

Post-War Migration Flows and Disparities in Mortality from Age 50 Years Onwards: the Case of Turin in Italy

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ABSTRACT

Compositional changes due to internal migration can modify the distribution of health outcomes, death rates, and socio-economic characteristics of a specific geographical area. Migration flows may affect patterns of socio-economic inequalities in mortality as well. However, despite these inequalities being an important social and geopolitical feature of an area, there is still little empirical evidence on this effect. This paper contributes to deepening the knowledge about this phenomenon by investigating whether post-war internal migration in Italy affected the pattern of mortality inequality by socio-economic status, from age 50 years onwards, in Turin, one of the main industrial areas of the country, to which many low-educated individuals from the southern regions migrated, seeking jobs in the car factories. Migrants might be selected in terms of robustness because of the healthy migrant effect. However, low-educated individuals are employed in heavier and riskier jobs. They thus undergo a faster health selection due to exposure to a higher mortality risk that selects the most robust individuals. This paper hypothesised that the interplay of these mechanisms might have produced a homogenisation process towards robustness of the population by reducing the unobserved heterogeneity in survival chances and that these processes affected men more than women, because women were likely to be more passive actors in the

migratory decisions and less heavily involved in the industrialisation process. The results show that women have higher levels of heterogeneity in susceptibility to death and wider differentials mortality by education level than men, which both support the hypotheses. © 2014 The Authors. *Population, Space and Place*. Published by John Wiley & Sons, Ltd.

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INTRODUCTION

Migratory movements can produce changes in the composition of the population in the area of destination, as well as in its demographic outcomes. Compared with the native population, migrants can have different demographic profiles and behaviours. The aim of this paper is to investigate the effect of internal migration on mortality disparities and inequalities by socio-economic status in adults.

The analysis used data from the Italian industrial city of Turin, which in the second half of the 20th century received massive flows of migrants from the poorest regions of Italy.

Two possible mechanisms seem particularly relevant. First, as several studies have documented, migrants might be selected in terms of robustness because of the healthy migrant effect (Feinleib *et al.*, 1982; Sharma *et al.*, 1990; Valkonen *et al.*, 1992; Kington *et al.*, 1998; Singh and Siahpush, 2001; Deboosere and Gadeyne, 2005). Therefore, a substantial inflow of individuals who were potentially healthier than the average native population might have had possible

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consequences on the health and mortality profiles of the population of the area of destination, especially among men. In the past, women were more likely to be only passive actors in the migratory decision (Mincer, 1978; Bielby and Bielby, 1992; Cooke, 2008), and it can be hypothesised that if a migration-related health selection occurred, men were more strongly affected than women.

Second, individuals who migrated to Turin in the post-war years were mainly low educated and employed in less-skilled, heavier, and riskier jobs (Canteri, 1964; Fofi, 1964; Pellicciari and Albertelli, 1970; D'onofrio, 2010). Therefore, they were likely to be exposed to higher health and mortality hazards. This might have caused a faster health selection of the most robust individuals. According to the literature on unobserved heterogeneity of frailty, the higher the pressure of mortality, the stronger and faster the selection towards robustness undergone by the surviving population, because the frailest individuals die earlier (Vaupel *et al.*, 1979; Manton *et al.*, 1981). As the migrants who were mainly employed in heavier and riskier jobs were characterised by a low level of education, such an educational group might have experienced the faster health selection just described. Therefore, compared with other educational classes, the low-education group might have a more robust population that would reduce the mortality differentials. Also, in this case, it is possible to imagine that this mechanism acted less strongly on women, as they were not as involved as men in the industrialisation process.

The paper hypothesises that the interplay of these two mechanisms might have produced a homogenisation process with respect to susceptibility to death (otherwise called unobserved frailty), especially of the male population. A decrease in the average frailty implies a decrease in the variance of individual differences in susceptibility to death, hence a more homogeneous population.

The same mechanisms are also likely to have had an impact on the differences in mortality risk by socio-economic level. An inflow of low-educated migrants, who are potentially healthier than non-migrants, might have lowered the average relative level of frailty not only of the general population but also of the group with low education, compared with other educational groups. The fact that most of them were employed in heavier and riskier jobs and, therefore, were exposed to a higher mortality hazard and to its

subsequent health selection might have strengthened this process and reduced even further the health and mortality differentials by education.

Because most of the work-related migrations happen at young working ages, if any selection due to exposure to heavier and riskier jobs occurs, it needs a certain time lapse to take place. Therefore, age 50 years was selected as the initial age of the mortality follow-up.

The next section briefly reviews the literature on the phenomenon of migration and its effects on the demographic characteristics. The section on Data and Methods presents the data and methods used in the analysis. The Results section contains the results: first, the most important descriptive results are illustrated, followed by the results of the regression analysis. Finally, the Discussion section discusses the results.

LITERATURE REVIEW

Migration is, together with fertility and mortality, one of the three major contributors to the demographic dynamics of a geographical area. Compared with the native population, migrants can have different reproductive behaviours (Mussino and Van Raalte, 2013) especially shortly after their arrival (Andersson, 2004; Mussino and Strozza, 2012) or different mortality and morbidity profiles (Feinleib *et al.*, 1982; Bennett, 1993; McCredie *et al.*, 1999) because of the influence of several factors such as lifestyle, dietary habits, physical environment, and hereditary predispositions of the population of origin.

Several studies have documented the so-called healthy migrant effect, the phenomenon of migrants showing better health status than persons who are not migrants (Feinleib *et al.*, 1982; Sharma *et al.*, 1990; Valkonen *et al.*, 1992; Kington *et al.*, 1998; Singh and Siahpush, 2001; Deboosere and Gadeyne, 2005), as well as the opposite phenomenon known as 'salmon bias' (Palloni and Arias, 2004), when weaker and sick migrants move back to their place of origin for receiving care from family, friends, and institutions (Lanska and Peterson, 1995; Brimblecombe *et al.*, 2000).

Migratory movements affect the structure of health and mortality outcomes of both the areas of origin and destination. Compositional changes of the population due to migration can modify the distribution of health outcomes, cause-specific or all causes of death rates, life style

factors, and socio-economic characteristics. The vast majority of studies have focused on long distance and international migrations, whereas fewer analyses have investigated shorter distance migratory movements, such as migration within country or between adjacent countries. Among these studies, some have analysed health inequalities between immigrants and natives (Wild and McKeigue, 1997; Kolčić and Polašek, 2009) or between migrants and non-migrant populations in the region of origin (Westman *et al.*, 2008). Others have focused on the effect of migration on the geographical variation in health and mortality, investigating how internal migration affected regional differences in mortality (Brimblecombe *et al.*, 1999, 2000; Luy and Caselli, 2007), variation in area deprivation levels (Norman *et al.*, 2005), and health neighbourhood inequalities (van Lenthe *et al.*, 2007). Finally, other studies have analysed the impact of migration on all-cause mortality of the area of destination (Rasulo *et al.*, 2012).

By contrast, there is still little empirical evidence on the effect of internal migration flows on the patterns of socio-economic inequality in mortality. However, as 'the migration dimension cannot be understood independently of social class and gender' (Malmusi *et al.*, 2010: 3), the reciprocal relation holds as well, and socio-economic differences in health and mortality need to be considered also in the light of migration. The study of socio-economic differences in health and mortality is an important public health issue with crucial policy-making implications. An extensive literature has shown that in many countries, despite medical improvement and the creation of welfare states, socio-economic inequalities in health and mortality have been steadily widening in the last decades (Marmot, 1986; Valkonen, 1993; Hattersley, 1997; Valkonen, 2001; Kunst, 2004; Mackenbach, 2006; Strand, 2010; Shkolnikov, 2011; Zarulli *et al.*, 2012). Analysing the trends and understanding the mechanisms behind this phenomenon are essential to tackling it.

This study used Italian data. In the second half of the 20th century, massive internal migration occurred from the poorer southern regions of Italy to the northern ones, which became the centre of the newly established industrial economy after WWII. These migratory movements accompanied the deepest social and economic transformation experienced in Italy (Ginsborg, 1989). Migration

reached its highest peak in the 1960s, continued substantially also in the first half of the 1970s, and then gradually declined (Bonifazi and Heins, 2000). Turin was among the major points of attraction, together with Milan and Genoa. These three north-western cities were also called the 'industrial triangle'. From 1955 to 1973, the in-migration rate to Turin was several times higher than the out-migration rate (Bonifazi and Heins, 2000). Turin's economy was characterised by the car industry, which was growing quickly after WWII and mainly attracted a low-educated labour force seeking jobs in the factories.

The aim of this paper is to investigate whether the internal migration flows that characterised Italy in the second half of the 20th century affected the pattern of mortality inequality by socio-economic status from age 50 years onwards in the north-western industrial city of Turin.

DATA AND METHODS

Data

We used individual longitudinal data from the Turin Longitudinal Study. Individuals who were registered during at least one of the four censuses in 1971, 1981, 1991, and 2001 were selected. Their migration and vital status was followed up until the end of July 2007. The result is an observation window of 36 years (from 24 October 1971, official date of the census in 1971, to the end of July 2007, end of the record linkage) during which the individuals were followed up until death, emigration from the city, or end of observation period. Individuals started to be followed up from age 50 years. The study population contains 391,170 men and 456,216 women.

The available information were date of birth, date of exit from the study, cause of exit (death or emigration), sex, region of birth, and education level, which, according to the literature, were used as proxy for the socio-economic status (Krieger *et al.*, 1997; Mirowsky and Ross, 2003; Doblhammer *et al.*, 2009). To facilitate the comparison between mortality levels of different education groups over a long follow-up period and over the many different cohorts included in the study, we created three broad categories: high (high school or higher), medium [intermediate school (corresponding to sixth, seventh, and eighth grades)], and low (elementary school or lower).

The focus on people older than 50 years makes this educational classification reasonable. The basic division into three levels of the Italian school system was set up in the 1920s.¹ A 5-year elementary school was followed by two types of 3-year intermediate school: one vocational type, which prepared the student for the labour market and did not allow accessing any higher levels of education, and one type that allowed accessing the technical high schools or the preparatory high schools for the university. The republican Constitution of 1948 kept the same system but introduced the compulsory 8 years of schooling,² although this was not really implemented until the important reform that occurred in the 1960s.³ The reform created a single compulsory 3-year intermediate level that did not preclude access to the various high schools. Until that time, *de facto*, only elementary school was compulsory, and even in that case, many children, especially in the southern regions, still did not attend all 5 years.⁴ Only a small part of the population studied for an extra 3 years. Individuals who attended high school then, especially women, represented an even more selected population who, almost certainly, would have continued their schooling careers by attending university, which is nowadays considered as a 'high' level of education.

Data quality is very high. The share of linked records between census and population registry was higher than 96% (except for 1971 when it was 84.7%). The unmatched census records are evenly distributed across the main socio-demographic categories, thus excluding bias problems related to a selected population. Information about education was unknown or unavailable in only 0.4% of the records for both men and women.

Methods

Given the longitudinal and individual-level nature of the data, the statistical technique of survival analysis regression for duration dependence models was used,⁵ adjusting for both right censoring and left truncation. Both types of censoring are present in the data: the first one due to emigration of the individuals before the end of the observation period or end of this period without having experienced the event of death and the second one due to the different ages

at entry in the observation window of the individuals.

Before estimating the mortality differentials by education level and macro-region of birth, a preliminary analysis for identifying the best functional baseline mortality hazard was performed. The baseline was modelled parametrically with the Gompertz (Gompertz, 1825) and Makeham (Makeham, 1860) functions,⁶ known to adequately describe patterns of adult human mortality, and compared via Akaike information criterion (Akaike, 1974). The results of the comparison indicated that the Gompertz model was the best fit for the men and the Makeham model the best fit for the women. Therefore, the rest of the analysis was conducted by adopting the Gompertz baseline for the men and the Makeham for the women.

Neglecting unobserved sources of heterogeneity (often called unobserved frailty) in survival analysis models might lead to biased estimates of the hazard and of the coefficients of the covariates (Gail *et al.*, 1984; Chamberlain, 1985; Trussell and Rodriguez, 1990; Aalen, 1994; Rodriguez, 1994; Aalen *et al.*, 2008). Frailty models (Vaupel *et al.*, 1979; Manton *et al.*, 1981) allow controlling for this component. As individuals differ in many unobserved and unobservable characteristics that influence their risk of death, we applied this approach and included a frailty term into the models. Frailty is a random-effect term, assumed to follow a gamma distribution with mean 1 and variance σ^2 to be estimated, which indicates the level of heterogeneity of the population with respect to susceptibility to death (Wienke, 2010b).

A first explorative analysis of the data revealed that from 1971 to 2007, a significant mortality improvement occurred, as it is shown in the mortality surface in Figure 1. The different cohorts included in the study passed through the years of observation at different ages and benefit from the mortality improvements occurring during those years at different ages.

To take this important phenomenon into account, we included covariates for the calendar periods and split the individual survival experience into several spells, one for each period the individual passed through. This implied an organisation of the data into clusters, where each cluster represents one individual that shares the same hidden frailty.

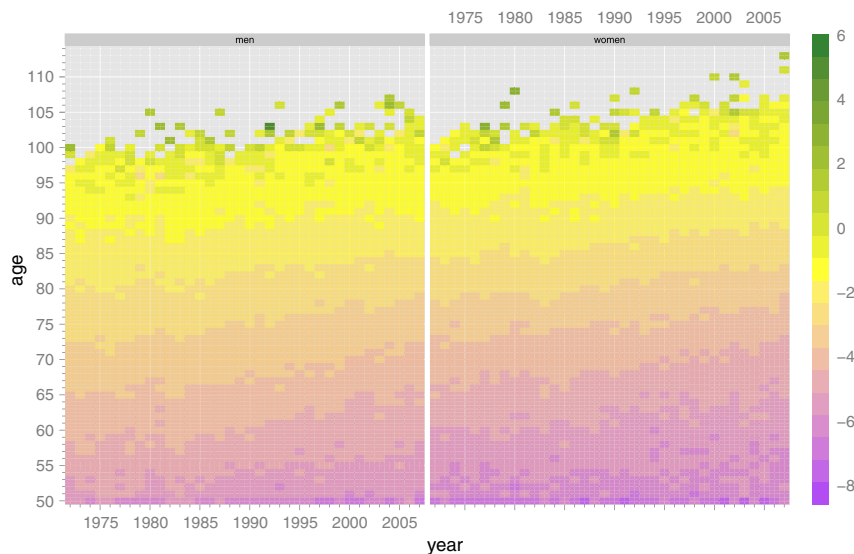


Figure 1. Representation of the death rates with a Lexis diagram over a 1-year age interval, on the y -axis, and a 1-year calendar time, on the x -axis. Data are shown on a logarithmic scale.

In these cases, to control for unobserved frailty, shared frailty models (Wienke, 2010c) had to be applied. Equation (3) describes the model:

$$\mu(x|u_{ij}, z_i) = z_i \mu_0(x) e^{u_{ij}\beta}, \quad (3)$$

where u_{ij} is the covariate profile of the j -th observation in the i -th cluster, z_i is the hidden frailty shared by the i -th cluster, and $\mu(0)$ is the baseline hazard.

Shared frailty models, especially with left truncated data, are very complex models [for the likelihood function, please see Van den Berg and Drepper (2011)], and when applied to a large dataset, they can be computationally challenging.⁷ For these reasons, it was impossible to estimate this model with a calendar period classification finer than two periods, 1971–1990 and 1991–2007, and the optimization routine needed to be applied via random subsampling. We estimated the models repeatedly over 1% sample of the data, randomly drawn without replacement (Hartigan, 1969, 1975; Politis and Romano, 1994), stratified by the major characteristics (education and region of birth). As noted by Efron (1979: 24), random subsampling ‘is very similar to bootstrap’. The basic idea is to approximate the parameter estimates on the basis of the distribution of the repeated estimates. Given the complexity of the model and the large size of the data set, 250 estimate repetitions were performed.⁸ It is generally advised to

choose a sufficiently large number of repetitions (Hesterberg, 2011), but in the application of very complex estimators, several studies have shown that between 100 and 500 can provide relatively small error margins (Efron and Tibshirani, 1993; Manly, 1997; Pattengale *et al.*, 2010).

RESULTS

Descriptive Results

Table 1 shows the distribution of the population by education and macro-region of birth. The

Table 1. Distribution of the Turin population included in the follow-up by education and by macro-region of birth.

	Men %		Women %	
Education				
Low	218,098	55.75	299,400	65.62
Medium	95,972	24.53	100,926	22.12
High	77,100	19.71	55,890	12.25
Total	391,170	100	456,216	100
Macro-region of birth				
North-west	192,660	49.25	244,613	53.61
North-east	39,189	10.02	49,680	10.89
Centre	13,198	3.37	19,900	3.05
South and islands	128,461	32.84	126,041	27.63
Abroad	17,662	4.51	21,982	4.82

majority of individuals (especially women) have a low education level. The share of medium education is similar for both sexes, whereas the percentage of highly educated individuals among men is higher than among women.

As expected, the share of individuals born in the 'north-west' region is the largest, as this is where Turin is located. We will consider these individuals as natives.⁹ Among the individuals born in the other areas, 33% of men and 28% of women were born in the 'south and islands' region, around 10% for both men and women come from the 'north-east' region, and only small numbers come from the 'centre' and 'abroad' regions.

The data confirm that migrants from the south were often individuals with low-education levels. Figure 2 shows that among men with low education, slightly less than 40% were natives and slightly more than 40% were born in the south, whereas for the other educational groups, the share of individuals from the south is smaller than the share of natives. The higher the level of education, the lower the share of individuals born in the south: almost 70% of the highly educated men were born in the north-west area (therefore, they are natives), and only around 20% were born in the south and islands area; almost 60% of the individuals with medium education come from north-west and only slightly more than 25% from south and islands. Women present a similar distribution.

Interestingly, these distributions change across different cohorts, as shown by Figures 3–5.

The share of the population with low education was the largest among the oldest cohorts (between 70% and 80%), and it gradually

decreased from older to younger cohorts. Meanwhile, the proportion of individuals in the medium-education and high-education categories increased. This is consistent with the gradual extension of access to higher education that took place worldwide over the 20th century, especially in economically developed countries and sharply accelerated after 1960 (Schofer and Meyer, 2005). In Italy and more specifically in the north-western region, the rate of high school and university enrolment increased from 6.51% in 1951 to 64.26% in 2001 (Felice, 2007: 385). This expansion process was facilitated by the economic growth and the education system reform in 1969¹⁰ that liberalised access to a mainly publicly funded university, which was made possible for anyone with a 5-year high school degree and not only for those coming from the preparatory high school.

Among younger cohorts, it is also possible to see that the shares of medium and high education are similarly distributed among men and women, whereas women belonging to previous cohorts had always been the minority among the highly educated group. Concerning those in the low-education group, the gender gap still persists. Although the difference tends to lessen, even in the youngest cohorts, the proportion of women with low education is bigger than the proportion of men.

The Italian history of post-war migration flows can be read in Figure 4. The share of migrants from the southern regions constantly grew from older to younger cohorts. It is particularly high among the immediate post-war generations, reflecting the fact that young adults with many small children (those were the years of the

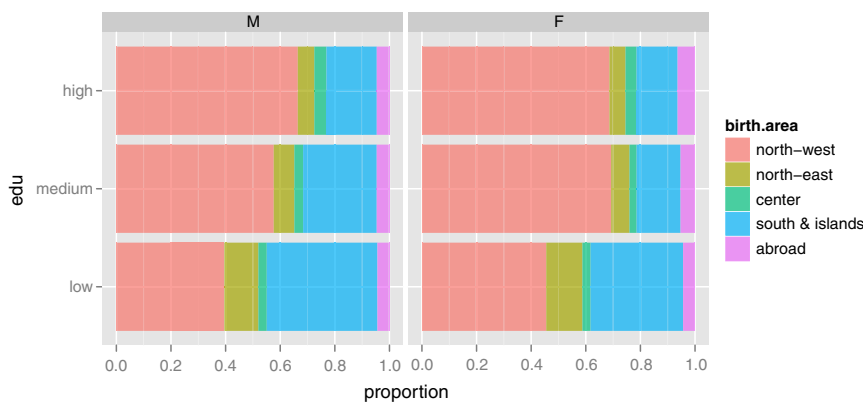


Figure 2. Distribution of the education groups in the Turin population by macro-region of birth.

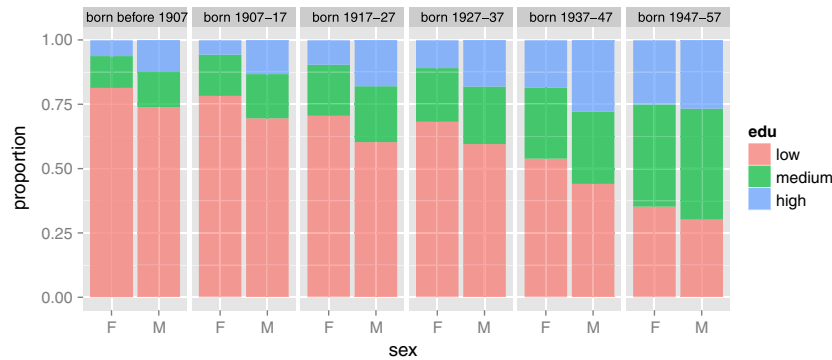


Figure 3. Distribution of the Turin population by education level for men (M) and women (F) in different 10-year birth cohorts.

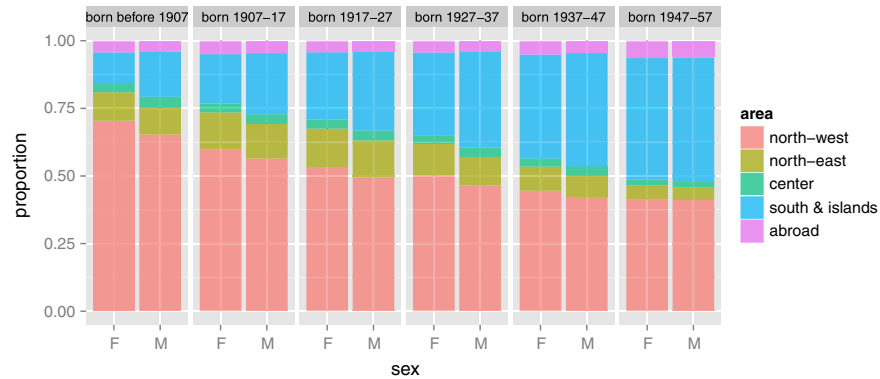


Figure 4. Distribution of the Turin population by macro-region of birth for men (M) and women (F) in different 10-year birth cohorts.

post-war baby boom) migrated from the south to the industrial centres in the north. It is striking that among the Turin population born between 1947 and 1957, almost 50% were born in the southern region and only slightly more than 40% were natives of the north-western one. Quantitatively, the major migration flows in those decades have been from the south to the north, of which more than 70% was directed to the north-west (Salvatore, 1980); the main determinants were regional differences in unemployment rates and earnings levels (Salvatore, 1977).

The north-east area, on the contrary, was an important source of migrants to the city among older cohorts, whereas its contribution decreases among younger cohorts, reflecting the economic history of this area in the post-war decades (Caselli and Egidi, 1981; Caselli and Reale, 1999). The percentages coming from the 'centre' and 'abroad' areas are negligible.

The recent economic history of Italy helps to understand these dynamics. Until WWII, because of a less advanced stage of economic development, the north-eastern regions experienced significant emigration flows both towards the north-west and foreign countries, mostly European ones, whereas individuals from southern regions emigrated mainly towards transoceanic destinations (Del Boca and Venturini, 2005). After the war, the north-east went through some years of demographic depression but, at the same time, together with the Central regions, started a slow (and for a long time unrecognised) process of economic development. This became visible in the 1970s, when a 'Third Italy' (Bagnasco, 1977) was discovered. This refers to the alternative industrial model characterised by small manufacturing firms, which were operating in the north-east and the centre, beyond the poor south and the modern north-west with its large-scale factories. Between the 1980s

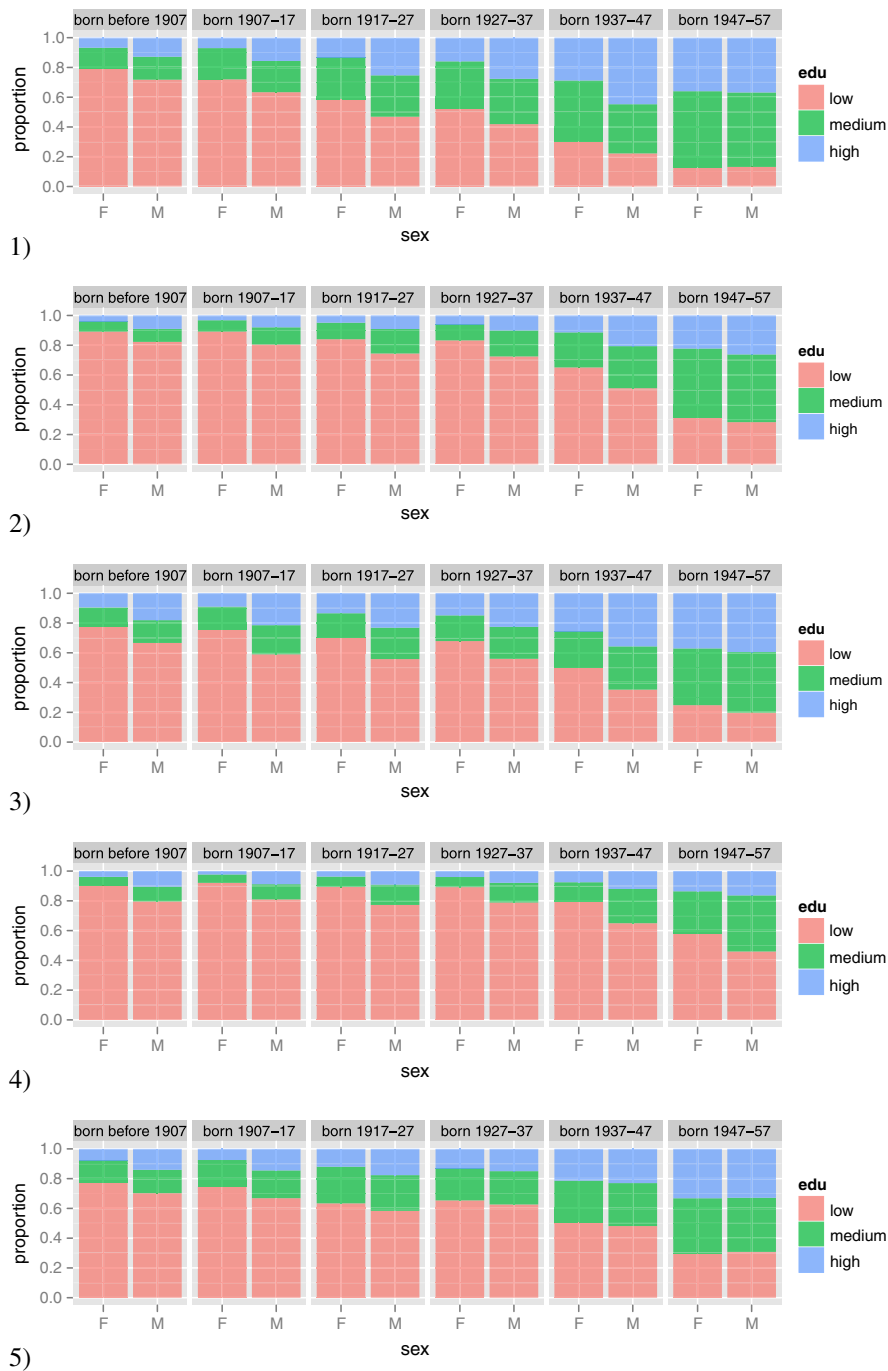


Figure 5. Distribution of the population by education, birth cohorts, and sex (M for men and F for women) for five macro-regions of birth: (1) north-west, (2) north-east, (3) centre, (4) south and islands, and (5) abroad.

and the 1990s, firm birth rates were the highest in the regions of the Third Italy (Garofoli, 1994), and from the 1990s, Veneto, one of the most important north-eastern regions, became a major labour

importer (Anastasia and Corò, 1996; Del Boca and Venturini, 2005).

Finally, Figure 5 shows how the pattern of persons with different levels of education, and

coming from different regions of origin, changed cohort by cohort.

From older to younger cohorts, all the regions of origin share the same pattern of gradual decrease of low-educated individuals and increase of medium and highly educated ones. This is true among both sexes. Cohort by cohort, the educational differential by gender, which saw the women over-represented among the low educated, narrows down. Among the youngest cohort, the distribution of education levels is virtually the same for men and women, with the exception of southern regions where the share of low education is still greater among women than among men. Meanwhile, men still have greater shares of medium and high educational levels than women.

Regression Analysis Results

Table 2 reports the results of the regression models for men and women: the baseline parameters (a and b of the Gompertz function used for the men; a , b , and c of the Makeham function used for the women), the variance of frailty σ^2 and the

mortality rate ratios for the education level, the region of birth, and the calendar period.

The estimated variance of frailty for the women is 0.29, whereas for men, it is 0.26. Therefore, women appear to be more heterogeneous than men with respect to their hidden susceptibility to death.

Another gender difference appears in the pace of mortality improvement over time, which is faster among men than among women. The mortality rate ratios for the period 1971–1990 relative to the period 1991–2007 are 0.728 for men and 0.888 for women. This is consistent with the recent narrowing of the gender mortality gap between Italian men and women.

The differences in mortality risks between education groups are found to be wider among women than among men. The relative risk for women with medium and low education, compared with women with high education, are 1.25 and 1.47, respectively. On the contrary, no clear gradient is visible among men: although medium-educated and low-educated men have a higher mortality risk compared with highly educated men, the rate ratios of medium-education and low-education groups are very similar, 1.27 and 1.26, respectively.¹¹

Table 2. Mortality rate ratios for men and women 50 years and older in a longitudinal study of the population of Turin, Italy, showing the effect of education level, region of birth, and calendar year.

	Women		Men	
	Mean estim.*	0.025–0.975 quant.*	Mean estim.*	0.025–0.975 quant.*
a	0.008	(0.000–0.016)	0.004	(0.000–0.010)
b	0.084	(0.073–0.106)	0.069	(0.061–0.163)
c	0.000**	(0.000–0.000)**	—	—
σ^2	0.292	(0.174–0.367)	0.269	(0.026–0.367)
Education level				
High	1	—	1	—
Medium	1.256	(1.053–1.347)	1.277	(1.054–1.349)
Low	1.475	(1.103–1.641)	1.268	(1.074–1.591)
Region of birth				
North-west	1	—	1	—
North-east	1.122	(0.888–1.217)	1.075	(0.855–1.220)
Centre	1.102	(0.864–1.218)	1.081	(0.854–1.217)
South	1.130	(0.904–1.220)	1.037	(0.854–1.216)
Abroad	1.082	(0.847–1.215)	1.082	(0.864–1.218)
Calendar year				
1971–1990	1	—	1	—
1991–2007	0.888	(0.671–1.035)	0.728	(0.613–0.985)

For the sake of simplicity, the values in the table have been rounded to three decimals.

*Mean estim. and quant. stand for the estimated mean value and the quantiles of the empirical distribution of parameters obtained from the repeated estimates via random subsampling, respectively.

**The actual parameter estimate and its confidence interval were respectively 2.852×10^{-6} and $(8.610 \times 10^{-7}$ to $2.997 \times 10^{-5})$.

Concerning the geographical differentials in mortality, the model did not identify any clear and significant pattern.

DISCUSSION

The different socio-demographic behaviours and characteristics of migrants can alter the composition of the population of the area of destination and, therefore, modify the demographic patterns of that area. This paper aimed to shed light on the effect of internal migration on the disparities in susceptibility to death in late-adult ages.

This study has shown how spatial population dynamics can affect the health and mortality profile of the places where the migratory movements are directed to. They do so by altering the composition of the population in the area of destination (and, although it was not investigated in this study, in the area of origin as well), but as pointed out by this study, these compositional changes might be subtle and involve also unobserved or unobservable characteristics that might be overlooked at first.

The analysis used data from the Italian industrial city of Turin, which attracted millions of Italians from other regions during the industrialisation process that took place after WWII. The majority of the migrants to Turin were low-educated individuals from the south of Italy seeking jobs in the car factories.

The paper hypothesised that the combined effect of the supposedly healthier status of migrants (Feinleib *et al.*, 1982; Sharma *et al.*, 1990; Valkonen *et al.*, 1992; Kington *et al.*, 1998; Singh and Siahpush, 2001; Deboosere and Gadeyne, 2005) and a faster selection due to higher mortality of the low-educated ones involved in heavier and riskier jobs could have caused a process of homogenisation and reduction of differences in susceptibility to death. Moreover, this effect is likely to be more pronounced among men because women were likely to be more passive actors in the migratory decision (Mincer, 1978; Bielby and Bielby, 1992) and less heavily involved in the industrialisation process and its aftermath.

By applying a survival analysis model with an unobserved heterogeneity component to a 36-year mortality follow-up period, the results of the regression showed that the female population is somewhat more heterogeneous than the male population (the estimated variance of the random term was higher for women than for men).

Moreover, the male mortality gradient by education level was less defined than the women's gradient. In particular, compared with the reference category (high education), the rate ratios for women with low education were higher than the rate ratio of women with medium education. Among men, by contrast, although medium-education and low-education groups showed higher mortality with respect to the high-education group, the rate ratios for the medium and low categories were very similar. This suggests that there is no clear mortality difference between the two educational groups and seems to confirm the hypothesis that a process of homogenisation took place, which made the male population more homogeneous with respect to susceptibility to death and reduced the differences in mortality by education, at least between the medium-education and low-education groups. This is furthermore strengthened by the estimated lower variance of frailty compared with the women.

Another mechanism might have played a role in somehow reducing the differences in survival, especially between educational groups among men. The so-called salmon bias (Palloni and Arias, 2004) [when weaker and sick migrants move back to their place of origin for receiving care (Lanska and Peterson, 1995; Brimblecombe *et al.*, 2000)] might have drained part of the weaker individuals out of the low-educated population, thus contributing to its healthier and less frail status, reflected in narrower mortality differential compared with the other educational groups. Unfortunately, the available data do not allow taking this mechanism into account, as it is not possible to follow the individuals up after they leave the city of Turin.

The analysis also included a variable for the macro-region of birth for which the model did not identify any clear pattern. At first, this is quite surprising because Italy is characterised by significant geographical differences in survival chances. For most of the 20th century, male mortality in the south was significantly lower than in the north (Caselli and Egidi, 1980, 1981; Caselli and Reale, 1999; Barbi and Caselli, 2003), and only cohorts born after WWII show a reversing trend (Caselli and Reale, 1999; Biggeri *et al.*, 2011).

On the one hand, one must be aware that these differences refer to mortality by region of death and not by the region of birth, because the available data on regional deaths do not allow

tracking of the migrants. The observation that cohorts born after WWII experience a reversed pattern supports the idea that the level of mortality was determined by the level of industrialisation and of exposure to its most negative effects. For older cohorts who were involved in the first phase of industrialisation, this coincided with an exposure to its dangers that raised mortality in the industrialised regions of the north and spared the less industrialised south. As industrialisation proceeded, it also improved wealth, which started to compensate for the mortality disadvantage with better health services, higher incomes and pensions, and so on. As a consequence, for more recent cohorts, living in the economically depressed south is no longer an advantage.

On the other hand, it is possible that the model failed to identify any pattern because the number of bootstrapping repetitions (250) might not have been sufficient, although such a number is considered by the literature adequate for very complex models (Manly, 1997; Pattengale *et al.*, 2010). A more likely explanation seems to be that the survival advantage of the male migrants from the south (either due to the migration-related health selection or due to a persisting geographical component) was nearly entirely captured by the low-education variable, as the majority of male migrants from the south had a low education level. This would explain why low-education and medium-education groups did not show clear differences in mortality, instead of presenting the expected gradient high-medium-low. It also lends support to the hypothesis that the migratory process contributed to reducing male mortality disparities and heterogeneity in susceptibility to death.

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NOTES

- (1) A series of royal legislative decrees between 1922 and 1923 (31 December 1922, n. 1679, 16 July 1923, n. 1753, 6 May 1923, n. 1054, 30 September 1923, n. 2102, and 1 October 1923, n. 2185) represent the so-called Gentile Reform, named after the

philosopher and minister of education Giovanni Gentile.

- (2) Constitution of the Italian Republic, article 34.
- (3) Law 31 December 1962, n. 1859.
- (4) Despite the national and centrally managed school system, strong geographical differences in access to education and literacy rates have characterised Italy for a long time, fading away only in the recent decades (Felice, 2007).
- (5) In this kind of analysis, the duration of the process under scrutiny (time until death), together with the occurrence of the event (death), represents the dependent variable. This allows controlling for the dynamic change over time of the population at risk, by taking into account, at any time unit of the observation period, the number of events that already occurred and at which ages they have occurred, as well as the number of individuals that, instead, are still at risk of experiencing the event. This implies also taking into account the age structure of the surviving population over time. The aim is generally to model the age profile of the mortality risk of the standard individual (otherwise called baseline hazard), who is the individual with characteristics corresponding to the reference categories of the covariates of interest, and to estimate the effect of those covariates on the baseline hazard. It is common to report the exponentiated coefficients, which represent mortality rate ratios with respect to the reference category, that is, by how much the covariate increases or decreases the risk of death at each age. For the interested reader, a brief but complete and detailed introduction to survival analysis can be found in Wienke (2010a).
- (6) Equations (1) and (2) show the Gompertz and the Makeham models

$$\mu(x) = ae^{bx} \quad (1)$$

$$\mu(x) = ae^{bx} + c \quad (2)$$

where $\mu(x)$ is the mortality hazard at age x .

- (7) Initially, the time from 1971 to 2007 had been divided into 12 periods of 3 years each. This means that the individual had up to a maximum of 12 spells, and the final size of the split data set was several million lines. For computational reasons, it was impossible to estimate this model, so the number of calendar periods had to be reduced to two, 1971–1990 and 1991–2007, and the optimization routine needed to be applied via random subsampling.
- (8) By way of illustration, one repetition for the Gamma-Gompertz model with education and macro-region of birth covariates, applied to the 1% sample drawn from the men dataset, required between 12 and 13 hours on a 4CPUs, 4GB computer.

- (9) This is not completely correct because those born in the north-west region include also the short-distance migrants from the areas around Turin. However, this does not affect our analysis because we are focused on the south–north migration flow.
- (10) Presidential Decree 31 October 1969, n. 1236.
- (11) Even though the confidence intervals are very broad, the results testify in favour of the possibility that the process assumed by the model might generate the observed pattern: they pertain to a full population and not to statistical samples. Therefore, the confidence intervals are not to be interpreted in the standard setting of hypothesis testing but rather represent the stochasticity in the model assumptions and not a possible sample bias.

REFERENCES

- Aalen O. 1994. Effects of frailty in survival analysis. *Statistical Methods in Medical Research* 3(3): 227.
- Aalen O, Borgan Ø, Gjessing H. 2008. Chap. 6: Unobserved heterogeneity: The odd effects of frailty. *Survival and Event History Analysis*. Springer: New York; 231–270.
- Akaike H. 1974. A new look at the statistical model identification. *Automatic Control, IEEE Transactions on* 19(6): 716–723.
- Anastasia B, Corò G. 1996. Evoluzione di un'economia regionale: il Nordest dopo il successo [The evolution of a regional economy: the North-East after the success.]. Nuova Dimensione Edizioni.
- Andersson G. 2004. Childbearing after migration: fertility patterns of foreign-born women in Sweden. *International Migration Review* 38(2): 747–774.
- Bagnasco A. 1977. Tre Italie: la problematica territoriale dello sviluppo italiano [Three Italies: the territorial problem of the Italian development.]. Il Mulino: Bologna.
- Barbi E, Caselli G. 2003. Selection effects on regional differences in survivorship in Italy. *Genus* 59(2): 37–61.
- Bennett S. 1993. Inequalities in risk factors and cardiovascular mortality among Australia's immigrants. *Australian Journal of Public Health* 17(3): 251–261.
- Bielby W, Bielby D. 1992. I will follow him: family ties, gender-role beliefs, and reluctance to relocate for a better job. *American Journal of Sociology* 97(5): 1241–1267.
- Biggeri A, Accetta G, Egidi V. 2011. Evoluzione del profilo di mortalità 30-74 anni per le coorti di nascita dal 1889 al 1968 nelle regioni italiane [Mortality time trends 30-74 years by birth cohorts 1889-1968 in the Italian regions]. *Epidemiologia & Prevenzione* 35(5-6): 50–67.
- Bonifazi C, Heins F. 2000. Long-term trends of internal migration in Italy. *International Journal of Population Geography* 6(2): 111–131.
- Brimblecombe N, Dorling D, Shaw M. 1999. Mortality and migration in Britain, first results from the British Household Panel Survey. *Social Science & Medicine* 49(7): 981–988.
- Brimblecombe N, Dorling D, Shaw M. 2000. Migration and geographical inequalities in health in Britain. *Social Science & Medicine* 50(6): 861–878.
- Canteri C. 1964. Immigrati a Torino. Edizioni l'Avanti!
- Caselli G, Egidi V. 1980. *Le differenze territoriali di mortalità in Italia: tavole di mortalità provinciali: (1971-72)*. Istituto di Demografia della Sapienza Università di Roma: Rome.
- Caselli G, Egidi V. 1981. L'analyse des données multidimensionnelles dan l'étude des relations entre mortalité et variable socio-économiques d'environment et de comportement individuel [Multivariate methods in the analysis of the relations between mortality and socio-economic, environmental and behavioural variables]. *Genus* 37(3/4): 57–91.
- Caselli G, Reale A. 1999. Does cohort analysis contribute to the study of the geography of mortality? *Genus* 55(1/2): 27–59.
- Chamberlain G. 1985. Heterogeneity, omitted variable bias, and duration dependence. In *Longitudinal Analysis of Labor Market Data*, Heckman J, Singer B (eds). Cambridge University Press: Cambridge; 3–38.
- Cooke TJ. 2008. Gender role beliefs and family migration. *Population, Space and Place* 14(3): 163–175.
- D'onofrio G. 2010. Un caso di studio: Torino. In *L'Italia delle migrazioni interne negli anni del miracolo economico*, D'onofrio G (ed.). Università degli Studi di Bologna: Bologna; 61–90.
- Deboosere P, Gadeyne S. 2005. Adult migrant mortality advantage in Belgium: evidence using census and register data. *Population (english edition)* 60(5): 655–698.
- Del Boca D, Venturini A. 2005. Italian migration. In *European Migration: What Do We Know?*, Zimmermann KF (ed.). Oxford University Press: Oxford; 303–336.
- Doblhammer G, Hoffmann R, Muth E, Westphal C, Kruse A. 2009. A systematic literature review of studies analyzing the effect of sex, age, education, marital status, obesity, and smoking on health transitions. *Demographic Research* 20(5): 37–64.
- Efron B. 1979. Bootstrap methods: another look at the jackknife. *The Annals of Statistics* 7(1): 1–26.
- Efron B, Tibshirani R. 1993. *An Introduction to the Bootstrap*, vol. 57. Chapman & Hall/CRC: Boca Raton.
- Feinleib M, Lambert P, Zeiner-Henriksen T, Rogot E, Hunt B, Ingster-Moore L. 1982. The British-Norwegian migrant study—analysis of parameters of mortality differentials associated with angina. *Biometrics* 38: 55–71.
- Felice E. 2007. I divari regionali in Italia sulla base degli indicatori sociali (1871-2001) [Regional differences in

- Italy based on social indicators (1871-2001)]. *Rivista di Politica Economica* 97(3/4): 359–405.
- Fofi G. 1964. L'immigrazione meridionale a Torino. Feltrinelli: Milano.
- Gail M, Wieand S, Piantadosi S. 1984. Biased estimates of treatment effect in randomized experiments with nonlinear regressions and omitted covariates. *Biometrika* 71(3): 431.
- Garofoli G. 1994. New firm formation and regional development: the Italian case. *Regional Studies* 28(4): 381–393.
- Ginsborg P. 1989. Storia d'Italia dal dopoguerra a oggi: Dal "miracolo economico" agli anni '80. Einaudi: Torino.
- Gompertz B. 1825. On the nature of the function expressive of the law of human mortality, and on a new mode of determining the value of life contingencies. *Philosophical Transactions of the Royal Society of London* 115: 513–583.
- Hartigan JA. 1969. Using subsample values as typical values. *Journal of the American Statistical Association* 64(328): 1303–1317.
- Hartigan J. 1975. Necessary and sufficient conditions for asymptotic joint normality of a statistic and its subsample values. *The Annals of Statistics* 3(3): 573–580.
- Hattersley L. 1997. *Expectation of Life by Social Class*. Office for National Statistics: London.
- Hesterberg T. 2011. Bootstrap. *Wiley Interdisciplinary Reviews: Computational Statistics* 3(6): 497–526.
- Kington R, Carlisle D, McCaffrey D, Myers H, Allen W. 1998. Racial differences in functional status among elderly US migrants from the south. *Social Science & Medicine* 47(6): 831–840.
- Kolčić I, Polašek O. 2009. Healthy migrant effect within Croatia. *Collegium antropologicum* 33(Suppl.): 141–145.
- Krieger N, Williams D, Moss N. 1997. Measuring social class in US public health research: concepts, methodologies, and guidelines. *Annual Review of Public Health* 18(1): 341–378.
- Kunst A. 2004. Monitoring of trends in socioeconomic inequalities in mortality: experiences from a European project. *Demographic Research Special Collection* 2(9): 229–254.
- Lanska D, Peterson P. 1995. Effects of interstate migration on the geographic distribution of stroke mortality in the United States. *Stroke* 26(4): 554–561.
- van Lenthe F, Martikainen P, Mackenbach J. 2007. Neighbourhood inequalities in health and health-related behaviour: results of selective migration? *Health & Place* 13(1): 123–137.
- Luy M, Caselli G. 2007. The impact of a migration-caused selection effect on regional mortality differences in Italy and Germany. *Genus* 63(1/2): 33–64.
- Mackenbach J. 2006. Health inequalities: Europe in profile. Tech. Rep.
- Makeham WM. 1860. On the law of mortality and the construction of annuity tables. *The Assurance Magazine, and Journal of the Institute of Actuaries* 8(6): 301–310.
- Malmusi D, Borrell C, Benach J. 2010. Migration-related health inequalities: showing the complex interactions between gender, social class and place of origin. *Social Science & Medicine* 71(9): 1610–1619.
- Manly B. 1997. *Randomization, Bootstrap and Monte Carlo Methods in Biology*. Chapman & Hall/CRC: Boca Raton.
- Manton K, Stallard E, Vaupel J. 1981. Methods for comparing the mortality experience of heterogeneous populations. *Demography* 18(3): 389–410.
- Marmot M. 1986. Mortality decline and widening social inequalities. *The Lancet* 328(8501): 274–276.
- McCredie M, Williams S, Coates M. 1999. Cancer mortality in migrants from the British Isles and continental Europe to New South Wales, Australia, 1975–1995. *International Journal of Cancer* 83(2): 179–185.
- Mincer J. 1978. Family migration decisions. *Journal of Political Economy* 86: 749–775.
- Mirowsky J, Ross C. 2003. Education, social status, and health. Aldine de Gruyter.
- Mussino E, Strozza S. 2012. The fertility of immigrants after arrival: the Italian case. *Demographic Research* 26(4): 99–130.
- Mussino E, Van Raalte A. 2013. Immigrant fertility: a comparative study between Italy and Russia. *International Migration* 51(5): 148–164.
- Norman P, Boyle P, Rees P. 2005. Selective migration, health and deprivation: a longitudinal analysis. *Social Science & Medicine* 60(12): 2755–2771.
- Palloni A, Arias E. 2004. Paradox lost: explaining the Hispanic adult mortality advantage. *Demography* 41(3): 385–415.
- Pattengale N, Alipour M, Bininda-Emonds O, Moret B, Stamatakis A. 2010. How many bootstrap replicates are necessary? *Journal of Computational Biology* 17(3): 337–354.
- Pellicciari G, Albertelli G. 1970. L'immigrazione nel triangolo industriale. Franco Angeli Editore: Milano.
- Politis D, Romano J. 1994. Large sample confidence regions based on subsamples under minimal assumptions. *The Annals of Statistics* 22(4): 2031–2050.
- Rasulo D, Spadea T, Onorati R, Costa G. 2012. The impact of migration in all-cause mortality: the Turin Longitudinal Study, 1971–2005. *Social Science & Medicine* 74(6): 897–906.
- Rodriguez G. 1994. Statistical issues in the analysis of reproductive histories using hazard models. *Annals of the New York Academy of Sciences* 709(1): 266–279.
- Salvatore D. 1977. An econometric analysis of internal migration in Italy. *Journal of Regional Science* 17(3): 395–408.
- Salvatore D. 1980. A simultaneous equations model of internal migration with dynamic policy simulations and forecasting: Italy, 1952–1976. *Journal of Development Economics* 7(2): 231–246.

- Schofer E, Meyer JW. 2005. The worldwide expansion of higher education in the twentieth century. *American Sociological Review* **70**(6): 898–920.
- Sharma R, Michalowski M, Verma R. 1990. Mortality differentials among immigrant populations in Canada. *International Migration* **28**(4): 443–450.
- Shkolnikov V. 2011. Increasing absolute mortality disparities by education in Finland, Norway and Sweden, 1971–2000. *Journal of Epidemiology and Community Health* **66**(4): 372–378.
- Singh G, Siahpush M. 2001. All-cause and cause-specific mortality of immigrants and native born in the United States. *American Journal of Public Health* **91**(3): 392.
- Strand B. 2010. Educational inequalities in mortality over four decades in Norway: prospective study of middle aged men and women followed for cause specific mortality, 1960–2000. *BMJ [British Medical Journal]* **340**: 1–10.
- Trussell J, Rodriguez G. 1990. Heterogeneity in demographic research. In *Convergent Issues in Genetics and Demography*. Oxford University Press: USA.
- Valkonen T. 1993. Socioeconomic mortality differences in Finland 1981–1990. Tech. Rep.
- Valkonen T. 2001. *Trends in Differential Mortality in European Countries*. Council of Europe Publishing: Strasbourg; 185–322.
- Valkonen T, Brancker A, Reijo M. 1992. Mortality differentials between three populations—residents of Scandinavia, Scandinavian immigrants to Canada and Canadian-born residents of Canada, 1979–1985. *Health reports/Statistics Canada, Canadian Centre for Health Information = Rapports sur la santé/Statistique Canada, Centre canadien d'information sur la santé* **4**(2): 137.
- Van den Berg GJ, Drepper B. 2011. Inference for shared-frailty survival models with left-truncated data. *IZA Discussion Paper No. 6031*.
- Vaupel J, Manton K, Stallard E. 1979. The impact of heterogeneity in individual frailty on the dynamics of mortality. *Demography* **16**(3): 439–454.
- Westman J, Martelin T, Härkänen T, Koskinen S, Sundquist K. 2008. Migration and self-rated health: a comparison between Finns living in Sweden and Finns living in Finland. *Scandinavian Journal of Public Health* **36**(7): 698–705.
- Wienke A. 2010a. Frailty models in survival analysis, chap. 2: Survival analysis. Chapman & Hall/CRC: Boca Raton; 15–54.
- Wienke A. 2010b. Frailty models in survival analysis, chap. 3: Univariate frailty models. Chapman & Hall/CRC: Boca Raton; 15–54.
- Wienke A. 2010c. Frailty models in survival analysis, chap. 4: Shared Frailty Models. Chapman & Hall/CRC: Boca Raton; 131–160.
- Wild S, McKeigue P. 1997. Cross sectional analysis of mortality by country of birth in England and Wales, 1970–92. *BMJ* **314**(7082): 705.
- Zarulli V, Jasilionis D, Jdanov DA. 2012. Changes in educational differentials in old-age mortality in Finland and Sweden between 1971–1975 and 1996–2000. *Demographic Research* **26**(19): 489–510.