183 775	674/116 434
Previously married	137 736/10.50 mill	1 884/169 893	1 008/122 267	859/131 490	280/102 075	286/48 211	258/83 409	188/71 597	388/30 464
Primary education[c]	7 753/375 928	1 229/174 059	625/133 707	972/256 693	546/171 111	634/139 413	461/150 415	274/97 209	253/44 454
Secondary education	331 292/29.69 mill	3 146/319 913	1 354/174 133	909/219 769	312/186 720	406/222 946	308/177 085	185/118 494	588/35 382
Lower tertiary	52 786/15.05 mill	836/198 205	595/136 891	564/318 360	139/125 825	117/95 747	115/112 324	113/78 108	179/25 757
Higher tertiary	41 205/16.86 mill	838/383 759	714/351 702	519/351 333	166/169 798	152/135 917	175/167 299	122/92 865	293/94 724

Notes: [a]The group 'Other countries' is not shown, but around 60% of observations in this group is comprised of individuals from South America. [b]Pyrs is an abbreviation for person-years. [c]Includes observations with missing information on this variable. Overall, this pertained <0.1% of the total person-years for parental status, 1.6% of the total person-years for marital status and 1.4% of the total person-years for educational level.

Table A2: Male death risks by country group of origin[a]

	Observations	Basic model (a)		Model a & family (b)		Model a & education (c)		Full model (d)	
	Deaths/pyrs[b]	OR[c]	95% CI[d]	OR	95% CI	OR	95% CI	OR	95% CI
Host population	263 192/30.93 mill	1	ref	1	ref	1	ref	1	ref
Nordic countries	3 669/524 410	1.15	1.11 – 1.18	1.00	0.97 – 1.04	1.03	0.99 – 1.06	0.95	0.92 – 0.98
West Europe	1 847/450 290	0.81	0.77 – 0.85	0.74	0.71– 0.78	0.78	0.74 – 0.82	0.75	0.72 – 0.79
East Europe	1 934/607 593	0.93	0.89 – 0.97	0.85	0.81 – 0.89	0.79	0.76 – 0.83	0.79	0.75 – 0.83
Middle East	867/405 511	0.80	0.74 – 0.85	0.80	0.75 – 0.86	0.62	0.58 – 0.66	0.70	0.65 – 0.75
South Asia	854/327 608	0.82	0.76 – 0.88	0.89	0.84 – 0.96	0.65	0.60 – 0.69	0.77	0.72 – 0.82
Asia	529/203 481	0.69	0.63 – 0.74	0.71	0.65 – 0.77	0.53	0.49 – 0.58	0.61	0.56 – 0.67
Africa	459/218 783	0.89	0.82 – 0.98	0.86	0.78 – 0.94	0.73	0.66 – 0.80	0.76	0.70 – 0.84
North America & Oceania	714/95 291	0.90	0.83 – 0.97	0.85	0.78 – 0.91	0.86	0.80 – 0.93	0.85	0.79 – 0.92
Other countries	306/115 780	0.79	0.71 – 0.88	0.72	0.65 – 0.81	0.69	0.61 – 0.77	0.68	0.61 – 0.76
Age 25–39	12 707/11.81 mill	0.49	0.48 – 0.50	0.43	0.42 – 0.44	0.52	0.51 – 0.53	0.46	0.45 – 0.47
Age 40–49	16 643/7.69 mill	1	ref	1	ref	1	ref	1	ref
Age 50–59	34 169/6.34 mill	2.53	2.49 – 2.58	2.64	2.59 – 2.69	2.42	2.37 – 2.46	2.52	2.48 – 2.57
Age 60–69	71 153/4.72 mill	7.09	6.97–7.21	7.58	7.46 – 7.71	6.44	6.33 – 6.55	6.93	6.81 – 7.05
Age 70–79	139 699/3.31 mill	19.84	19.52 – 20.17	20.80	20.46 – 7.71	17.26	16.98 – 17.54	18.3	18.03 – 18.63
1990–1994	70 942/6.80 mill	1	ref	1	ref	1	ref	1	ref
1995–1999	65 234/7.12 mill	0.91	0.90 – 0.92	0.91	0.90 – 0.92	0.93	0.92 – 0.94	0.93	0.92 – 0.94
2000–2004	56 454/7.36 mill	0.78	0.77 – 0.79	0.78	0.77 – 0.79	0.82	0.81 – 0.83	0.81	0.81 – 0.82
2005–2012	81 741/12.59 mill	0.65	0.64 – 0.66	0.64	0.64 – 0.65	0.71	0.70 – 0.71	0.69	0.69 – 0.70
Childless[e]	72 607/6.87 mill	N/A[f]	N/A	1	ref	N/A	N/A	1	ref
1+ child(ren)	201 764/27.00 mill	N/A	N/A	0.71	0.70 – 0.72	N/A	N/A	0.74	0.73 – 0.75
Never married[e]	56 695/10.88 mill	N/A	N/A	1	ref	N/A	N/A	1	ref
Married	152 047/18.73 mill	N/A	N/A	0.63	0.62 – 0.63	N/A	N/A	0.66	0.65 – 0.67
Previously married	64 629/4.26 mill	N/A	N/A	1.10	1.09 – 1.12	N/A	N/A	1.13	1.11 – 1.14
Primary education[e]	8 048/876 282	N/A	N/A	N/A	N/A	1	ref	1	ref
Secondary education	192 771/14.08 mill	N/A	N/A	N/A	N/A	0.58	0.56 – 0.59	0.73	0.71 – 0.75
Lower tertiary education	43 772/9.95 mill	N/A	N/A	N/A	N/A	0.41	0.40 – 0.42	0.55	0.53 – 0.56
Higher tertiary education	29 780/8.96 mill	N/A	N/A	N/A	N/A	0.29	0.28 – 0.30	0.39	0.38 – 0.40

Notes: [a]Estimates from a basic model of specification 3 including only age and year of observation (model a) compared to models with adjustment for various sociodemographic characteristics. The final, fully adjusted model (model d) is shown to the far right. [b]Deaths per person-years of observation. [c]Odds ratio. '1' denotes the reference category. [d]Confidence interval. 'ref' denotes the reference category. [e]Very few individuals had missing information on covariates, and missing were included in the reference category. [f]N/A refers to not applicable.

Table A3: Female death risks by country group of origin[a]

	Observations	Basic model (a)		Model a & family (b)		Model a & education (c)		Full model (d)	
	Deaths/pyrs[b]	OR[c]	95% CI[d]	OR	95% CI	OR	95% CI	OR	95% CI
Host population	169 844/31.04 mill	1	ref	1	ref	1	ref	1	ref
Nordic countries	2 380/551 526	0.98	0.94 – 1.02	0.95	0.91 – 0.98	1.02	0.98 – 1.06	1.00	0.96 – 1.04
West Europe	1 441/346 143	0.91	0.86 – 0.96	0.87	0.82 – 0.91	0.96	0.91 – 1.01	0.93	0.89 – 0.98
East Europe	1 030/538 562	0.89	0.83 – 0.94	0.77	0.72 – 0.82	0.73	0.69 – 0.78	0.70	0.65 – 0.74
Middle East	296/247 943	0.74	0.66 – 0.83	0.70	0.62 – 0.78	0.44	0.40 – 0.50	0.49	0.44 – 0.55
South Asia	455/266 415	0.95	0.87 – 1.05	0.90	0.82 – 0.99	0.58	0.53 – 0.64	0.63	0.57 – 0.69
Asia	530/403 642	0.76	0.70 – 0.83	0.70	0.64 – 0.76	0.52	0.48 – 0.57	0.54	0.50 – 0.59
Africa	235/167 893	1.04	0.92 – 1.19	0.93	0.82 – 1.06	0.68	0.60 – 0.78	0.69	0.60 – 0.78
North America & Oceania	599/105 026	0.96	0.89 – 1.04	0.93	0.86 – 1.01	0.97	0.90 – 1.05	0.96	0.89 – 1.04
Other countries	198/135 655	0.77	0.67 – 0.89	0.70	0.61 – 0.81	0.63	0.55 – 0.72	0.62	0.54 – 0.71
Age 25–39	5 476/11.33 mill	0.36	0.35 – 0.38	0.34	0.32 – 0.35	0.40	0.39 – 0.42	0.37	0.36 – 0.38
Age 40–49	9 690/7.32 mill	1	ref	1	ref	1	ref	1	ref
Age 50–59	20 779/6.14 mill	2.57	2.51 – 2.64	2.61	2.54 – 2.67	2.37	2.31 – 2.43	2.40	2.35 – 2.46
Age 60–69	41 048/4.89 mill	6.37	6.23 – 6.51	6.33	6.19 – 6.47	5.49	5.37 – 5.62	5.46	5.34 – 5.59
Age 70–79	100 015/4.13 mill	18.28	17.90 – 18.67	16.36	16.01 – 16.71	15.21	14.89 – 15.54	13.63	13.34 – 13.93
1990–1994	44 547/6.90 mill	1	ref	1	ref	1	ref	1	ref
1995–1999	41 691/7.17 mill	0.94	0.93 – 0.95	0.96	0.95 – 0.98	0.96	0.94 – 0.97	0.98	0.97 – 0.99
2000–2004	37 042/7.36 mill	0.86	0.85 – 0.87	0.90	0.89 – 0.91	0.90	0.88 – 0.91	0.93	0.92 – 0.95
2005–2012	53 728/12.38 mill	0.77	0.75 – 0.77	0.79	0.78 – 0.80	0.82	0.81 – 0.83	0.86	0.85 – 0.87
Childless[e]	38 162/4.63 mill	N/A[f]	N/A	1	ref	N/A	N/A	1	ref
1+ child(ren)	138 846/29.18 mill	N/A	N/A	0.68	0.67 – 0.69	N/A	N/A	0.68	0.67 – 0.69
Never married[e]	221 92/7.89 mill	N/A	N/A	1	ref	N/A	N/A	1	ref
Married	76 414/18.87 mill	N/A	N/A	0.70	0.69 – 0.71	N/A	N/A	0.69	0.68 – 0.71
Previously married	78 402/7.05 mill	N/A	N/A	1.07	1.05 – 1.09	N/A	N/A	1.05	1.03 – 1.06
Primary education[e]	4 868/712 049	N/A	N/A	N/A	N/A	1	ref	1	ref
Secondary education	145 880/17.13 mill	N/A	N/A	N/A	N/A	0.49	0.47 – 0.50	0.62	0.60 – 0.64
Lower tertiary education	11 747/6.24 mill	N/A	N/A	N/A	N/A	0.34	0.33 – 0.35	0.43	0.41 – 0.44
Higher tertiary education	14 513/9.72 mill	N/A	N/A	N/A	N/A	0.26	0.25 – 0.27	0.32	0.31 – 0.33

Notes: [a]Estimates from a basic model of specification 3 including only age and year of observation (model a) compared to models with adjustment for various sociodemographic characteristics. The final, fully adjusted model (model d) is shown to the far right. [b]Deaths per person-years of observation. [c]Odds ratio. '1' denotes the references category. [d]Confidence interval. 'ref' denotes the reference category. [e]Very few individuals had missing information on covariates, and missing were included in the reference category. [f]N/A refers to not applicable.

Table A4: Death risks by select countries of origin[a]

	Men and women jointly					Men			Women		
	Observations	Basic model (a)		Full model (d)		Observations	Full model (d)		Observations	Full model (d)	
	Deaths/pyrs[b]	OR[c]	95% CI[d]	OR	95% CI	Deaths/pyrs	OR	95% CI	Deaths/pyrs	OR	95% CI
Somalia	203/137 110	0.94	0.82 – 1.08	0.69	0.60 – 0.79	135/76 402	0.78	0.66 – 0.92	68/60 708	0.56	0.44 – 0.71
Poland	721/374 270	0.83	0.77 – 0.89	0.66	0.61 – 0.71	515/233 287	0.66	0.61 – 0.72	206/140 983	0.76	0.67 – 0.88
Pakistan	839/288 979	1.06	0.99 – 1.14	0.96	0.90 – 1.03	558/155 834	0.99	0.91 – 1.08	281/133 145	0.90	0.80 – 1.01
Iran	287/176 182	0.68	0.61 – 0.77	0.61	0.55 – 0.69	211/105 142	0.71	0.62 – 0.81	76/58 673	0.45	0.36 – 0.56
Iraq	207/160 410	0.69	0.60 – 0.79	0.60	0.55 – 0.69	144/101 737	0.64	0.54 – 0.75	63/58 673	0.55	0.43 – 0.71
Vietnam	425/206 174	0.72	0.65 – 0.79	0.61	0.55 – 0.67	272/104 062	0.68	0.60 – 0.76	153/102 112	0.50	0.43 – 0.59
Thailand	107/102 085	1.00	0.83 – 1.21	0.78	0.64 – 0.94	14/6 479	0.98	0.58 – 1.66	93/95 606	0.64	0.52 – 0.78

Notes: [a]Estimates from a basic model of specification 4 including only sex, age and year of observation (model a) compared to a model with adjustment also for various sociodemographic characteristics (model d) for men and women combined. It also shows the fully adjusted models (model d) for men and women separately. [b]Deaths per person-years of observation. [c]Odds ratio. The reference category is '1', and refers to all individuals not included in the relevant country it is compared to. [d]Confidence interval. 'ref' denotes the reference category.

Table A5: Death risks by duration of residence[a]

		Men and women jointly				Men		Women		Age < 60		Age ≥ 60		1990–1999		2000–2012	
		Basic model (a)		Full model (d)		Full model (d)		Full model (d)		Full model (d)		Full model (d)		Full model (d)		Full model (d)	
	Deaths/pyrs[b]	OR[c]	95% CI[d]	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Host pop	433 036/61.97 mill	1	ref	1	ref	1	ref	1	ref	1	ref	1	ref	1	ref	1	ref
0–1 years	607/824 189	0.48	0.45 – 0.52	0.25	0.23 – 0.27	0.24	0.22 – 0.27	0.29	0.25 – 0.33	0.10	0.09 – 0.11	0.26	0.23 – 0.30	0.30	0.26 – 0.35	0.21	0.20 – 0.24
2–3 years	693/652 444	0.67	0.62 – 0.73	0.43	0.40 – 0.47	0.45	0.41 – 0.49	0.43	0.37 – 0.48	0.16	0.15 – 0.18	0.44	0.38 – 0.50	0.49	0.43 – 0.55	0.39	0.35 – 0.42
4–5 years	624/522 723	0.71	0.65 – 0.76	0.48	0.45 – 0.53	0.48	0.43 – 0.53	0.51	0.45 – 0.58	0.21	0.19 – 0.23	0.46	0.40 – 0.52	0.58	0.51 – 0.66	0.42	0.38 – 0.47
6–7 years	595/421 789	0.78	0.72 – 0.85	0.57	0.52 – 0.62	0.60	0.54 – 0.66	0.52	0.46 – 0.59	0.29	0.27 – 0.32	0.46	0.48 – 0.63	0.60	0.52 – 0.69	0.53	0.48 – 0.59
8–9 years	584/371 248	0.81	0.75 – 0.88	0.61	0.56 – 0.66	0.63	0.56 – 0.70	0.58	0.51 – 0.66	0.32	0.29 – 0.36	0.55	0.53 – 0.63	0.61	0.53 – 0.71	0.59	0.53 – 0.65
10–14 years	1 497/753 309	0.89	0.85 – 0.94	0.71	0.67 – 0.75	0.76	0.71 – 0.81	0.63	0.57 – 0.68	0.47	0.44 – 0.50	0.58	0.54 – 0.64	0.67	0.61 – 0.74	0.71	0.66 – 0.75
15–19 years	1 366/591 290	0.84	0.80 – 0.89	0.70	0.66 – 0.74	0.72	0.68 – 0.77	0.66	0.60 – 0.72	0.56	0.52 – 0.60	0.59	0.54 – 0.64	0.67	0.61 – 0.74	0.70	0.66 – 0.75
20–24 years	1 504/469 490	0.93	0.88 – 0.98	0.78	0.74 – 0.83	0.80	0.74 – 0.85	0.76	0.70 – 0.83	0.76	0.71 – 0.81	0.64	0.60 – 0.70	0.81	0.74 – 0.88	0.76	0.71 – 0.81
25–29 years	2 887/435 662	1.02	0.98 – 1.06	0.98	0.94 – 1.02	0.97	0.92 – 1.02	1.02	0.96 – 1.08	1.08	1.01 – 1.15	0.88	0.84 – 0.92	1.04	0.99 – 1.09	0.89	0.84 – 0.95
30+ years	7 986/668 408	1.04	1.02 – 1.07	1.06	1.03 – 1.08	1.07	1.04 – 1.10	1.05	1.02 – 1.09	1.30	1.22 – 1.39	1.04	1.02 – 1.07	0.98	0.94 – 1.02	1.07	1.05 – 1.10

Notes: [a]Estimates from a basic model of specification 5 including only sex, age and year of observation (model a) compared to a model with adjustment also for various sociodemographic characteristics (model d) for men and women combined. It also shows the fully adjusted models (model d) stratified by sex, age and calendar period. [b]Deaths per person-years of observation. [c]Odds ratio. The reference category is '1', and refers to all individuals not included in the relevant country it is compared to. [d]Confidence interval. 'ref' denotes the reference category.

Table A6: Average marginal effects for various specifications of immigrant background[a]

	Full model (d)		Low education		High education		Married		Not married		Parents		Childless	
	APM (%)[b]	95% CI[c]	APM (%)	95% CI	APM (%)	95% CI	APM (%)	95% CI	APM (%)	95% CI	APM (%)	95% CI	APM (%)	95% CI
Specification 1														
All Immigrants	**-0.04**	-0.05 – -0.03	**-0.08**	-0.10 – -0.06	**-0.03**	-0.03 – -0.02	<0.001	-0.01 – 0.01	**-0.09**	-0.10 – -0.07	<0.001	-0.01 – 0.01	**-0.19**	-0.21 – -0.17
Specification 2														
1st gen. immigrants	**-0.04**	-0.05 – -0.03	**-0.08**	-0.09 – -0.06	**-0.02**	-0.03 – -0.02	0.00	-0.01 – 0.01	**-0.09**	-0.10 – -0.07	0.002	-0.01 – 0.01	**-0.19**	-0.21 – -0.17
2nd gen. immigrants	**-0.12**	-0.19 – -0.04	**-0.22**	-0.37 – -0.08	-0.03	-0.09 – 0.03	**-0.17**	-0.28 – -0.07	-0.10	-0.21 – 0.003	**-0.15**	-0.23 – -0.07	-0.14	-0.29 – 0.02
Specification 3														
Nordic countries	**0.02**	0.006 – 0.04	**0.04**	0.01 – 0.06	-0.01	-0.03 – 0.01	**0.03**	0.01 – 0.05	0.01	-0.02 – 0.03	**0.04**	0.02 – 0.05	**-0.07**	-0.10 – -0.04
West Europe	**-0.06**	-0.08 – -0.05	**-0.10**	-0.13 – -0.07	**-0.04**	-0.05 – -0.03	**-0.03**	-0.05 – -0.01	**-0.09**	-0.12 – -0.07	-0.02	-0.04 – 0.003	**-0.23**	-0.26 – -0.19
East Europe	**-0.05**	-0.07 – -0.03	**-0.10**	-0.14 – -0.07	**-0.02**	-0.04 – -0.01	**0.03**	0.001 – 0.05	**-0.13**	-0.15 – -0.10	**0.04**	0.02 – 0.07	**-0.25**	-0.28 – -0.22
Middle East	**-0.11**	-0.14 – -0.09	**-0.21**	-0.25 – -0.17	**-0.05**	-0.08 – -0.03	**-0.07**	-0.01 – -0.03	**-0.16**	-0.20 – -0.12	**-0.07**	-0.10 – -0.04	**-0.27**	-0.32 – -0.22
South Asia	**-0.06**	-0.09 – -0.04	**-0.12**	-0.17 – -0.08	**-0.04**	-0.06 – -0.01	0.01	-0.02 – 0.04	**-0.14**	-0.19 – -0.10	0.01	-0.02 – 0.04	**-0.29**	-0.34 – 0.24
Asia	**-0.14**	-0.16 – -0.12	**-0.25**	-0.30 – -0.21	**-0.05**	-0.08 – -0.03	**-0.06**	-0.09 – -0.02	**-0.23**	-0.27 – -0.20	**-0.09**	-0.12 – -0.06	**-0.31**	-0.36 – -0.27
Africa	**-0.05**	-0.09 – -0.01	**-0.17**	-0.23 – -0.11	0.02	-0.01 – 0.01	0.01	-0.04 – 0.07	**-0.11**	-0.16 – -0.06	-0.02	-0.07 – 0.02	**-0.17**	-0.24 – -0.11
North Am. & Oceania	-0.01	-0.04 – 0.01	-0.03	-0.09 – 0.02	-0.02	-0.04 – 0.01	0.03	-0.001 – 0.07	**-0.07**	-0.11 – -0.03	0.03	-0 01 – 0.06	**-0.17**	-0.23 – -0.11
Other countries	**-0.12**	-0.15 – -0.08	**-0.22**	-0.29 – -0.15	**-0.04**	-0.07 – -0.01	0.01	-0.01 – 0.07	**-0.23**	-0.27 – -0.18	**-0.09**	-013 – -0.04	**-0.24**	-0.31 – -0.17
Specification 4														
Somalia	**-0.08**	-0.14 – -0.02	**-0.21**	-0.30 – -0.11	0.01	-0.08 – 0.09	0.03	-0.01 – 0.01	**-0.18**	-0.26 – -0.10	-0.02	-0.10 – 0.06	**-0.26**	-0.37 – -0.16
Poland	**-0.12**	-0.15 – -0.09	**-0.18**	-0.23 – -0.12	**-0.07**	-0.10 – -0.05	-0.02	-0.07 – 0.13	**-0.21**	-0.26 – -0.17	**0.06**	0.004 – 0.11	**-0.36**	-0.41 – -0.32
Pakistan	**0.05**	0.01 – 0.09	0.06	-0.01 – 0.12	<0.001	-0.05 – 0.05	**0.09**	0.05 – 0.14	0.03	-0.05 – 0.11	**0.09**	0.05 – 0.13	**-0.12**	-0.22 – -0.02
Iran	**-0.16**	-0.20 – -0.12	**-0.27**	-0.35 – -0.19	**-0.07**	-0.10 – -0.03	**-0.11**	-0.18 – -0.05	**-0.21**	-0.27 – -0.15	**-0.12**	-0.17 – -0.07	**-0.30**	-0.38 – -0.21
Iraq	**-0.16**	-0.21 – -0.11	**-0.29**	-0.38 – -0.20	**-0.06**	-0.11 – -0.01	**-0.08**	-0.15 – -0.01	**-0.23**	-0.31 – -0.16	**-0.11**	-0.17 – -0.05	**-0.30**	-0.41 – -0.20
Vietnam	**-0.14**	-0.19 – -0.11	**-0.24**	-0.30 – -0.17	**-0.09**	-0.13 – -0.05	**-0.06**	-0.11 – -0.01	**-0.26**	-0.31 – -0.20	**-0.11**	-0.15 – -0.08	**-0.29**	-0.38 – -0.20
Thailand	-0.03	-0.12 – 0.07	-0.11	-0.26 – 0.04	-0.01	-0.13 – 0.10	0.05	-0.08 – 0.18	-0.11	-0.24 – 0.03	-0.01	-0.14 – 0.12	**-0.16**	-0.31 – -0.01
Other countries	**-0.03**	-0.04 – -0.02	**-0.07**	-0.08 – -0.05	**-0.02**	-0.03 – -0.01	0.00	-0.01 – 0.01	**-0.07**	-0.09 – -0.06	0.003	-0.01 – 0.01	**-0.17**	-0.19 – -0.15

Table A6: (Continued)

	Full model (d)		Low education		High education		Married		Not married		Parents		Childless	
	APM (%)[b]	**95% CI[c]**	**APM (%)**	**95% CI**	**APM (%)**	**95% CI**	**APM (%)**	**95% CI**	**APM (%)**	**95% CI**	**APM (%)**	**95% CI**	**APM (%)**	**95% CI**
Specification 5														
0-4 yrs in Norway	**-0.28**	-0.30 – -0.27	**-0.42**	-0.45 – -0.40	**-0.19**	-0.20 – -0.17	**-0.14**	-0.17 – -0.12	-0.39	-0.40 – -0.37	**-0.20**	-0.22 – -0.17	**-0.47**	-0.50 – -0.45
5-19 yrs in Norway	**-0.11**	-0.13 – -0.10	**-0.19**	-0.22 – -0.17	**-0.05**	-0.06 – -0.04	**-0.04**	-0.06 – -0.02	-0.18	-0.20 – -0.15	**-0.06**	-0.08 – -0.04	**-0.22**	-0.25 – -0.19
20+ yrs in Norway	**0.04**	0.02 – 0.05	**0.04**	0.02 – 0.06	**0.01**	0.002 – 0.02	**0.03**	0.02 – 0.05	0.05	0.03 – 0.07	**0.03**	0.02 – 0.04	**0.04**	0.01 – 0.07
Covariates														
Male[d]	**0.34**	0.33 – 0.35	**0.53**	0.51 – 0.54	**0.15**	0.14 – 0.16	**0.28**	0.27 – 0.29	**0.40**	0.38 – 0.41	**0.33**	0.31 – 0.34	**0.36**	0.34 – 0.38
Child(ren)[e]	**-0.14**	-0.16 – -0.13	**-0.21**	-0.24 – -0.19	**-0.08**	-0.09 – -0.07	**-0.12**	-0.14 – -0.10	**-0.16**	-0.18 – -0.15	N/A	N/A	N/A	N/A
Married[f]	**-0.23**	-0.25 – -0.22	**-0.38**	-0.41 – -0.35	**-0.10**	-0.11 – -0.08	N/A	N/A	N/A	N/A	**-0.28**	-0.31 – -0.25	**-0.20**	-0.23 – -0.18
Previously married[f]	-0.01	-0.03 – 0.01	**-0.04**	-0.07 – -0.01	0.01	-0.01 – 0.03	N/A	N/A	N/A	N/A	**-0.07**	-0.10 – -0.04	**0.04**	0.02 – 0.07
High education[g]	**-0.23**	-0.24 – -0.22	N/A[h]	N/A	N/A	N/A	**-0.18**	-0.19 – -0.17	**-0.28**	-0.30 – -0.27	**-0.20**	-0.21 – -0.20	**-0.31**	-0.33 – -0.29

Notes: [a]Average marinal effects from a fully adjusted model d are shown in column 2. The effects of covariates are included below, but the estimates for age group (25–39, 40–49, 50–59, 60–69 and 70–79) and calendar period (1990–1994,1995–1999, 2000–2004 and 2005–2012) are not shown. The average predicted margins for covariates are from specification 1, but were virtually the same across all specifications. For each table column, Model d (or a modified version excluding the stratifying variable itself) was run five times, i.e. with five different specifications (1–5) of immigrant background. The models were run on a similar sample consisting of all immigrants and a 10% subsample of hosts. In the the stratified models, the subsample was limited to those who fulfilled the stratifying criteria. [b]Average predictive margins in percent. For all immigrant specifications, hosts represent the reference group. The margins represent the discrete change from the base level. To improve readability, statistically significant estimates are shown in bold. [c]95% confidence interval. [d]Female is the reference. [e]Childless is the reference. [f]Never-married is the reference. [g]Low education is the reference. [h]N/A refers to 'not applicable', as the stratifying variable was left out of the respective analyses.