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Mortality in Brussels: A Comparative Analysis of Belgian and non-Belgian Populations

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Abstract

The population enumerated in the Belgian census of 1991, resident in the Brussels capital region, was linked with all death records in the population register over 6 years, and the relative probability of dying was estimated for male and female populations of various national origins. Males had a greater risk of dying than females, and most non-Belgian and foreign-born populations had a reduced mortality risk, especially at adult ages. Important exceptions were the Moroccan and Turkish populations, particularly women, who had a greater childhood mortality risk; and the African populations with a greater risk at all ages. By comparing these rates with the relative risks of migration for the various groups, it is concluded that it is unlikely that these results can be explained through administrative loss of individuals due to unrecorded leaving of the country.

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Introduction

Geographically, socially, and today also politically, Brussels is at the crossroads of Europe. Not surprisingly, the Brussels population is characterised by a large and very heterogeneous immigrant population. Yet unlike many other European capitals, few of these migrants have reached Brussels because of specific historical ties between their locations of origin and destination, as for instance, in the case of former colonial country residents migrating to the *soi-disant* "mother country". Rather, migration to Brussels has been far more directly related to work opportunities and pre-existing migration chains. In the present analysis, we seek to follow the fortunes of these migrants with respect to their survivorship in their new land. In particular, we shall consider the mortality risks of migrants from different countries of origin, in comparison with their locally born Belgian counterparts.

Brussels is a particularly propitious location for such an analysis. The concentration in Brussels of the so many international institutions (European Community, NATO, etc.) has led to the growth of a large and very heterogeneous international population, across a broad range of social locations, ranging from unskilled job seekers at one end of the scale to well-established career officials at the other. Of the population of close to 1 million living in the Brussels region at the time of the 1991 Census (March 1st, 1991), over a quarter (28 percent) were non-Belgian, of whom two thirds (68 percent) were born abroad; and of the Belgian nationals, too, almost one tenth (9 percent) were born abroad. Thus, only 65 percent of the resident population were native born Belgians, and of these only two-thirds were actually born in Brussels. Of the other 35 percent, almost a half were of European origin; a third were from Morocco or Turkey, and the remaining fifth were from the rest of the world, including Africa, Middle East, Asia and North America.

Although a number of recent mortality studies have been able to follow up large scale populations over a long time (see, e.g. Hummer, Rogers et al. 1999; Koenig, Hays et al., 1999; Oman & Reed 1998; Rogers, 1995) the number of persons in the initial cohort followed up has usually been no more than a few thousands. Some, indeed, have followed up over an extremely long time (Strawbridge, Cohen et al. 1997) and the English OPCS longitudinal survey has been able to base itself on a very large sample (Fox & Goldblatt, 1982; Harding, 1995) over a long period of time, but rarely have mortality analyses been able to follow up whole populations (for a review, see Fox, 1989). The present analysis is able to base itself on precisely such a follow up of the full population enumerated in Brussels at the time of the 1991 census, through linking with the death records in the Belgian national population register (Deboosere & Gadeyne, 1999) over almost six years, from March 1st 1991 to 31st December 1996.

Nonetheless, the analysis of mortality in such a population is necessarily problematic. Any attempt to analyse mortality risks must necessarily focus on the number of deaths relative to a known base population, over a time period long enough for a consistent estimate of the rate to be made. Yet a population with such a large proportion of migrants is liable to be a very changeable population, as people enter and leave over relatively short periods, and such mercurial and volatile populations, though they may make for a lively city, are a demographer's nightmare! To deal with this problem, we shall analyse, in parallel, the probabilities of dying and of emmigrating, using a follow up of the 1991 census linked to the records of the Belgian population registry, over a period of six years. Although we cannot register or impute unrecorded migration of residents, we hope that by such a comparative analysis, in which we can identify groups with a high propensity to emigrate, we shall be able to evaluate the reliability of our estimates of the relative risks of dying for the different population groups.

Migrants in Belgium: a historical overview

The demographic history of Belgium is the history of migration, and of migrant settlement. Indeed, as Lambert (1992) points out, to think of Belgium without migrants would be quite preposterous (*sagrenue)*. Belgium, and Flanders in particular, has been a trading centre for the last millennium at least, and the same geographic conditions which made the southern Netherlands a natural passageway for armies crossing Europe, not only facilitated trade, but also made it a natural passageway, and point of settlement, for migrants. There has, however, been a qualitative growth in the number and concentration of migrants in the past two centuries, both in Brussels and in Belgium as a whole, and it is these which have largely formed the present native population and, of course, the current migratory population.

Although Brussels has long been the provincial capital for the area approximately covered by today's Belgium, its population growth only began with the creation of the Belgian state in 1830. De Schaepdrijver (1990, reviewed by Lynch, 1997) notes that the population of Brussels, which was only 76,000 in 1800 had grown to 235,000 by 1856. Impressive as this tripling of the population may be, it actually amounts to no more than a two percent average annual rate of growth – though if we assume that most of this growth took place after 1830, the rate exceeds four percent per year. By 1842, de Schaepdrijver notes, migrants made up 43 percent of all the Brussels population, which suggests that all the growth derived from migration. Of these migrants, about one sixth were of non-Belgian origin (7.5 percent of the total population), mostly educated Francophones attracted in to staff and manage the burgeoning state services. Belgian migrants, by contrast, were mainly Flemish artisans and peasants pushed off the land, and were thus divided both by class and culture from the Francophone élite (which suggests that Flemish Brussels became Francophone as much by lower class Flemings taking on the language of the Francophone élite as by the influx of Walloons). The smallness of the country, and the rapid growth of the rail network led to the growth of Brussels and Antwerp as the main commercial centres (Lesthaeghe, 1977) and the growth of industrialisation in Wallonnia fuelled the further growth of Brussels as its commercial and service centre. It is to be noted, however, that Brussels never grew to be a primal city as have other capitals (London, Paris, etc.), rather, the later development in Belgium, at a time of far better communications, coupled with the relatively short distances, has led to a far more gradual distribution of city sizes (Brussels, with almost a million inhabitants, has about ten percent of the Belgian population, but Antwerp has close to half a million residents; Charleroi, Gent and Liège have about 200,000 each and Namur and Brugge have about 100,000, see NIS, 1992, pp. 14-35).

In the twentieth century both the country of origin, and social standing, of the migrants to Belgium changed dramatically. Between the world wars most migration was of contract labour, in particular Italian, recruited for the mines and heavy industries of Wallonia and Limburg. After 1945 these industries began to decline, to be replaced by a growth in the service sector and more modern industries, mainly in Flanders, and migration, still mainly European, moved with the economy (Grimmeau, 1984; Lesthaeghe, 2000). However, the post-war boom was felt across Europe, and employers looked further afield for recruiting cheap labour, mainly to Turkey and Morocco. In 1961 immigrants from these countries numbered only a 1000, but by 1991 their number had grown to a quarter of a million (Lodewijckx, 1995). As with the Italian recruits of the 1920's, what began as temporary recruitment soon became circular and more permanent as contracts were repeatedly renewed (Reniers, 2000). Active worker recruitment ceased in the late 1960's with the economic slowdown, and new immigration has been restricted to family reunions since the early 1970's. Nonetheless, the strong localisation of these populations, in particular the Turks, together with the maintenance of strong ties with the towns and villages of origin, has led to a large movement of imported brides and grooms (Lievens, 2000). At the same time, Zairean independence led to an influx of migrants from Africa; and the setting up, and expansion, of the European headquarters in Brussels led to the growth in migration of white collar European workers, many, but not all, on a short term basis.

Over the past 200 years, then, Brussels has grown more than tenfold. In the process, it has become a heterogeneous centre of international migration in which first and second generation immigrants make up over a third of the population. Our aim in the following pages is to consider how their mortality experience differs from that of the native, Belgian residents of Brussels.

The Mortality of Migrants

There is a consistent finding in most of the literature, that adult migrants have lower mortality than the host population, although their children may have a higher level of mortality (Abraído-Lanza et al., 1999; Choinière, 1993; Maffenini, 1980; Peters & Van der Veen, 1990; Rosenwaike, 1990; Sharma et al., 1990; Young, 1991). Only Wild and McKeigue (1997) report a higher level of mortality for migrants. In Belgium, Maffenini reported that immigrants to Belgium, around 1970, showed lower mortality, for both sexes and at all ages except males under 5, and Peters and Van der Veen (1990) reported a greater risk of stillbirths and perinatal deaths for Turkish and Moroccan mothers in Belgium. Choinière showed that life expectancy at birth in Montreal census tracts rose as the proportion of migrants rose, controlling for wealth, but so did infant mortality, and Sharma et al., (1990) reported that all immigrant groups to Canada have higher life expectancy than the native Canadian population and, except for Africans, higher life expectancy than their populations of origin; Rosenwaike (1990) reported lower cancer and circulatory mortality for Puerto Ricans in the United States than US whites, but higher levels of external-cause mortality; and Young (1991) showed the same result for immigrants to Australia. Abraído-Lanza et al., (1999) consider the possibility that this reduced mortality is a statistical artefact deriving from migrants' undocumented return home ("salmon bias" reflecting a salmon-like tendency to return in old age to one's place of birth) but reject this explanation on the grounds that Cubans and Puerto Ricans, two groups to which the salmon bias could not apply, also show reduced mortality. They also reject a selection of healthy migrants effect, arguing instead for a healthier life-style among Latino migrants to the United States, an advantage that is lost with acculturation, although Browning and Feindt (1969) did report, for instance, that migrants to Monterey, CA were educationally advantaged compared with their region of origin. By contrast, Wild and McKeigue, comparing standardised mortality ratios for migrants into England and Wales around the 1971 and 1991 censuses, report a higher level of mortality for all except Caribbean migrants, who have lower mortality, particularly from ICD and cancer. Here too, however, this advantage cannot be attributed to class, given the overwhelming concentration of Caribbean immigrants in blue-collar occupations.

This English evidence is not to be treated lightly, but the weight of the evidence does appear to be in the other direction, namely, that adult migrants show *reduced* mortality in comparison with the native population, but children of migrants, especially young children, show a higher level of mortality. Previous research has indicated this to be the case for Belgium in previous decades, and we may expect the same to be true for migrants' experience in the 1990's.

Migrants in Brussels: social locations

Before analysing the effects of particular migrations statuses on mortality, we commence with a brief overview of the social location of various migrant populations in the Belgian capital. This overview is necessarily cursory, it is designed to give the reader a brief sense of who the different groups of migrants are, and how they are distinguished from their native Belgian counterparts. Any definition of migrant status is problematic, and begs many questions as to who is a migrant, or a Belgian, or both. For the purpose of this analysis we have considered three separate issues:

1. Declared nationality at the census, Belgian or non-Belgian;
2. Place of birth, in Belgium or abroad;
3. Origin, by national affiliation and/or place of birth:
    - i. Brussels for Belgian nationals born in the city of Brussels;
    - ii. Flemish for Belgian nationals born in Flanders;
    - iii. Walloon, for Belgian nationals born in Wallonia;
    - iv. Major population groups, by place of birth or nationality:
        - a. France
        - b. Italy
        - c. Spain
        - d. Other N. European[2]
        - e. Other S. European[2]

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[2] All countries with less than one percent of the total Brussels population.

f. Africa (South of Sahara)[2]

g. Morocco

h. Turkey

i. Other and unknown (all groups with fewer than 1 percent of the population: E. Europe; Other Middle East; Other Anglo-Saxon; Asia and Latin America)

Table 1 About Here

Table 1 and Figure 1 present the breakdown of the population, by these categories. Overall, 43 percent of the Brussels population at census were Belgians native born in Brussels, and a further 20 percent were Belgians born in Flanders or Wallonia who had moved into Brussels. A further nine percent were locally (mostly Brussels) born but of non-Belgian nationality, of which Moroccans made up almost half, and Italians and Turks more than 10 percent each. The largest group of non-native origin is the Moroccans, followed by a number of European groups, in particular the Italians, the French and the Spanish, and then the Turks. Some comparisons between the columns are also instructive indicators of the patterns of migration. For the population of African origin, over half the population are naturalised Belgians born abroad; for the French, the Italians and Others about a third, and for the rest (including Europeans, Moroccans and Turks) fewer than five percent are in this category. On the other hand, the ratio of non-Belgians locally born to those born abroad is almost at parity (9:10) for the Moroccan population, is slightly lower for the Turks (2:3),and is lowest for the North Europeans (1:5), suggesting clear differences not only in

Table 1: Population Groups by Belgian Nationality and Place of Birth

Population Group	Non-Belgian Born Abroad	Non-Belgian Born in Belgium	Belgian Born Abroad	Belgian Born in Belgium	Total *Percent*
Brussels	0.0	0.0	0.0	65.3	406,592 *42.6*
Flemish	0.0	0.0	0.0	21.8	135,764 *14.2*
Walloon	0.0	0.0	0.0	12.9	80,285 *8.4*
France	11.6	6.2	18.4	0.0	37,776 *4.0*
Italy	11.1	12.8	2.9	0.0	33,375 *3.5*
Spain	9.6	8.9	2.5	0.0	26,891 *2.8*
N. Europe	10.2	4.4	16.9	0.0	32,783 *3.4*
S. Europe	9.0	5.5	2.3	0.0	22,751 *2.4*
Africa	5.0	2.0	20.8	0.0	23,382 *2.5*
Morocco	21.9	42.5	5.5	0.0	80,699 *8.5*
Turkey	7.6	10.9	1.8	0.0	24,573 *2.6*
Other & Unknown	14.0	6.9	28.9	0.0	49,167 *5.2*
Total	184,284	87,301	59,812	622,641	954,038
Percent Total	*19.3*	*9.2*	*6.3*	*65.3*	*100*

Note: Population groups are assigned by nationality, for non-Belgians; and by place of birth for Belgian nationals. For details see text.

the fertility patterns of the different groups of migrants, but also in their stages of family life cycle.

Figure 1 About Here

Figure 2 About Here

Age Distribution

Figure 2 presents the age distribution of the Brussels population at the time of the census, broken down by nationality (Belgian or Other) and place of birth (Belgium or Other). The central columns, representing the Belgian born Belgian nationals, shows a typical European pyramid, with a baby-boom bulge in ages 25-44 (birth years 1947-1966), a decline in subsequent cohorts, particularly those born 1972-1982, and a slight increase in the last decade, largely reflecting births to the larger age cohorts in the reproductive years. Above age 70 there is a dramatic decline in the proportion of males, a combination of heightened mortality, war losses and sex-selective migration. The current low level of indigenous fertility can be judged from the observation that from age 20 to age 84 there are actually more Belgian born Belgian national women in each age group than in the youngest, age 0-4 cohort. The second layer, of Belgian nationals born abroad, very much follows the pattern of those locally born (the correlation between the two columns=0.96), and offers no special insights. The third layer, of children born locally to foreign parents, indicates that they make up a third of locally born children, though the proportions decline dramatically after age group 15-19. Foreign nationals born abroad, by contrast, the fourth layer, are predominantly to be found in the working age groups 20-44, in which ages they constitute up to a third of the population; and to a lesser extent in ages 45-69. From age 60, however,

Figure 1: Brussels Population Groups, by Origin

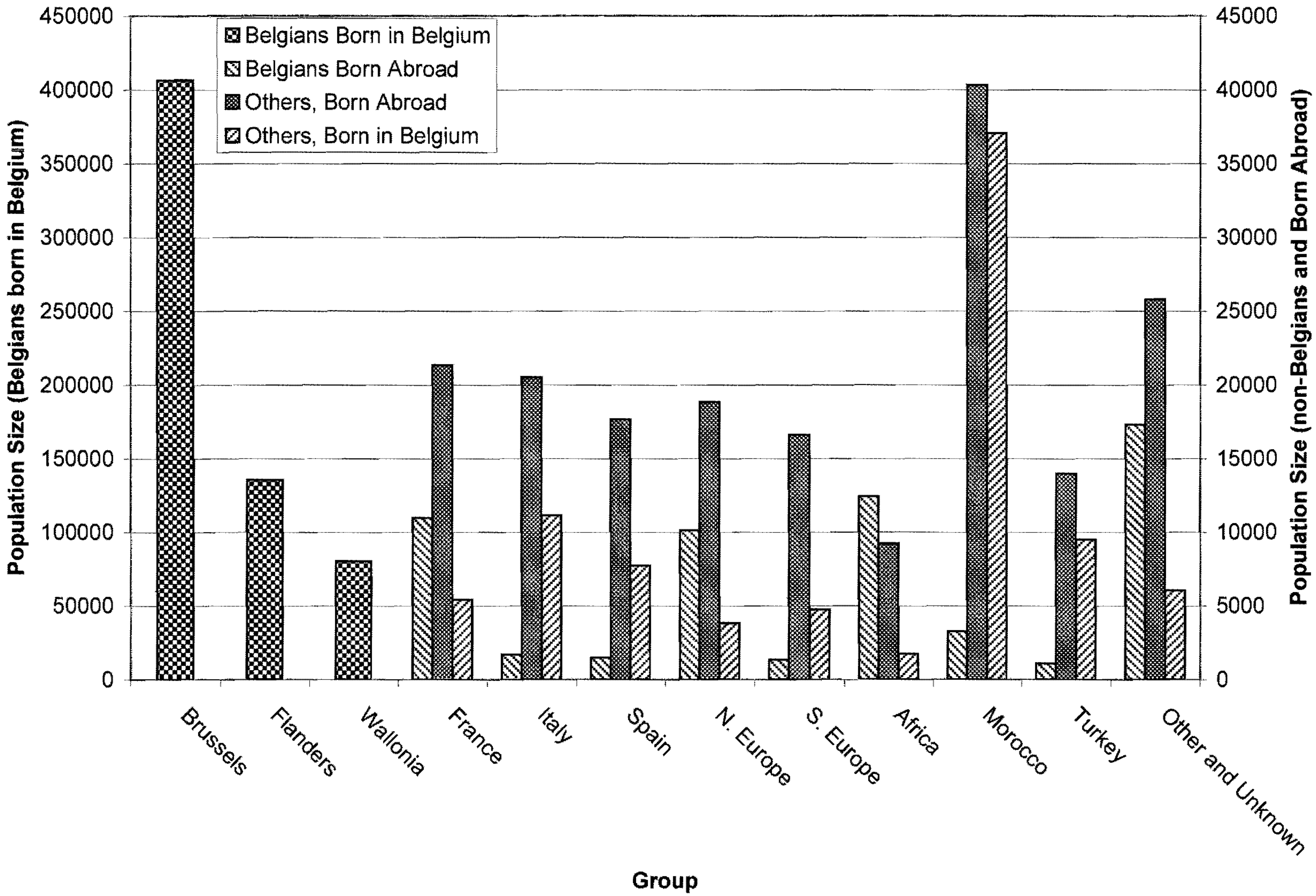
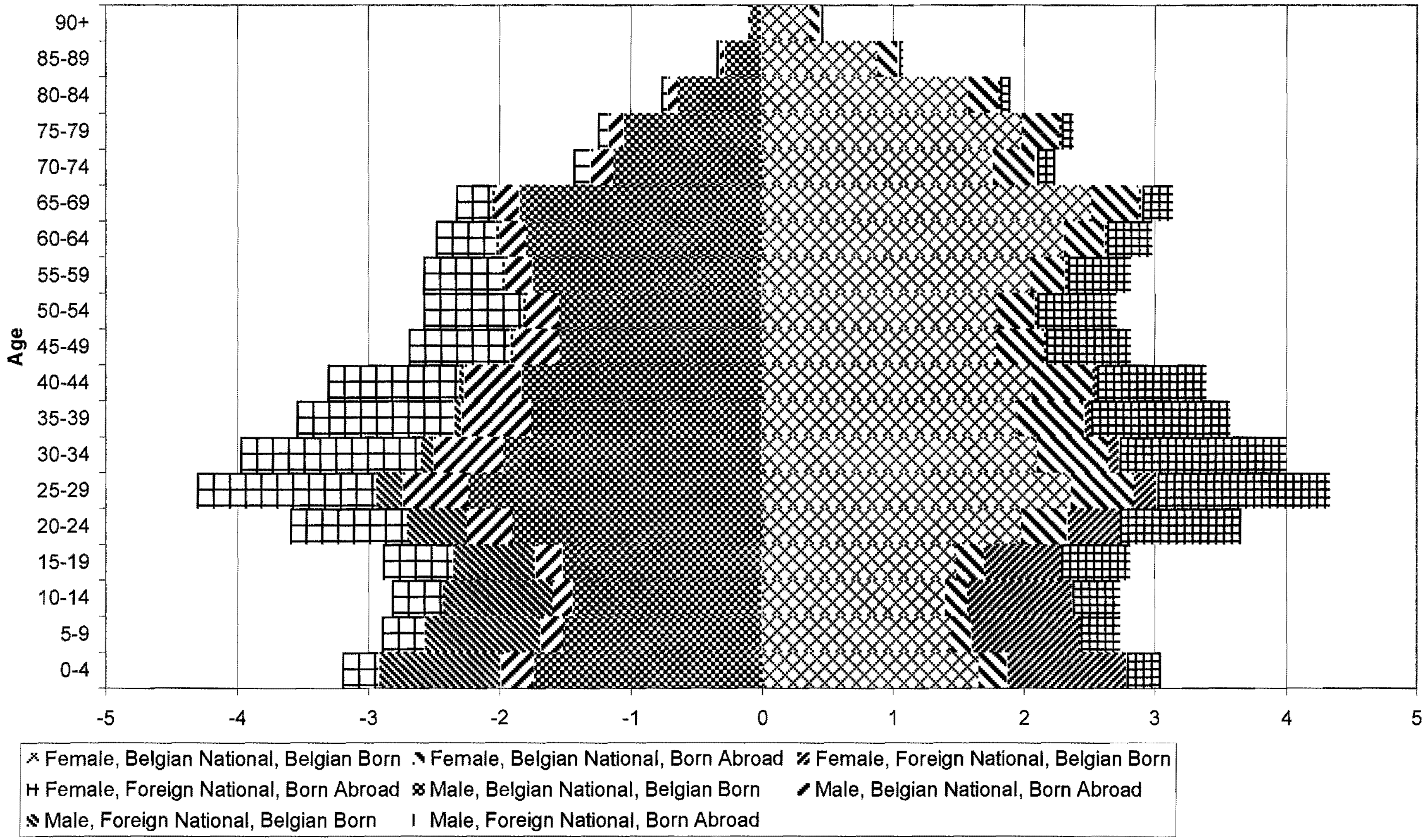


Figure 2: Population Pyramid, Brussels, by Nationality and Place of Birth



there are clear signs of a decline in their proportion in each age group, reflecting variations in the period of migration, as well as a probable return home of pensioners to their home countries.

Physical Location

Table 2 About Here

Table 2 analyses the distribution of the population over age 20 (to allow for differing levels of fertility) by population group and their location in the 19 Brussels communes. The values in the table are the percentage distribution of each group in the commune. Not surprisingly, the distribution of the larger populations very much matches the total distribution of the population in the communes. Figure 3 (left hand columns) presents concentration indices ($\sum p_{ij} \cdot \ln(p_{ij}/r_{i.})$, where p_{ij}=proportion in each cell, $r_{i.}$= proportion in each row total, see Theil 1967), indicating the distance of the group distribution from the distribution of the total population. The two most concentrated appear to be the Turkish and Moroccan populations, with the former being heavily concentrated in Sint-Joost-ten-Noode and in Schaarbeek, the latter in Sint-Joost-ten-Noode, Brussel and Sint-Jans-Molenbeek. Both have a conspicuously low proportion of their population in Sint-Lambrechts-Woluwe, Sint-Pieters-Woluwe, Ouderghem, Watermaal-Bosvoorde and Ganshoren. However, this index is closely correlated with the relative size of the group in the total population (the correlation between the log of the index and the log proportion of the group in the population is -0.771). If we multiply this index by the percentage in each population group, to allow for their influence on the total distribution (Figure 3, right hand columns), we eliminate the dependence on the size of the population (the correlation log index with log

Table 2: Population Distribution, by Population Group and Commune, Brussels 1991

	Brussels	Flanders	Wallonia	France	Italy	Spain	N.Europe	S.Europe	Africa	Morrocco	Turkey	Other	Total
Anderlecht	10.9	9.0	8.2	6.5	13.4	11.3	4.0	9.2	4.3	9.2	7.1	4.9	9.3
Brussel	12.3	13.7	13.0	14.1	14.2	19.4	15.7	14.3	14.4	23.0	16.1	15.6	14.1
Elsene	6.4	8.0	8.4	11.9	7.4	6.5	12.7	12.1	14.2	5.5	2.4	15.2	8.1
Etterbeek	3.9	4.4	5.0	4.7	4.3	3.4	5.4	3.6	5.8	2.3	2.9	5.6	4.2
Evere	3.8	3.7	3.7	2.2	2.0	1.2	2.1	1.1	2.5	1.3	0.8	2.2	3.1
Ganshoren	2.9	2.7	3.0	1.8	1.0	1.0	1.5	0.7	1.9	0.6	0.2	1.2	2.3
Jette	5.3	4.6	5.1	2.9	2.4	1.9	2.6	1.3	4.2	1.5	1.4	3.0	4.2
Koekelberg	1.8	1.6	1.9	1.6	1.4	1.3	0.9	1.4	1.5	2.2	2.4	1.6	1.7
Ouderghem	3.7	3.6	4.0	2.6	1.5	1.4	3.6	1.2	3.4	0.3	0.2	3.0	3.2
Schaarbeek	8.7	10.1	10.1	9.5	10.7	9.1	8.6	13.9	8.5	15.6	37.2	9.4	10.2
Sint-Agatha-Berchem	2.5	2.3	2.6	1.3	1.0	1.2	1.0	0.5	1.5	0.7	0.1	1.1	2.0
Sint-Gillis	3.1	3.4	3.3	4.7	7.8	15.6	3.3	14.4	3.8	7.3	2.6	5.0	4.4
Sint-Jans-Molenbeek	6.9	5.4	5.6	6.2	9.6	6.6	3.2	5.3	4.3	16.5	6.6	4.6	6.7
Sint-Joost-ten-Node	1.2	1.5	1.5	1.9	3.3	2.1	1.7	1.5	2.3	5.2	16.9	2.4	2.0
Sint-Lambrechts-Woluwe	5.3	6.0	5.9	5.6	3.6	2.6	8.5	3.9	7.9	0.6	0.4	5.5	5.2
Sint-Pieters-Woluwe	4.1	4.5	4.4	4.5	2.9	2.3	8.3	3.6	4.6	0.3	0.3	4.4	4.0
Ukkel	9.0	8.2	7.3	10.9	4.9	4.7	10.7	5.7	8.4	1.5	1.5	8.8	7.9
Vorst	4.7	4.9	4.3	4.7	7.8	8.0	3.2	5.8	3.8	6.4	0.8	4.0	4.8
Watermaal-Bosvoorde	3.4	2.7	2.8	2.5	1.0	0.7	3.0	0.7	2.9	0.2	0.1	2.5	2.6
Total	36.9	16.8	9.8	3.0	3.3	2.7	2.1	2.2	0.9	5.3	1.5	2.5	733158
Concentration Index	0.006	0.006	0.010	0.025	0.073	0.168	0.093	0.151	0.056	0.301	0.692	0.056	
Weighted Index	0.111	0.051	0.050	0.038	0.120	0.230	0.098	0.164	0.025	0.796	0.512	0.069	

proportion drops to -0.002). We now see that the Moroccan concentration is actually greater than the Turks, and the Brussels born population itself is fairly concentrated, in Anderlecht, Jette and Ukkel. The apparently low levels of concentration of the African and Other-Foreign populations may very well reflect the internal heterogeneity of these groups, with substantial sub-concentrations by particular origins.

Figure 3 About Here

Fertility

Figure 4 About Here

To give a first idea of the social differences between the different population groups, Figure 4a presents a weighted Child-Women Ratio measure of fertility[1] in each group, and Figure 4b shows its distributed in the 19 Brussels communes. For this analysis, children have been assigned to the population group of the mothers. Fertility is lowest among the Belgians born outside Brussels (Flemish and Walloon), and among the North Europeans, and high among the Turks and the Moroccans. In between these are the other Europeans (France, Italy, Spain and Southern Europeans) followed by Africans, Others and Brussels born Belgians. Note that this last group has significantly higher fertility than other Belgian or North European populations, and a very homogeneous level of fertility across all the communes,

[1] The measure is, the number of children under 5, divided by the number of women aged 20-49, weighted by relative fecundity to allow for the effects of different age distributions of women on the fertility measure. For five year age groups, 20-24, 25-29, . . ., 45-49 the respective weights are: 1.0; 0.95; 0.86; 0.72; 0.41; 0.08, see Chernichovsky & Anson, 1993.

Figure 3: Concentration Indices for Population Groups in Communes

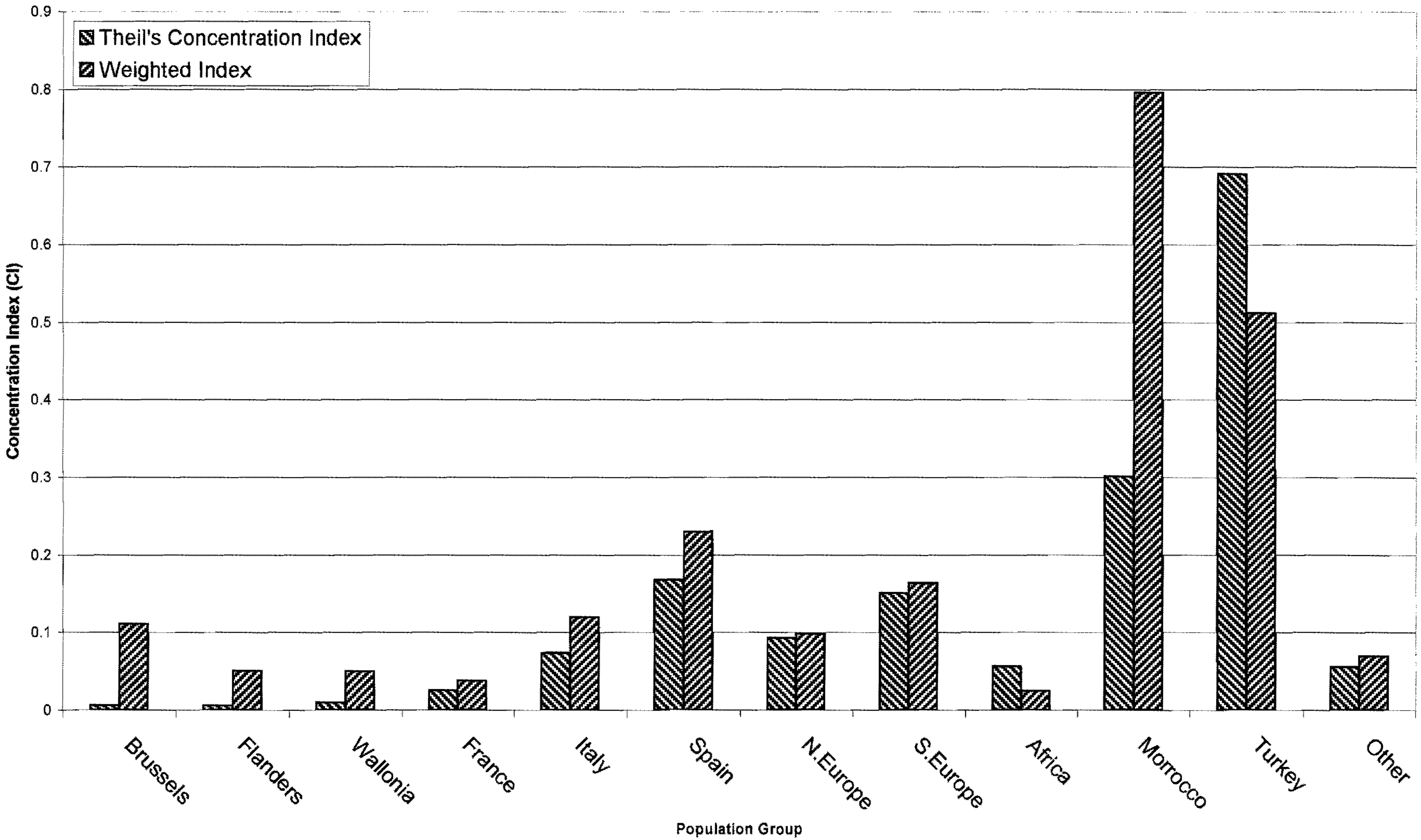


Figure 4a: Child-Women Ratios, by Population Group

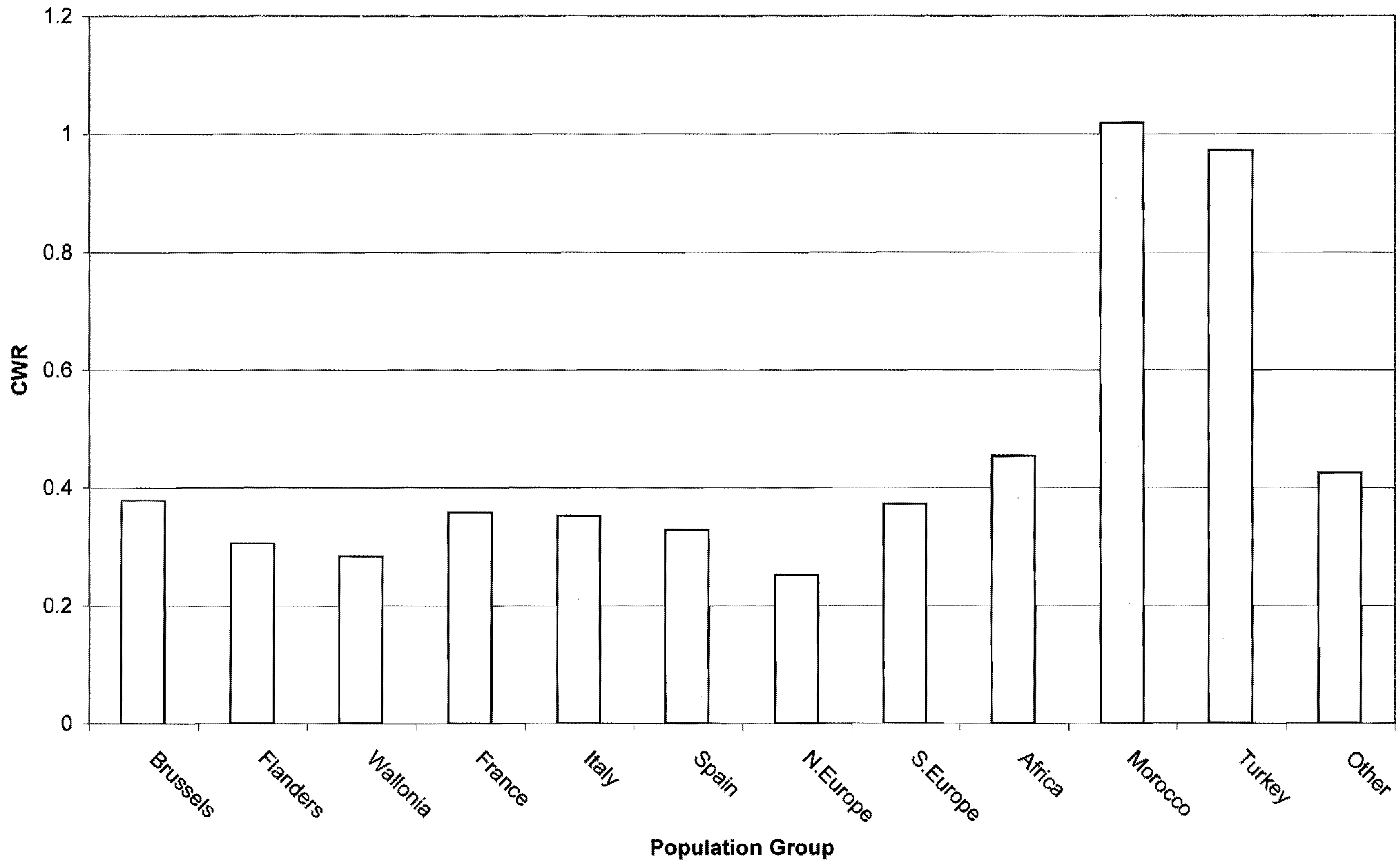
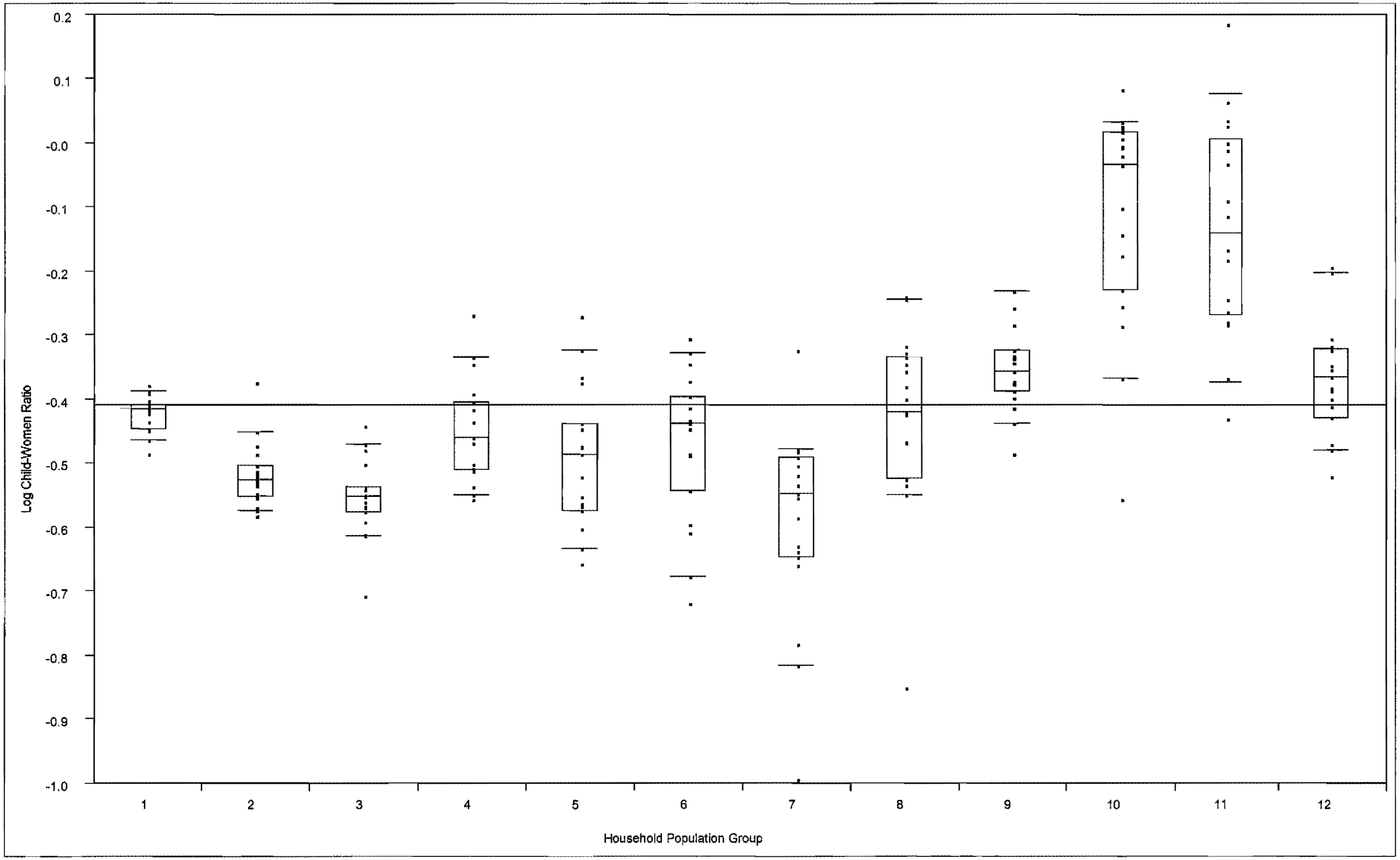


Figure 4b: Quartile Plots, Weighted Log Child-Women Ratios in Communes, by Household Population Group



Population Groups: 1=Brussels; 2=Flanders; 3=Wallonia; 4=France; 5= Italy; 6=Spain; 7=N.Europe; 8=S.Europe; 9=Africa; 10=Morocco; 11=Turkey; 12=Other suggesting that this is not just the effects of high-fertility groups entering into the Brussels-born Belgian population through naturalisation. The distribution of fertility levels in the different communes in part reflects the size of the groups, but only in part. Belgian fertility shows a very narrow distribution, as does the African fertility. Moroccan and Turkish fertility levels, by contrast, differ quite considerably between the communes, suggesting considerable life-cycle and social differentiation within these groups.

Basic Survivorship

The Census was enumerated on the 1st of March, 1991, on which date there were 954,038 residents of known age living in the Brussels Capital region. By combining census information with the recording of death and international migration in the population register (Deboosere & Gadeyne, 1997), we estimated the mortality risk by person-days of exposure, from the date of the census and up to 31st December 1996 inclusive. During this period, 64,112 people were reported as having died, and 43,916 as having left Belgium. Altogether there were 5,250,375 years of exposure, making for a annual mortality rate of 12.2‰ and a migration rate of 8.36‰.

Definitions

1. *Age:* Age at census was defined by subtracting the date of census (1 March 1991) from the recorded day of birth, and dividing by 365.25, to give an age in years.

Where month or day of birth were missing (approximately 2.5% of the population) the date of birth was imputed to 1st July, the median day of the year.

2. *Duration:* Duration to event was defined as the number of days from the census to the "last recorded entry" in the population register. This entry was one of four kinds:

   a. deceased;

   b. emigrated to known foreign country;

   c. administratively removed from register;

   d. Migrated to another commune (in Brussels or elsewhere in Belgium).

As this is only the *last* recorded entry, we have no indication of population movement between communes, and in particular, we cannot know when the individual left the commune in which s/he was enumerated at the census. *For purposes of this analysis, all individuals who were not known to have died or migrated abroad were treated as still resident in their commune of enumeration.* Similarly, the recorded date of emigration, whether recorded as such or administratively removed, must be regarded as recording an upper bound on the exposure duration. It is very possible that the actual recording was made some time after the actual emigration, at which time the person may, or may not, still have been alive. We must, perforce, treat exposure dates as given, but note that (as we shall show below) death and migration are complementarity competing risks: many of the groups at low risk of dying are at high risk of migrating, with the result that unreported, or late reported, migration may be inflating the number of people at risk.

Cox regressions: Effects of Age, sex and Nationality

The Cox model (Cox & Oakes, 1984; StataCorp, 1997) estimates a non-parametric baseline hazard, or risk, of failure on day(t), conditional on survivorship up to and including day(t-1). Censored cases are removed from the calculation at the end of the recorded day of censoring. Individuals who had not died, migrated or been administratively removed by 31st December 1996 were recorded as censored on 1st January 1997.

For each covariate, the model estimates the multiplicative effect of a unit increase in the covariate on the hazard. If h(t) is the hazard at time (t), then the model for the hazard, conditional on covariates $x_1, x_2, \ldots x_n$ can be represented as:

$$h(t|\mathbf{x}) = h(t)\exp(\beta_1 x_1 + \beta_2 x_2 + \ldots \beta_n x_n) \qquad (1)$$

In the tables below, we present the raw and the exponentiated coefficients ($\exp(\beta_i)$ thus indicating the multiplicative, or proportional, effect of each variable on the baseline hazard (relative risks).

Table 3 About Here

Table 3a presents the baseline analysis for the risk of mortality. The effects are not only significant, but also substantive. For men the risk is more than double the risk for women; and the positive coefficient for age-squared indicates that the risk increases faster at higher ages (introducing age as a categorical variable did not improve the goodness of fit, and did not change the other parameters significantly). The interaction effect for age is non-significant, but it is significantly negative for age-squared, indicating a slower mortality

Table 3: Basic Patterns of Mortality and Migration

a. Mortality

Variable	Parameter (s.e.)	Relative Risk	$\chi^2_{(DF)}$
Sex	0.781*** (0.0216)	2.184	$169{,}406_{(9)}$
Age	0.0744*** (0.000927)	1.077	
Age Squared	0.000413*** (0.0000159)	1.000	
Non Belgian	-0.201*** (0.0270)	0.818	
Born Abroad	-0.0577** (0.0191)	0.944	
Age * Sex	0.00156 (0.00119)	1.002	
Age^2 * Sex	-0.000199*** (0.0000223)	1.000	
Non Belgian *Sex	0.0553 (0.0385)	1.057	
Born Abroad *Sex	-0.115*** (0.0302)	0.891	

Note: ** indicates coefficient significant at $p < 0.01$
*** indicates coefficient significant at $p < 0.001$
Baseline χ^2(-2 Log likelihood) = 1,757,837

b. Migration

Variable	Parameter (s.e.)	Relative Risk	$\chi^2_{(DF)}$
Sex	0.447*** (0.0244)	1.564	$52{,}406_{(9)}$
Age	-0.0140*** (0.000409)	0.986	
Age Squared	-0.0000552* (0.0000171)	1.000	
Non Belgian	1.04*** (0.0199)	2.822	
Born Abroad	1.50*** (0.0207)	4.494	
Age * Sex	0.00197*** (0.000594)	1.002	
Age^2 * Sex	-0.000265*** (0.0000255)	1.000	
Non-Belgian * Sex	-0.187*** (0.0277)	0.830	
Born Abroad * Sex	-0.107*** (0.0289)	0.899	

Note: * indicates coefficient significant at $p < 0.05$
*** indicates coefficient significant at $p < 0.001$
Baseline χ^2(-2 Log likelihood) = 1,204,208

increase for men at older ages. Non-Belgians and those born abroad both have a lower risk of dying than the locally born, with a slightly greater relative risk for foreign-born men than for women. The net effect, therefore, is that a non-Belgian woman born abroad has an almost 25 percent net reduced risk (0.818*0.944=0.772) in comparison with a locally born Belgian woman. For men the relative risk is 0.727 (=0.744*1.057*0.891). The more recent, non-naturalised migrants thus have a considerably smaller mortality risk (allowing for sex and age) than does the rest of the population. However, substantive as some of these relative effects may be, it is to be noted that the model χ^2, at 169,406 is only 10 percent of the baseline value without coefficients, indicating that the risk of death over the six years is very much a chance event whose occurrence remains largely unexplained, even when these critical factors are taken into account.

These results for the relative risk of dying should be contrasted with Panel b, in which we present results for the risk of migrating. As is to be expected, men have a higher risk, 56 percent higher than for women, and the effects of age are negative, but far less than the positive effect for mortality. The interaction effects for age are both significant, indicating a lesser reduction for men than for women in middle age, and a greater reduction in old age. The most dramatic contrast is for the foreign born women, who stand a more than fourfold greater chance of migrating out than do those locally born, an effect that is slightly less for men (4.494*0.899=4.04); and the foreign nationals, with women showing an almost three times greater chance of migrating than that of Belgian nationals, though this effect, too, is reduced (2.82*0.822=2.34) for the men. Overall, the net effect is a more than 12-fold greater risk (2.82*4.494=12.7) of migrating for non-Belgian women who have come from abroad, and 9.46 (=12.7*0.83*0.899) for men. Our attention is thus drawn, in particular, to the more recent, non-naturalised migrant population, who are *more* likely to migrate out, but *less* likely to die. Given the problems of registration of emigrants, is it possible that the low mortality risk of foreign nationals reflects unregistered loss of a part of this group from the base population?

Table 4 About Here

Figure 5 About Here

Table 4 and Figure 5 present the effects of age, sex and population group on the risk of dying, relative to Brussels born Belgian population aged 40 on the day of census and with other origin groups nested by sex. We have nested the population groups within sex, so that each column shows the coefficient and the relative risk for that group, relative to the native born Brussels female baseline. Thus, for instance, the relative mortality risk of a 60.2-year old Moroccan male, of Moroccan nationality and born abroad, is:

$$\exp(0.769+0.0763*20.2+0.000205*20.2^2-0.162-0.405+0.113)=\exp(1.94)=6.96$$

His risk, relative to a Brussels man of the same age would be:

$$\exp(-0.162-0.405+0.113)=\exp(-454)=0.635$$

Overall, males have a greater risk of dying and of migrating than do females, and the male excess mortality is far greater than the excess migration. Secondly, there is a very strong relation between the male and female propensities to migrate in the different origin groups (r=0.984). Specifically, it is high for the non-Belgians and for those born abroad, lower for the Italians, the Spanish and the Southern Europeans, and very low for Moroccans

Table 4: Mortality and Migration Risks, by Sex and National Origin

	Mortality				Migration			
	Males		Females		Male		Female	
	Coefficient (standard error)	Relative Risk	Coefficient (standard error)	Relative Risk	Coefficient (standard error)	Relative Risk	Coefficient (standard error)	Relative Risk
Sex	0.769*** (0.0232)	2.16			0.366*** (0.0289)	1.442		
Age	0.0763*** (0.000768)	1.08	0.0747*** (0.000951)	1.078	-0.0153*** (0.000440)	0.985	-0.0176*** (0.000419)	0.983
Age Squared	0.000205*** (0.0000160)	1.00	0.000407*** (0.0000161)	1.00	-0.000292*** (0.0000184)	1.00	-0.0000627*** (0.0000169)	1.00
Non-Belgian	-0.162*** (0.0347)	0.851	-0.148*** (0.0344)	0.862	1.70*** (0.0324)	5.460	1.01*** (0.0309)	6.100
Born Abroad	-0.405*** (0.0566)	0.667	-0.190** (0.0580)	0.827	1.41*** (0.0290)	4.092	1.42*** (0.0298)	4.148
Brussels	0	1	0	1	0	1	0	1
Flanders	0.0214 (0.0148)	1.022	-0.00121 (0.0132)	0.999	0.372*** (0.0347)	1.451	0.228*** (0.0377)	1.256
Wallonia	0.00324 (0.0175)	1.003	-0.0213 (0.0156)	0.979	0.304*** (0.0440)	1.355	0.0800 (0.0493)	1.083
France	0.432*** (0.0667)	1.540	0.136* (0.0636)	1.146	-0.387*** (0.0486)	0.679	-0.421*** (0.0483)	0.656
Italy	0.225** (0.0779)	1.252	0.0837 (0.0863)	1.087	-1.99*** (0.0510)	0.333	-0.919*** (0.0514)	0.399
Spain	0.222** (0.0850)	1.248	-0.236* (0.0992)	0.790	-0.766*** (0.0508)	0.465	-0.538*** (0.0502)	0.584
N. Europe	0.288*** (0.0679)	1.333	0.148* (0.0646)	1.159	-0.0369 (0.0478)	0.964	0.0163 (0.0476)	1.016
S. Europe	0.0983 (0.0923)	1.103	-0.383** (0.121)	0.682	-0.693*** (0.0511)	0.500	-0.664*** (0.0521)	0.515
Africa	0.493*** (0.0874)	1.637	0.488*** (0.0939)	1.630	-0.307*** (0.0485)	0.736	-0.355*** (0.0504)	0.701
Morocco	0.113 (0.0794)	1.119	0.102 (0.0980)	1.108	-2.41*** (0.0535)	0.090	-2.81*** (0.0605)	0.060
Turkey	0.233* (0.0964)	1.262	-0.197 (0.125)	0.821	-2.656*** (0.0763)	0.070	-2.66*** (0.0807)	0.070
Others	0.173* (0.0674)	1.189	0.163* (0.0692)	1.177	-0.271*** (0.0463)	0.762	-0.0824 (0.0463)	0.921
-2 Log likelihood, No Covariates			1,757,837				1,204,208	
Model χ^2			169,603				72,665	
d.f.			31				31	

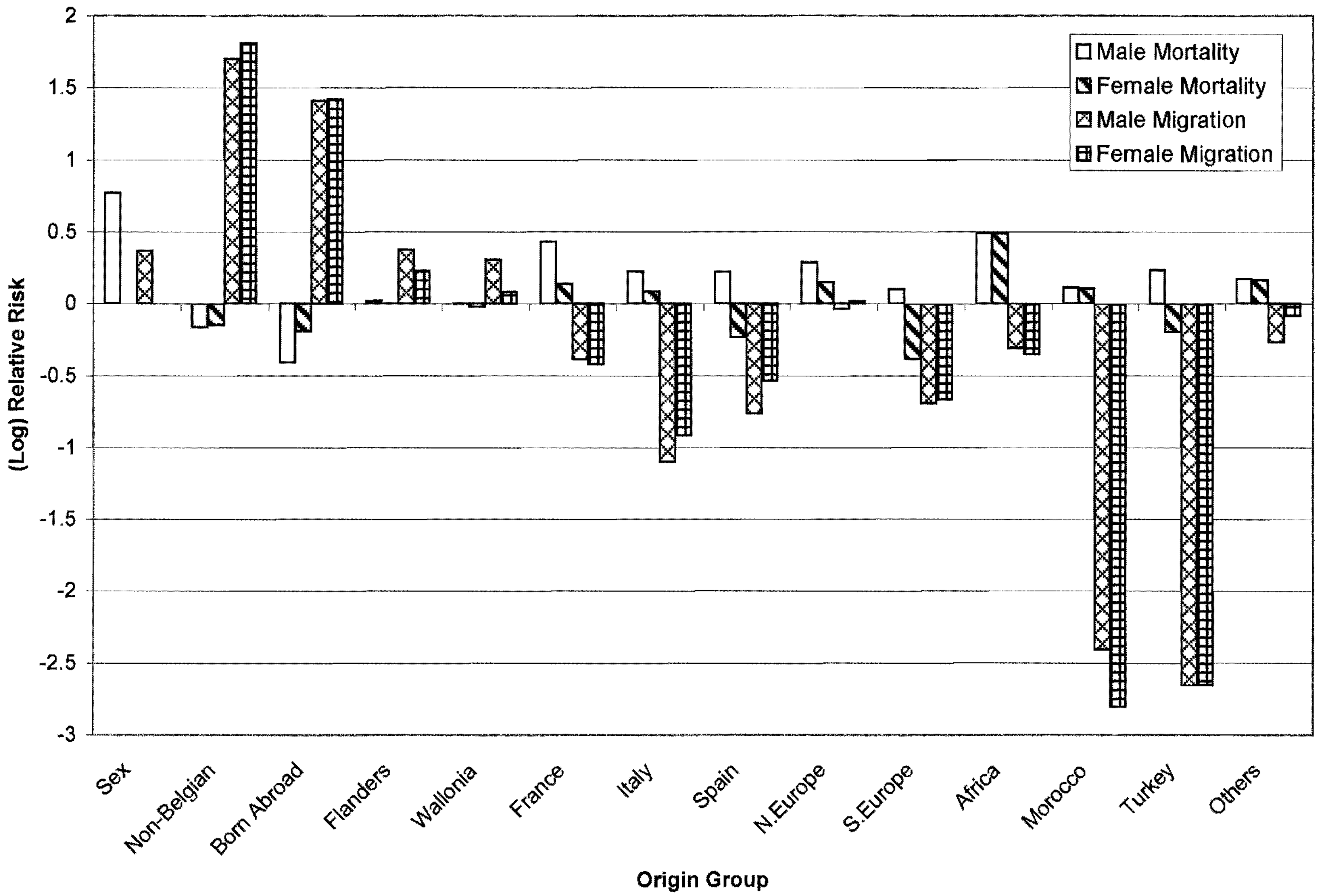
Note: Effects are nested within sex. Each column thus represents the coefficient and relative risk for a particular effect and sex combination, relative to the baseline of Belgian national, Belgian born, Brussels females aged 40 on the date of the census. The *relative risk* of dying for an Non-Belgian, Italian born man, aged 60.2 on the date of the census is thus:

$$R.R. = \exp(0.769+0.0763*20.2+0.000205*20.2^2-0.162-0.405+0.225) = \exp(2.052) = 7.78$$

Similarly, the relative risk of emigration for Moroccan woman aged exactly 25, born in Belgium, would be:

$$R.R. = \exp(-0.0176*(-15)-0.0000627*15^2+1.01-2.81) = \exp(1.55) = 0.212$$

Figure 5: Migration and Mortality Risks, by Origin Group and Sex
Brussels Females=0



and the Turks. We note also that Belgians, particularly males, born in Wallonia and Flanders are more likely to migrate than are those born in Brussels. There is a weaker correlation between the male and female mortality risks of the different populations (r=0.564), with mortality on the whole lower among the migrant than the non-migrant groups, and those born abroad stand out with the lowest relative mortality risk. However, the risk of dying is not significantly correlated with the risk of migrating for women, ($r=0.206$, $p < 0.01$) or for men ($r=-0.0519$). There is, therefore, no support here for a non-registration of mortality for those groups with high migration. There is, indeed, a lower level of mortality for the foreign-born, coupled with a higher risk of migration; but also an insignificant relative mortality risk, together with a very low migration risk, for the Moroccans and Turks. Comparison of group-specific mortality and migration risks thus indicates two separate processes at work, and in particular, that the lower mortality of migrants is in all probability real, and not a statistical artefact.

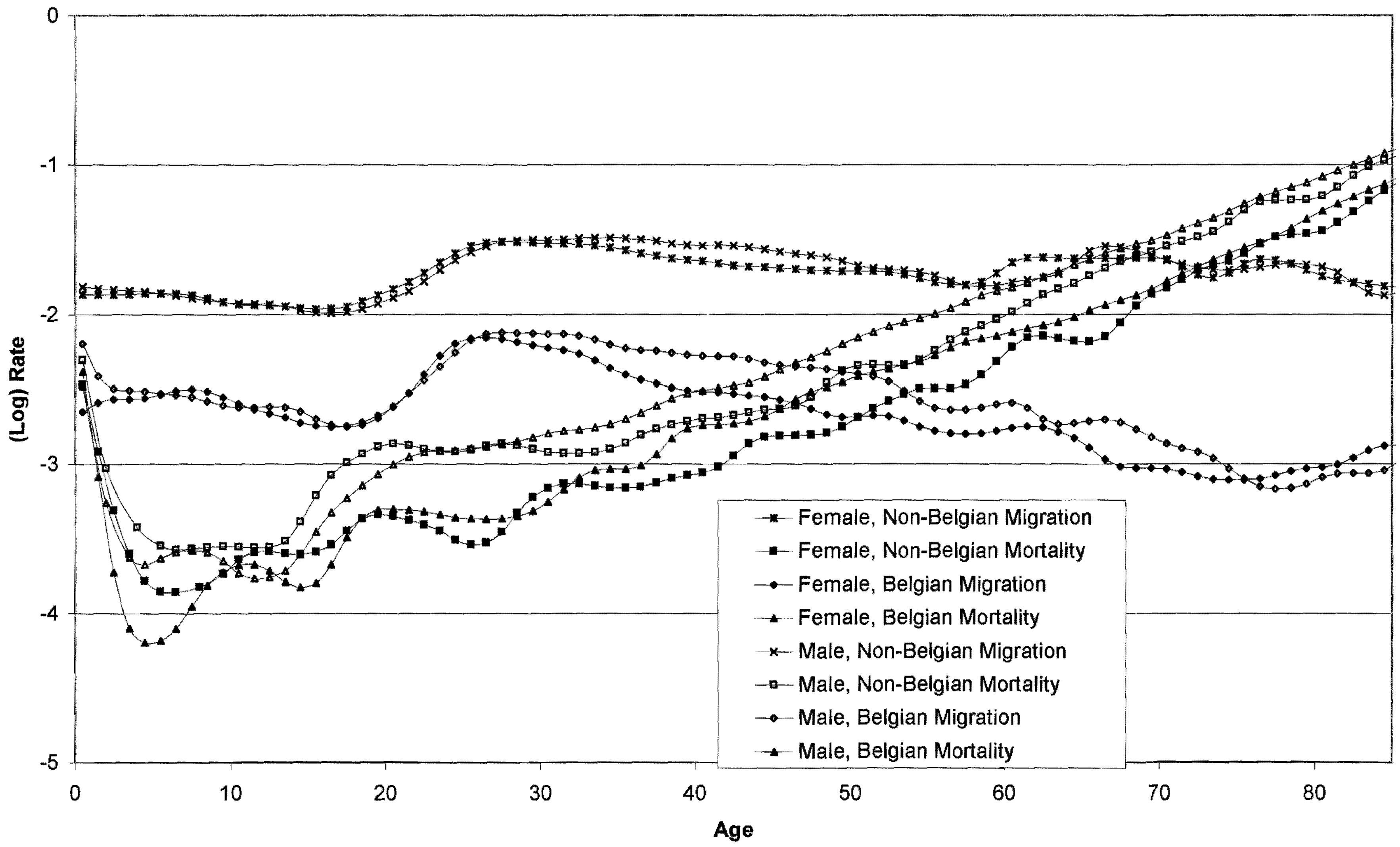
Age Specific Mortality patterns

Figure 6 About Here

The different age specific risks for mortality and migration are brought out in Figure 6, in which we plot the age-specific relative risk of dying (logged)[3]. For mortality, as age

3 In evaluating this estimate of age specific mortality risks we proceeded as follows: the Kaplan-Meier survival probabilities were estimated, using age as the time variable, and age at census as the entry point. From the survival curve we read off the probability of survival at each age (l_x) and

Figure 6: Mortality and Migration Curves, by Nationality and Sex



increases, the mortality risk increases; for migration, the opposite is true, as age increases, the risk of migration decreases, particularly after age 30 or so. The effects of age are far more dramatic for mortality than for migration: by age 80 the relative risk of dying is 100 times the risk at age 30; whereas the migration risk is still only one tenth the risk at age 30. There are also important differences by nationality, and between the sexes. Migration risks are considerably greater for the non-Belgians than for the Belgians, and for the non-Belgians there is almost no difference between the sexes, though for Belgians men have a slightly greater propensity to migrate. Mortality, in particular adult mortality, is greater for men than for women, and beyond the mid-20's is consistently higher for Belgians than for non-Belgians, the biggest (relative) difference being in mid-life, ages 20 to 40. At younger ages, however, particularly below age 10, it is the Belgians nationals who have a lower mortality. The major conclusion remains, however, that at ages where the risk of mortality is high, for both men and women, the risk of migration is low. It is thus unlikely that unrecorded migration is seriously biassing the results of the mortality analysis.

---

the probability of survival over the n years since the previous age-year in which there was a death. The n-year survival probability was then derived as

$$ {}_nq_x = 1 - \frac{l_{x+n}}{l_x} $$

and the mortality rate as:

$$ {}_nm_x = \frac{2\,{}_nq_x}{n(2 - {}_nq_x)} $$

Finally, the derived mortality rate was smoothed using a robust nonlinear smoother, 4253EH (Tukey, 1977; Velleman, 1977).

Table 5 About Here

Figure 7 About Here

To get a clearer view of the mortality differences between the population groups in the major age groups, Table 5 presents the relative risks, by sex and national origin group, for four major age groups by age at death or censoring: 0-14; 15-34; 35-59 and 60 and over. Age has been adjusted to the starting point for each analysis, thus 0, 15, 35 and 60 respectively, and the coefficient thus reflects the increase in age, and age square, beyond this starting point. In light of the results in Table 4, which indicated no mortality differences between the Belgian groups (Brussels, Flanders and Wallonia) these have been combined to create the Belgian-nationality, Belgian-born baseline group with which all others are compared. The youngest age group could not be broken down further due to the small number of deaths. Figure 7 presents these relative risks in graphic form. As before, the population-origin categories are nested within sex, and the sex coefficient reflects the overall risk for males, relative to females. The small number of deaths in many of the categories leads to many non-significant coefficients, but by considering the size and direction of the coefficients, certain consistencies and differences can be observed:

i. Males have a considerably greater mortality risk than females, particularly at the youngest and the oldest ages. Note that for age groups 0-14 and 15-34 the sex coefficient is not significant, and should thus be treated with caution, even though it is very large in the youngest age group.

Table 5: Mortality Risks by Age Group, Sex and National Origin

Origin	Age 0 - 14					
	Males			Females		
	Population *Deaths*	Coefficient (Standard Error)	Rel. Risk	**Population** *Deaths*	Coefficient (Standard Error)	Rel. Risk
Sex (Male=1)	**85,057** *176*	2.40 (6.93)	11.02	**81,380** *118*	0.00	1.00
Age		-0.257*** (0.66)	0.77		-0.266*** (0.08)	0.77
Age-Squared		0.191*** 0.00	1.02		0.0179*** (0.01)	1.02
Non-Belgian	**34,845** *89*	-0.304 (0.59)	0.74	**33,321** *55*	0.02 (0.60)	1.02
Born Abroad	**8,348** *16*	-0.302 (0.33)	0.74	**7,953** *10*	-0.276 (0.38)	0.76
Belgium	**48,482** *83*	0.00	1.00	**46,392** *62*	0.00	1.00
France	**2,291** *5*	0.72 (0.74)	2.06	**2,211** *3*	0.23 (0.82)	1.26
Italy	**2,769** *3*	-0.123 (0.84)	0.89	**2,591** *4*	0.21 (0.78)	1.23
Spain	**1,916** *5*	0.77 (0.75)	2.15	**1,719** *1*	-0.726 (1.16)	0.48
N. Europe	**1,398** *1*	-0.325 (1.14)	0.72	**1,364** *0*	Excluded – No Deaths	
S. Europe	**2,164** *5*	0.75 (0.77)	2.11	**2,002** *2*	-0.104 (0.94)	0.90
Africa	**1,720** *5*	1.02 (0.74)	2.78	**1,634** *5*	1.07 (0.73)	2.92
Morocco	**15,592** *46*	0.87 (0.63)	2.39	**14,920** *24*	0.23 (0.64)	1.54
Turkey	**4,448** *15*	1.00 (0.66)	2.71	**4,279** *11*	0.69 (0.67)	1.99
Other	**4,277** *8*	0.57 (0.66)	1.77	**4,268** *6*	0.30 (0.69)	1.35
-2 Log Likelihood, No Covariates			7,057.00			
Model χ^2			69.00			
Degrees of Freedom			26.00			

Note: For interpretation, see Table 4.

Table 5 (contd)

Origin	Age 15 - 34					
	Males			Females		
	Population *Deaths*	Coefficient (Standard Error)	Rel. Risk	**Population** *Deaths*	Coefficient (Standard Error)	Rel. Risk
Sex (Male=1)	**140,882** *1,150*	0.255 (0.347)	1.291	**141,162** *497*	0	1
Age		0.911 (0.0813)	1.095		0.262* (0. 125)	1.300
Age Squared		0.000607 (0.00103)	1.001		0.00250 (0. 00160)	1.003
Non-Belgian	**53,088** *373*	-0.221* (0.163)	0.802	**50,397** *147*	0.109 (0.206)	1.115
Born Abroad	**45,171** *310*	-0.438*** (0.121)	0.645	**45,484** *148*	-0.529** (0.203)	0.589
Belgium	**81,083** *720*	0	1	**82,517** *309*	0	1
France	**5,099** *38*	0.520* (0.247)	1.683	**5,537** *14*	0.0413 (0.371)	1.042
Italy	**6,317** *38*	0.104 (0.243)	1.110	**5,683** *17*	0.0157 (0.338)	1.016
Spain	**4,898** *24*	-0.109 (0.272)	0.896	**4,798** *5*	-1.02 (0.507)	0.359
N. Europe	**4,560** *21*	-0.0133 (0.276)	0.987	**5,868** *19*	0.349 (0.347)	1.417
S. Europe	**4,627** *35*	0.419 (0.254)	1.520	**4,334** *15*	0.258 (0.370)	1.294
Africa	**5,393** *42*	0.421 (0.215)	1.523	**5,321** *49*	1.33*** (0.275)	3.767
Morocco	**15,340** *142*	0.617** (0.208)	1.853	**14,662** *43*	0.0987 (0.309)	1.104
Turkey	**4,909** *40*	0.536* (0.253)	1.710	**4,714** *7*	-0.497 (0.471)	0.609
Other	**8,656** *50*	0.209 (0.227)	1.233	**7,728** *19*	0.0675 (0.346)	1.070
-2 Log Likelihood, No Covariates			41,274			
Model χ^2			479			
Degrees of Freedom			27			

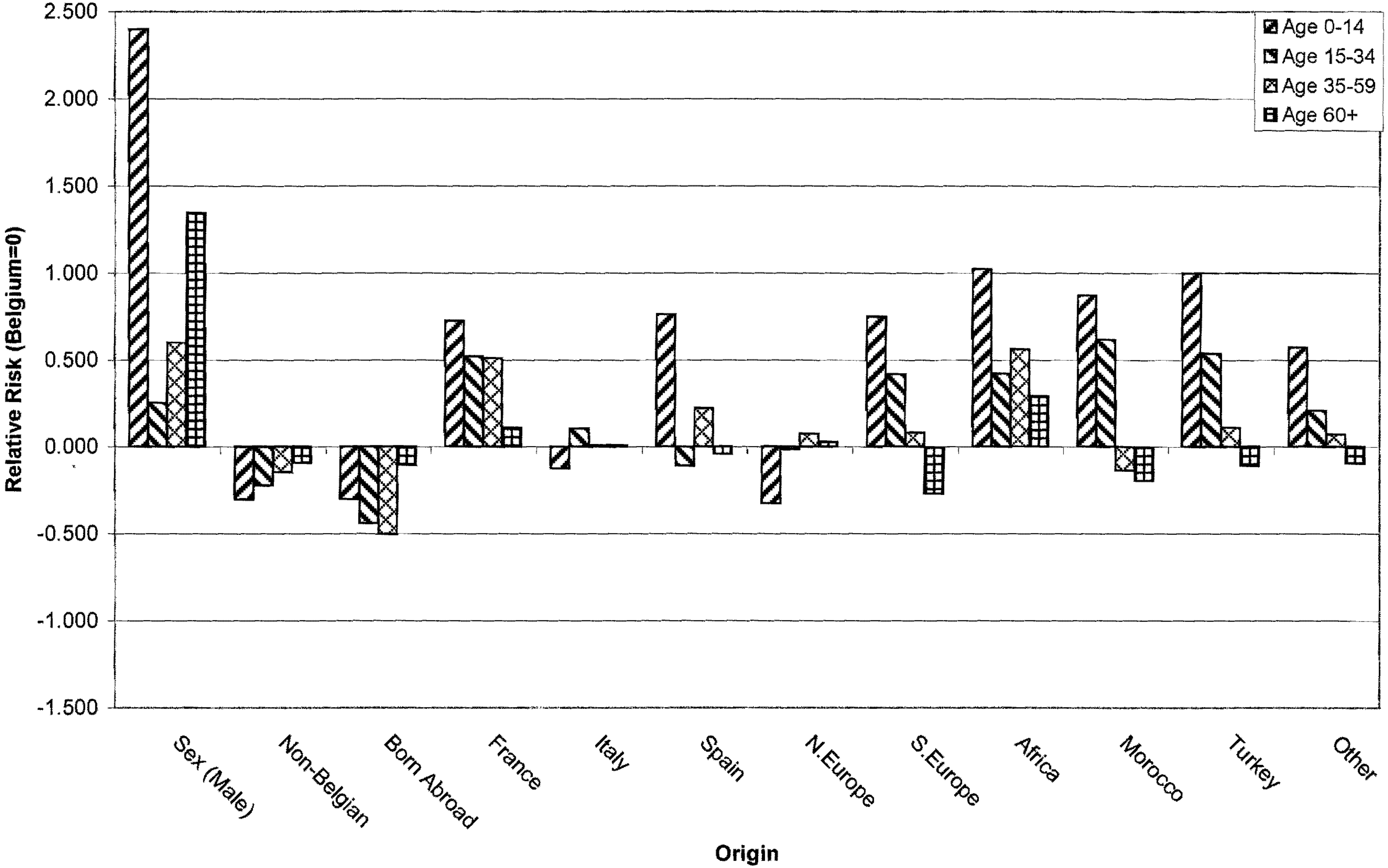
Table 5 (contd)

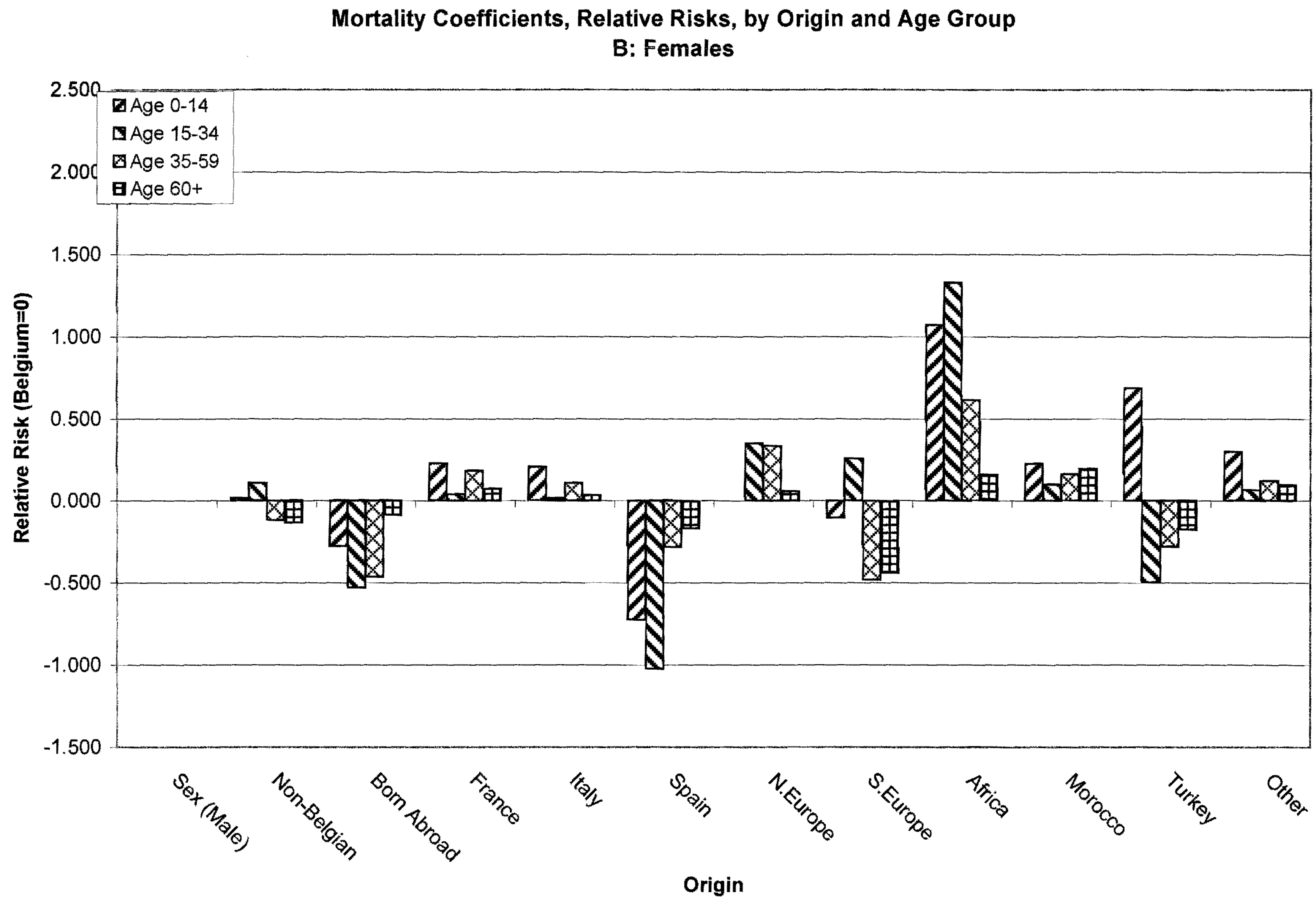
Origin	Age 35 - 59					
	Males			Females		
	Population *Deaths*	Coefficient (Standard Error)	Rel. Risk	**Population** *Deaths*	Coefficient (Standard Error)	Rel. Risk
Sex	**140,342** *5,326*	0.601*** (0.0482)	1.825	**146,319** *3,082*	0	1
Age		0.0824*** (0.00319)	1.086		0.0801*** (0.00422)	1.083
Age Squared		0.0000126 (0.000311)	1.00		-0.000413 (0.000411)	1.000
Non-Belgian	**43,049** *1,002*	-0.145 (0.0773)	0.865	**36,232** *442*	-0.119 (0.0958)	0.888
Born Abroad	**52,004** *1,252*	-0.503*** (0.146)	0.605	**48,558** *655*	-0.463* (0.208)	0.630
Belgium	**86,883** *4,021*	0	1	**96,532** *2,401*	0	1
France	**5,939** *206*	0.511** (0.170)	1.667	**7,225** *116*	0.182 (0.226)	1.199
Italy	**6,430** *147*	0.0110 (0.181)	1.011	**5,573** *80*	0.109 (0.248)	1.115
Spain	**4,686** *145*	0.221 (0.190)	1.248	**5,273** *55*	-0.281 (0.272)	0.755
N. Europe	**5,343** *119*	0.0764 (0.170)	1.079	**6,170** *109*	-0.333 (0.233)	1.396
S. Europe	**3,916** *91*	0.0806 (0.199)	1.084	**3,727** *28*	-0.480 (0.304)	0.619
Africa	**4,356** *130*	0.561** (0.175)	1.752	**4,061** *79*	0.615* (0.239)	1.850
Morocco	**10,581** *205*	-0.136 (0.183)	0.873	**7,768** *101*	0.163 (0.261)	1.176
Turkey	**2,862** *68*	0.110 (0.208)	1.116	**2,493** *22*	-0.279 (0.322)	0.756
Other	**9,346** *194*	0.0717 (0.170)	1.704	**7,497** *91*	0.121 (0.242)	1.129
-2 Log Likelihood, No Covariates			210,613			
Model χ^2			4,153			
Degrees of Freedom			27			

Table 5 (contd)

Origin	Age 60 and over					
	Males			Females		
	Population *Deaths*	Coefficient (Standard Error)	Rel. Risk	**Population** *Deaths*	Coefficient (Standard Error)	Rel. Risk
Sex	**83,266** *22,929*	1.35*** (0.147)	3.845	**135,630** *30,834*	0	1
Age		0.112*** (0.00946)	1.118		0.135*** (0.00771)	1.145
Age Squared		-0.000191* (0.0000839)	1.000		-0.000220*** (0.0000648)	1.000
Born Abroad	**10,324** *1,851*	-0.0926* (0.0420)	0.912	**10,329** *1,507*	-0.134*** (0.0388)	0.875
Belgium	**15,088** *3,119*	-0.102 (0.0934)	0.903	**21,490** *3,725*	-0.0861 (0.0694)	0.917
Brussels	**67,669** *19,682*	0	1	**113,083** *26,836*	0	1
France	**2,792** *716*	0.108 (0.100)	1.114	**6,682** *1,341*	0.0715 (0.0740)	1.074
Italy	**2,100** *416*	0.0115 (0.117)	1.012	**1,912** *274*	0.0328 (0.103)	1.033
Spain	**1,649** *213*	-0.0406 (0.128)	0.960	**1,952** *155*	-0.169 (0.118)	0.845
N. Europe	**2,788** *728*	0.0276 (0.102)	1.028	**5,292** *1,091*	0.0583 (0.0749)	1.060
S. Europe	**1,046** *124*	-0.271 (0.140)	0.762	**935** *63*	-0.439** (0.153)	0.644
Africa	**355** *74*	0.294 (0.150)	1.342	**542** *63*	0.160 (0.144)	1.173
Morocco	**1,252** *149*	-0.195 (0.137)	0.823	**584** *57*	0.194 (0.160)	1.214
Turkey	**465** *78*	-0.110 (0.154)	0.895	**403** *56*	-0.176 (0.159)	0.839
Other	**3,150** *749*	-0.0943 (0.103)	0.910	**4,245** *898*	0.0978 (0.0804)	1.103
-2 Log Likelihood, No Covariates			1,306,568			
Model χ^2			41,158			
Degrees of Freedom			27			

Figure 7: Mortality Coefficients, Relative Risks, by Origin and Age Group
a: Males




Mortality Coefficients, Relative Risks, by Origin and Age Group
B: Females
Age 0-14
Age 15-34
Age 35-59
Age 60+
2.500
2.000
1.500
1.000
0.500
0.000
-0.500
-1.000
-1.500
Relative Risk (Belgium=0)
Sex (Male)
Non-Belgian
Born Abroad
France
Italy
Spain
N.Europe
S.Europe
Africa
Morocco
Turkey
Other
Origin

ii. The young (0-14) and young adult (15-34) non-Belgian populations have lower mortality than their Belgian counterparts, particularly the males, but this holds, effectively, only for the European migrants. For the Africans, Moroccans and Turks it is more than offset by positive coefficients, particularly in the youngest age group.

iii. Populations of non-Belgian origin have lower mortality risks at older ages (35 and above) than the native Belgian population. This effect appears stronger for women than for men.

iv. The Moroccan and Turkish populations have a higher mortality risk at younger ages, and a lower risk at older ages. The African populations, by contrast, have a higher risk at all ages.

v. Other populations (Middle East, Americas, Oceania etc) have higher levels of mortality at younger ages, but this is not significant and may not be reliable. It is also possible that the specific population composition of this heterogeneous group varies at different ages.

Conclusion

The linking of records from the population census with death records from the national population register has enabled us to obtain an overview of the relative mortality risks to which the different population groups residing in Brussels were exposed during the final decade of the twentieth century. The general picture which emerges matches closely that depicted for Belgium and elsewhere in most of the literature, namely, a reduced level of mortality for most adult immigrant groups, but a higher level of infant and child mortality, particularly amongst males. Two important exceptions to this rule were the African populations, who showed a consistently higher level of adult mortality, and the younger Moroccan and Turkish populations, who also suffered a higher mortality risk. By comparing the pattern of mortality risks with that for recorded emigration risks, we have shown that it is extremely unlikely that these results can be explained by migrants having left the country unbeknown to the population register (salmon bias). Adult migrants thus appear, in general, to enjoy a lower mortality risk than does the indigenous population, but this advantage appears to be specific to the migrants themselves. Children of foreign origin, most of whom were born in Brussels, are much more susceptible to the local conditions in which they live. Further analysis must now consider how much of these mortality differences, particularly at adult ages, reflect living conditions of the populations in Brussels, and how much must be attributed to the particular selection processes which “sift” migrants on their road to Brussels.

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