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TITLE PAGE

A comparative analysis of premature mortality among urban immigrants in Bremen, Germany: a retrospective register-based linkage study

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Keywords: (1) premature mortality, (2) migrant health, (3) immigration (4) Turkey, (5) former Soviet Union

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ABSTRACT

Objectives

The man object of this study was to explore differences in mortality patterns. In doing so, we investigated indicators of premature mortality.

Design

This study was conducted as retrospective population-based study based on mortality register linkage.

Setting and participants

In this study we used unique possibilities of register-based research in relation to migration and health. We carried out our analyses for in three population groups in the federal city state of Bremen, Germany: immigrants from Turkey, from the former Soviet Union (FSU), and the general population.

Results

The standardized death rates for premature deaths of the two immigrant population groups were lower compared to the general population. The standardized mortality ratios remained under 1. When we used the indicator of years of potential life lost, we could observe higher age-standardized years of potential life lost rates among immigrant populations, particularly among males from the former Soviet Union as compared to other sex and population groups 4,238/100,000, 95% CI [4,119; 4,358]. While the main causes of premature death were the same across populations, namely neoplasms and diseases of circulatory system, we found larger contributions of infant mortality and diseases of the respiratory system among Turkish immigrants, and of injuries and poisonings and mental and behavioral disorders among immigrants from the former Soviet Union.

Conclusion

While the overall trends favour the immigrant populations, the indicator of YPLL and cause-specific results indicate areas where the health care system´s responsiveness may need to be improved, including preventive services. Further work with broader databases providing a similar level of differentiation is necessary to substantiate these findings.

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ARTICLE SUMMARY

Strengths and limitation of this study

In a novel approach, we used name-based algorithm as well as a combination of different methods for the determination of migrant background, i.e. country of birth, birthplace and nationality to get higher numbers of immigrant populations. We successfully implemented record linkage method with registered based data – the Bremen Mortality Index. With the concept of premature mortality and indicator of years of potential life lost, we could indicate areas where the health care provision need to be improved.

In this study we touched on the important issue of the availability of data. Mortality data are widely available in European countries. The coding of the underlying cause of death according to International Classification of Diseases (the 10th version) offers a standardized methodological basis. The epidemiological concept of avoidable mortality has been studied among immigrants in some European studies, e.g. Sweden, The Netherlands and Estonia, making use of registry linkage.

Limitations of the current study include the absence of population-group specific denominator data for the years 2004–2009, for which we used an imputation procedure based on available data for 2010 and data on changes in population numbers per nationality group. This procedure introduces some imprecision, but we believe it does not invalidate the overall findings. Numbers of deaths in specific age-bands and subgroups were small, and thus need to be interpreted with caution. Missing data were higher among Turkish immigrants (8.9% compared to 2.4% among FSU immigrants) after record linkage with the Bremen Mortality Index. We assume that this is due to higher re-migration of elderly Turkish immigrants.

Methods

- We used mortality data for the period 2004-2010.
- We calculated age-standardized death rates (SDR) and standardized mortality ratios (SMR) for premature deaths (< age 65).
- We also computed years of potential life lost (YPLL).
- Additionally, we analyzed the underlying causes of death contributing to premature mortality.

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INTRODUCTION

Immigrant populations, which typically have a higher concentration of socio-economic and health disadvantages compared to host populations, are of growing social, demographic and political importance in many countries. Among the potential adverse factors affecting migrant health, inequalities in health care access and sub-optimal services in host countries are among those amenable by public health measures and thus of particular concern. However, up to now comparative research that captures the complexity and heterogeneity of immigrants and at the same time identifies their shared risks is still scarce [1]. Reliable and comparable quantitative data on the patterns of diseases, access to health care, overall mortality, as well as specific mortality causes amongst immigrants are rarely available. This is mainly due to the fact that most data sources do not provide consistent information on the origin of immigrants. In Germany for example, the Federal Health Monitoring System provides information on foreign populations based on their nationality. This indicator however excludes immigrants who have taken up German citizenship, although this group now constitutes a non-negligible part of the immigrant population in Germany [2]. Overall, almost 20% of the population of Germany has a migration background [3]. A recent comprehensive investigation into migrant morbidity and mortality in Germany confirmed the problem of insufficient characterization of migrant status in official data [4], although using nationality as only an indicator this study found lower mortality among foreign adult population aged 20 to 60 years compared to Germans. However, differences in mortality among immigrant groups were noted [4].

In epidemiology, the study of mortality patterns is central to the goal of assessing the overall health situation of one or more demographic groups. Population-based mortality data are a continuous and accessible source of health information in most developed countries. With higher life expectancy, most deaths occur among the older aged people (75 +), such that classic mortality and cause of death investigations are strongly influenced by this age group. From a public health perspective, it is even more interesting to pay attention to premature mortality (also referred to as amenable mortality), i.e. mortality occurring before the age of the average life expectancy. Premature deaths occurring in young ages refer to *"all those deaths that, given current medical knowledge and technology, could be avoided by the healthcare system through either prevention or treatment"* [5]. Evidence derived from the study of premature mortality can be used in public health planning to compare the relative importance of different causes of premature deaths, to set priorities for prevention or health care activities, and to compare the premature mortality between different populations [6].

The use of indicators of premature mortality such as years of potential life lost (YPLL) to quantify health status in population groups is gaining importance [5, 7, 8]. YPLL offers a method to measure the impact of premature mortality in the population [9, 10].

Previous comprehensive studies indicate a reduction of premature mortality by more than half since 1970 and outline general trends by sex and underlying causes of death contributing to premature mortality [7, 11–14] but do not provide information on vulnerable population groups. Variations in the distribution of diseases in different population groups could be caused by high exposure risks, unhealthy life style, insufficient medical care or unequal access to health care services. Thus, a better understanding of premature mortality patterns in populations may be useful for various aspects of health improvements in populations, including improving access to health care services.

We made use of the exceptional data sources available in the federal state of Bremen, Germany to investigate premature mortality of immigrants from Turkey and the former Soviet Union (FSU) for the period 2004-2010 in a population based approach. Turkish and FSU immigrants form the two largest immigrant populations in Germany, each comprising nearly 3 million people. Our main objective is to explore premature mortality to help identify specific diseases and health needs among immigrants from FSU and Turkey, which will be important for setting priorities in medical health care provision and prevention activities.

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METHODS

Determination of denominator populations

We obtained population figures for the general population living in the federal state of Bremen during the period 2004-2010 from the German federal health monitoring system [15].The federal health monitoring system however does not provide data on immigrant populations by country of origin; instead, it contains numbers of all foreigners by nationality for every federal state and in 5-year age groups [16]. To avoid relying on nationality only, we searched the full population file for 2010 in the Residents' Registration office in Bremen using (i) nationality as well as country and place of birth to identify immigrants from the FSU (n=33,497) and (ii) the name-based algorithm to identify immigrants from Turkey (n=49,518). Detailed descriptions of the two approaches can be found in Makarova et al. [3] and in Spallek et al. [2].

We then used the figures for FSU and Turkish immigrants obtained for 2010 to estimate the missing denominators for 2004 – 2009. To this end, we initially estimated the percentage increase or decrease in the foreign population in the federal state of Bremen between each year, 2004 – 2010. Thereafter, we used the obtained percentage changes to project figures for FSU and Turkish immigrants for 2004 – 2009 backwards, based on the figures obtained for 2010 for each of the population groups.

The denominator population for the full study period was thus stratified into the general population (all residents living in the federal state Bremen, including the two migrant populations) and the population with migrant background from Turkey and from the FSU. The data were available differentiated by sex and categorized in five-year age groups.

Mortality data and linkage

For the mortality analysis of each of the three population groups of interest, we used data from the Bremen Mortality Index (BreMI). The BreMI is an electronic database providing all information recorded on death certificates of Bremen citizens who died since 1998 including ICD-10 Code of underlying cause of death. Data from the Bremen Residents' Registration office were linked with the BreMI using only the death registration number.

Statistical analyses

Based on the methodological approach of health monitoring used in Germany and following the recommendations of the Robert Koch-Institute, we selected the age of 65 years as upper limit for the calculation of premature mortality [8].

We calculated age-standardized death rates/100,000, using the European Standard Population (ESP) for ages 0-64 for both sexes in the different populations (SDR), and years of potential life lost (YPLL) for premature deaths. To determine YPLL, we added the age-specific deaths occurring at each age and weighted them by the number of remaining lost years up to the selected age limit of < 65. For example, a death occurring at five years of age is counted as 60 YPLL [7, 8]. The indicator is expressed per 100,000 persons. Data were standardized to the ESP [8]. We considered more detailed age-specific death rates (ASDR) per 100,000 persons and calculated ratios of the age-specific death rates in every age- and population group for men and women. Furthermore standardized mortality ratios (SMR) were calculated. Precision was estimated using 95% confidence intervals (CIs). We also descriptively analyzed major causes of death contributing to premature mortality. We focused on the ten leading causes of death for premature mortality.

RESULTS

According to our population based calculations, we estimated the proportion of Turkish and FSU immigrants living in Bremen as measured by the number of general population between 2004 and

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2010: 5.1% were from the FSU and 7.6% originated from Turkey. Over the study period 2004-2010, a total of 774 deaths among Turkish immigrants, 1,288 deaths among immigrants from the FSU and 52,258 deaths in the general population were identified in the data of the residents' registration office. After record linkage with the BreMI, mortality information was retrieved for 706 deaths (8.9% missings) among Turkish immigrants and for 1,258 deaths (2.4% missings) among immigrants from the FSU. 51% (N=360) of all deaths among Turkish immigrants, 28% (N=350) of those among immigrants from the FSU, and 18% (N=9,759) of those in the general population occurred prematurely. Note that for the general population no missings could be determined, as only the BreMI database was used. Regarding sex specific percentage points of premature mortality increased values we found among men from the FSU compared to every other sex and population group (table 1).

Table 1 Mortality parameters 2004-2010 by sex, population and age group

Age at death	FSU immigrants		Turkish immigrants		General population	
	Male	Female	Male	Female	Male	Female
Total (n) of premature death both sexes	350		360		9,759	
Sex specific total (n) of premature death	251	99	233	127	6,432	3,327
Total (n) of all death cases both sexes	1,258		706		52,258	
Sex specific total (n) of all death cases	656	602	461	245	24,688	27,570
% of premature mortality in relation to the (n) of all death cases both sexes	28		51		18	
Sex specific percentage points of 28%, 51%, 18% of premature death	71	29	65	35	67	33
Age-standardized death rates for all premature causes of death with 95% CI	140 [125; 155]		136 [121; 150]		207 [203; 211]	
Sex specific age-standardized death rates for all premature causes of death with 95% CI	214 [187; 241]	76 [60; 91]	178 [154; 203]	94 [77; 111]	273 [266; 279]	142 [137; 147]
Standardized mortality ratios with 95% CI	0.67 [0.61; 0.75]		0.64 [0.58; 0.71]			
Sex specific standardized mortality ratios with 95% CI	0.79 [0.69; 0.89]	0.53 [0.43; 0.64]	0.63 [0.55; 0.72]	0.66 [0.55; 0.79]	General population = 1	
YPLL age-standardized with 95% CI	5,949 [5,808; 6,089]		4,137 [4,042; 4,233]		6,043 [6,011; 6,076]	
Sex specific YPLL age-standardized with 95% CI	4,238 [4,119; 4,358]	1,710 [1,631; 1,789]	2,560 [2,430; 2,581]	1,631 [1,569; 1,693]	3,880 [3,854; 3,907]	2,163 [2,142; 2,184]

We further calculated age-standardized death rates/100,000, using the ESP for ages 0–64 for both sexes in the different populations. The SDR for premature deaths of the two immigrant population groups were lower compared to the general population. Among Turkish immigrants, the SDR was 136/100,000, 95% CI [121; 150] versus 140/100,000, 95% CI [125; 155] among FSU immigrants, and 207/100,000, 95% CI [203; 211] in the general population. Regarding sex specific SDRs, men in every population group had higher SDRs as compared to women. Among Turkish immigrants men showed the SDR of 178/100,000, 95% CI [154; 203] as compared to women with SDR of 94/100,000, 95% CI [77; 111]. Men from the FSU demonstrated the SDR of 214/100,000, 95% CI [187; 241] as compared

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to the women in this population group with the SDR of 76/100,000, 95% CI [60; 91]. In the general population group the SDR among males was 273/100,000, 95% CI [266; 279] vs. 142/100,000, 95% CI [137; 147] among females. Sex and age-specific death rates (ASDRs) comparing the three populations are provided in Table 2.

Table 2 Age-specific death rates 2004-2010 by sex, population group, per 100.000 persons, up to age 64

Age at death	FSU immigrants		Turkish immigrants		General population	
	Male (n, death cases)	Female (n, death cases)	Male (n, death cases)	Female (n, death cases)	Male (n, death cases)	Female (n, death cases)
0-4	129 (9)	43 (3)	126 (22)	151 (25)	136 (133)	111 (101)
5-19	35 (5)	23 (3)	35 (17)	9 (4)	23 (74)	16 (49)
20-34	110 (42)	27 (12)	28 (13)	15 (7)	65 (299)	27 (124)
35-49	346 (75)	130 (33)	117 (52)	40 (14)	269 (1,459)	142 (721)
50-64	560 (120)	192 (48)	725 (129)	382 (77)	1,038 (4,469)	523 (2,332)
Total	245 (251)	87 (99)	133 (233)	79 (127)	347 (6,434)	184 (3,327)

Comparing males and females, we observed generally higher age-specific death rates among males than among females in all population groups. Detailed analyses of ASDRs in age groups comparing immigrant groups to the general population as well as within immigrant groups showed a general trend towards higher premature mortality among men from the FSU in the age group 20-49 years compared to men from the general population. In the younger age groups, there were increased ASDRs among females from the FSU aged 5-19 years compared to the two other groups. The highest under-five mortality was found among children with Turkish migrant background. We also calculated ratios for age specific death rates, with the general population as reference (see figure 1). The figure clearly shows the differences as outlined above, but also the similarities mainly regarding under-five child mortality.

Similar to the observations we made for SDRs, the SMRs in both immigrant groups remained significantly below 1, indicating lower premature mortality risks than in the general population: the SMR for FSU immigrants was 0.67, 95% CI [0.61; 0.75] and for Turkish immigrants – 0.64, 95% CI [0.58; 0.71]. Differentiating between men and women in every immigrant group, the SMR ranged from 0.53, 95% CI [0.43; 0.64] for women from the FSU to 0.79, 95% CI [0.69; 0.89] for FSU males, with estimates for Turkish migrants between 0.63, 95% CI [0.55, 0.72] (males) and 0.66, 95% CI [0.55, 0.79] (females).

In terms of YPLL, FSU males had the highest age-standardized YPLL rate (4,238 per 100,000 with 95% CI [4,119; 4,358]), while Turkish females had the lowest age-standardized YPLL rate (1,631 per 100,000 with 95% CI [1,569; 1,693]) (table 1). In contrast, the age-specific YPLL were the highest among female Turkish migrant children in the age group 0-4 compared to every other sex and population group (table 3).

Insert figure 1 about here

Table 3 Age-specific YPLL per 100,000 for all causes of death for the age at death < 65, between 2004 and 2010 by sex, immigrant- and age group

Age at death	FSU immigrants		Turkish immigrants		General population	
	Male	Female	Male	Female	Male	Female

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0-4	8,344	2,800	8,177	9,286	8,831	6,697
5-19	1,734	1,111	1,784	429	1,131	770
20-34	4,138	1,204	975	566	2,373	1,003
35-49	7,018	2,986	2,642	653	5,705	2,797
50-64	4,799	2,073	3,987	3,014	6,888	3,710
Total	4,840	1,859	2,647	1,667	4,516	2,414

Main causes of death

In each of the population group, neoplasms and diseases of circulatory system accounted for over 40% of premature deaths. Generally, the proportions of major causes of death which contributed to premature mortality in all three population groups were higher among men than women (table 4). We however observed differences in specific causes of death in the three population groups. For example, infant mortality and diseases of the respiratory system were higher among Turkish than among FSU immigrants, and injuries and poisonings as well as mental and behavioral disorders were considerably higher among immigrants from the FSU than in the other two groups. Using the BreMI, we were able to ascertain that the premature deaths coded as injuries and poisonings among men from the FSU were often due to alcoholism, alcohol abuse, smoking, and intoxication.

Table 4 Causes of death contributing to premature mortality between 2004 and 2010 for three population groups; Percentage in relation to the total number of premature death cases

Cause of death*	FSU immigrants		Turkish immigrants		General population	
	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
Neoplasms *(C00-D48)*	19.1	10.6	14.2	10.8	19.6	15.1
Diseases of the circulatory system *(I00-I99)*	13.7	4.9	15.6	7.8	14.8	5.6
Mental and behavioral disorders *(F00-F99)*	11.4	1.7	3.3	0.3	7.9	2.1
Injuries, poisonings *(S00-T98)*	12.3	2.0	6.7	0.6	5.3	1.6
Diseases of the digestive system *(K00-K93)*	0.9	2.0	2.2	0.6	3.6	1.9
Diseases of the respiratory system *(J00-J99)*	2.0	0.3	5.3	1.7	3.2	1.9
Certain conditions originating in the perinatal period *(P00-P96)*	2.0	0.9	4.2	3.9	-	-
Certain infectious and parasitic diseases *(A00-B99)*	1.7	1.1	1.7	2.2	2.2	1.2
Endocrine, nutritional and metabolic diseases *(E00-E90)*	0.9	0.9	-	-	1.7	0.6
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified *(R00-R99)*	2.6	0.6	-	-	-	-

* ICD, 10th version

DISCUSSION

In this study, we examined patterns of premature/avoidable mortality among immigrants from Turkey and the FSU compared to the host population in the federal state of Bremen, Germany. Through the exploration of premature mortality, we aimed to identify specific health problems contributing to premature death, and derive information to address priorities in medical care or prevention for migrant populations. We combined different methodological approaches for analyzing premature/avoidable mortality: we selected the age of ≤65 for analyzing premature deaths, calculated different mortality indicators including years of potential life lost and documented the major causes of death to gain further insight into mortality patterns.

When assessing premature mortality using standardized death rates and mortality ratios, we found lower mortality rates of the two immigrant groups than in the general population. We did not observe differences in the distribution of the two leading causes of premature mortality: neoplasms and diseases of the circulatory system accounted for over 40% of premature deaths in each population group.

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Only with the indicator of YPLL and when looking at specific causes of death and analyses in specific age groups, we were able to demonstrate that certain subgroups among immigrant groups had higher premature mortality. The indicator of YPLL provides a common denominator for judging the priority to be given with regard to planning and organization of health care or prevention to each cause of mortality occurred in identified risk age groups [17, 18]. For instance, we observed increased years of life lost among Turkish children, especially females, for death at ages between 0-4 years of age. Further analyses showed increased mortality in relation to pregnancy and infant mortality, especially from extreme immaturity among Turkish immigrants. In terms of setting priorities and thinking about developing migrant-sensitive health systems, one focus could be on strengthening health literacy of mothers. Patients with Turkish migrant background should be informed that for example consanguineous marriages can lead to an increased risk for genetic disorders and infant mortality [19], and the obstetricians should be able to give qualified information to support early diagnosis to prevent deaths. The setting of targets relating to avoidable mortality and evaluation of their achievement also provides a powerful means of audit [20].

We observed that compared to Turkish men and those in the general population, men from the former Soviet Union lost more years of life if the death occurred between 20 and 50 years. Premature deaths in this population group coded as injuries and poisonings as well as mental and behavioral disorders were often noted as being associated with alcoholism, alcohol abuse, smoking, and intoxication. Our results are, in general, in line with those reported in studies conducted in the Russian Federation, which also link premature mortality with hazardous alcohol- and nicotine consumption [21–23]. Such findings raise two important questions: (1) whether immigrants from the former SU bring their lifestyle habits along to Germany and keep them over the time after migration; and (2) whether this group can be reached through better health care integration and support for the adoption of a healthier lifestyle? With regard to setting priorities in the group of FSU immigrants, sex-specific interventions in this population group to reduce alcohol, nicotine and substance consumption seem of importance and individual and community-based interventions needs to be explored.

In this study we touched on the important issue of the availability of data. Mortality data are widely available in European countries. The coding of the underlying cause of death according to ICD-10 offers a standardized methodological basis. The epidemiological concept of avoidable mortality has been studied among immigrants in some European studies, e.g. Sweden, The Netherlands and Estonia, making use of registry linkage [24–26]. For Estonia, Baburin et al. documented the most important preventable causes of death among men such as accidental poisonings, suicide and alcohol-related diseases [26]. Westerling et al. also assumed that observed variations in mortality reflected differences in smoking and alcohol habits [24]. Stirbu et al. assessed mortality in a number of immigrant groups in The Netherlands, including immigrants from Turkey. The study population comprised mainly women. Turkish immigrants had a higher risk of death from maternity-related conditions compared to the native Dutch population [25]. Our own investigations highlight the need for a differentiated epidemiological assessment of premature mortality, and indicate specific risks for particular groups, notable young and middle aged men from the former FSU. We believe that further investigations in premature mortality for immigrant and ethnic minority groups in German and the European region will be useful and informative for epidemiological surveillance and for evidence based interventions. More standardization of methodological approaches will enhance the opportunities for comparisons within and across countries.

CONCLUSION

Our analyses of premature mortality demonstrated differences and similarities between the immigrant and the general population in Bremen, Germany. While the overall trends surprisingly favour the immigrant populations, age and cause-specific results indicate areas where the health care system's

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responsiveness may need to be improved, including preventive services. Further work with broader databases providing a similar level of differentiation is necessary to substantiate the findings.

CONTRIBUTORS

NM conceptualized the study, its design and methods. She conducted the analyses and presented the results. TB and HP were involved in the conceptualization of methods and statistical analyses. SL was involved in the acquisition, management and interpretation of data. CBK carried out the linkage approach and was partly involved in the data management as well as data interpretation. TB, HP, SL and CBK revised critically the manuscript and approved the final version of the manuscript.

COMPETING INTERESTS

There are no competing interests.

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ETHICAL APPROVAL

All research work with the BreMI follows a specific set of rules and requires clearance by the Bremen Senator for Health. All linkage procedures were done by authorized personnel only, and the study center received an anonymized data set. Under these conditions, no ethical approval was required.

DATA SHARING

No additional data available.

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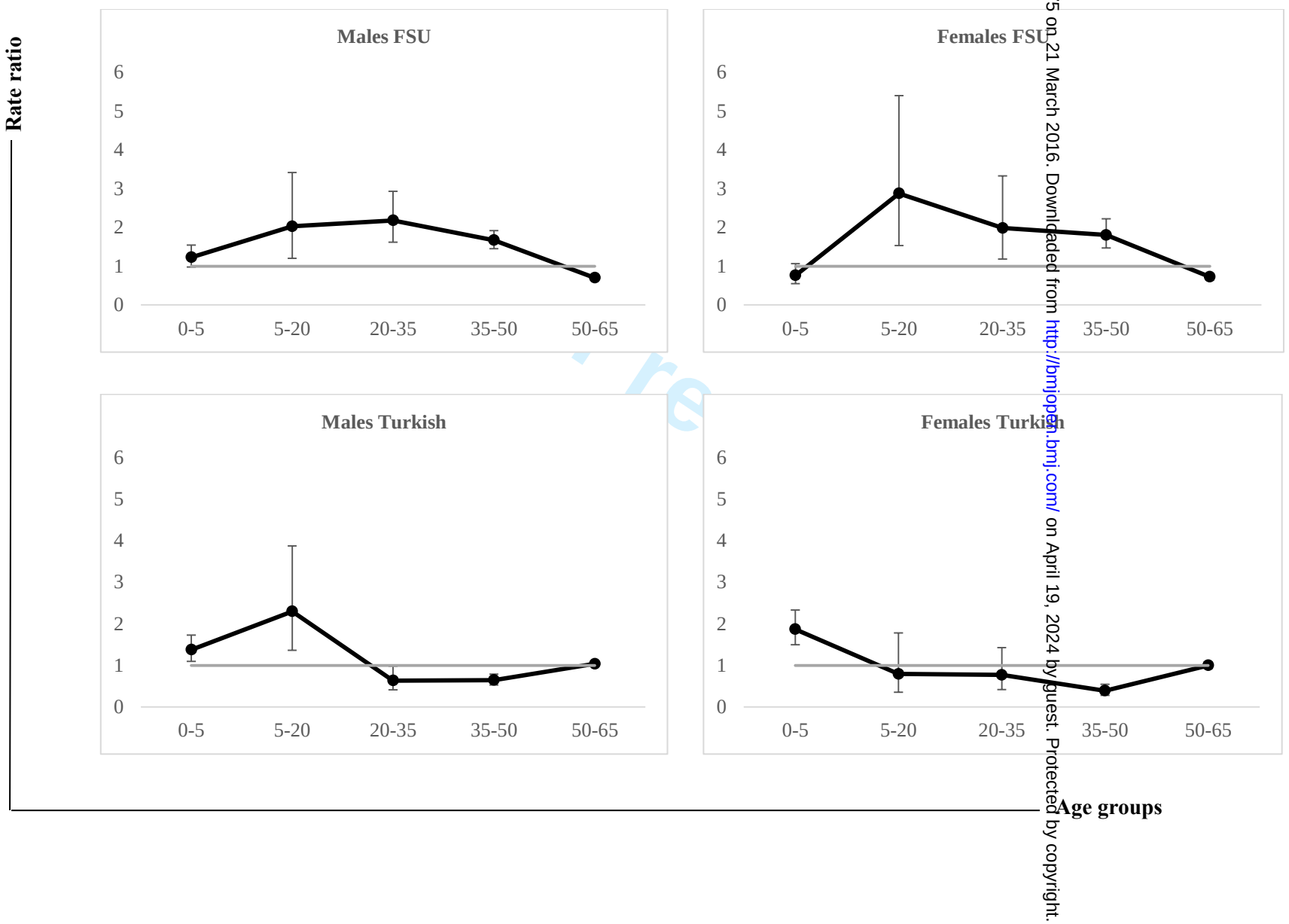
Figure 1 Rate ratios for age-specific death rates 2004-2010 by sex, immigrant group. General population = 1. Error bars denote 95% CI



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A comparative analysis of premature mortality among urban immigrants in Bremen, Germany: a retrospective register-based linkage study

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TITLE PAGE

A comparative analysis of premature mortality among urban immigrants in Bremen, Germany: a retrospective register-based linkage study

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ABSTRACT

Objectives

The main object of this study was to explore differences in mortality patterns among two large immigrant groups in Germany: from Turkey and from the former Soviet Union (FSU). To this end, we investigated indicators of premature mortality.

Design

This study was conducted as a retrospective population-based study based on mortality register linkage. Using mortality data for the period 2004-2010, we calculated age-standardized death rates (SDR) and standardized mortality ratios (SMR) for premature deaths (< age 65). We computed years of potential life lost (YPLL) and analyzed the underlying causes of death contributing to premature mortality.

Setting and participants

In this study we made use of the unique possibilities of register-based research in relation to migration and health. Analyses were performed in three population groups in the federal state of Bremen, Germany: immigrants from Turkey, from the FSU, and the general population.

Results

The SDRs for premature deaths of the two immigrant groups were lower compared to those of the general population. The SMRs remained under 1. Using the indicator of YPLL, we observed higher age-standardized YPLL rates among immigrant populations, particularly among males from the FSU compared to other sex and population groups 4,238/100,000, 95% confidence interval (CI) [4,119; 4,358]. Regarding main causes of premature death, we found larger contributions of infant mortality and diseases of the respiratory system among Turkish immigrants, and of injuries and poisonings and mental and behavioral disorders among immigrants from the FSU.

Conclusion

While the overall trends favour the immigrant populations, the indicator of YPLL and cause-specific results indicate areas where the health care system´s responsiveness may need to be improved, including preventive services. Further work with broader databases providing a similar level of differentiation is necessary to substantiate these findings.

ARTICLE SUMMARY

Strengths and limitation of this study

We used a name-based algorithm as well as a combination of different methods for the determination

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of migrant background, i.e. country of birth, birthplace and nationality to get a more accurate estimation of the immigrant populations. We successfully implemented the record linkage method to link registry data with Bremen Mortality Index data. Using the concept of premature mortality and indicator of years of potential life lost, we were able to indicate areas where health care provision needs to be improved.

In this study we touched on the important issue of data availability. Mortality data are widely available in European countries. The coding of the underlying cause of death according to International Classification of Diseases (the 10th version) offers a standardized methodological basis. The epidemiological concept of avoidable mortality has been studied among immigrants in some European studies, e.g. Sweden, the Netherlands and Estonia, making use of registry linkage.

Limitations of the current study include the absence of population-group specific denominator data for the years 2004–2009, for which we used an imputation procedure based on available data for 2010 and data on changes in population numbers per nationality group. This procedure introduces some imprecision, but we believe it does not invalidate the overall findings. Numbers of deaths in specific age-bands and subgroups were small, and thus need to be interpreted with caution. Missing data were higher among Turkish immigrants (8.9% compared to 2.4% among FSU immigrants) after record linkage with the Bremen Mortality Index. We assume that this is due to higher re-migration of elderly Turkish immigrants.

Methods

- Usage of mortality data for the period 2004-2010.
- Calculation of age-standardized death rates (SDR) and standardized mortality ratios (SMR) for premature deaths (< age 65).
- Computation years of potential life lost (YPLL).
- Analyses of the underlying causes of death contributing to premature mortality.

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INTRODUCTION

Immigrant populations, which typically have a higher concentration of socio-economic and health disadvantages[1] compared to host populations, are of growing social, demographic and political importance in many countries. Among the potential adverse factors affecting migrant health, inequalities in health care access and sub-optimal services in host countries are among those amenable by public health measures and thus of particular concern. There is however also evidence that immigrant populations often show a better health status compared to the general population of the host-country (healthy migrant effect; selective migration etc.).[2-5] Despite this evidence, reviewing the topic of migration, an expert commission recently came to the conclusion that the health status of migrants is on average lower than that of non-migrants.[6] The combination of the selection mechanisms towards healthy migrants and the potential adverse factors in the host country makes it particularly difficult to assess the health situation of migrants. Up to now comparative research that captures the complexity and heterogeneity of immigrants and at the same time identifies their shared risks is still scarce.[7] Reliable and comparable quantitative data on the patterns of diseases, access to health care, overall mortality, as well as specific mortality causes amongst immigrants are rarely available. This is mainly due to the fact that most data sources do not provide consistent information on the origin of immigrants. In Germany for example, the Federal Health Monitoring System provides information on foreign populations based on their nationality. This indicator however excludes immigrants who have taken up German citizenship, although this group now constitutes a non-negligible part of the immigrant population in Germany.[8] Overall, almost 20% of the population of Germany has a migration background.[9] A recent comprehensive investigation into migrant morbidity and mortality in Germany confirmed the problem of insufficient characterization of migrant status in official data.[10] They used nationality as the only indicator and found lower mortality among foreign adult population aged 20 to 60 years compared to Germans. However, there was some evidence that further differences in mortality among immigrant groups were present.[10]

In epidemiology, the study of mortality patterns is central to the goal of assessing the overall health situation, taking the status and accessibility of the healthcare system of one or more demographic groups into account.[11] Population-based mortality data are a continuous and accessible source of health information in most industrialized countries. With higher life expectancy, most deaths occur among the older aged people (75 +), such that classic mortality and cause of death investigations are strongly influenced by this age group. From a public health perspective, it is even more interesting to pay attention to premature mortality (also referred to as amenable mortality), i.e. mortality occurring before the age of the average life expectancy. Premature deaths occurring in young ages refer to *"all those deaths that, given current medical knowledge and technology, could be avoided by the healthcare system through either prevention or treatment"*.[12] Evidence derived from the study of premature mortality can be used in public health planning to compare the relative importance of different causes of premature deaths, to set priorities for prevention or health care activities, and to compare the premature mortality between different populations.[13]

The use of indicators of premature mortality such as years of potential life lost (YPLL) to quantify health status in population groups is gaining importance.[12,14,15] YPLL offers a method to measure the impact of premature mortality in the population.[16,17]

Previous international comprehensive studies[18] indicate a reduction of premature mortality by more than half since 1970 and outline general trends by sex and underlying causes of death contributing to premature mortality, but do not provide information on vulnerable population groups.[14,19-22]

Only few European studies have investigated premature or avoidable mortality among immigrants[21]. These studies, which originate from Sweden,[23] the Netherlands,[24] and Estonia[25] reported heterogeneous premature mortality results for the selected immigrant groups. Components of avoidable mortality used in these studies were chosen from the classical approach of the concept.[12,17] In this respect, studies from Sweden and the Netherlands included indicators of medical intervention

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and national health policy in their analysis. The study from Estonia on the other hand linked the causes of death to preventable versus treatable conditions. In studies from Sweden and the Netherlands, the most common causes of death found among immigrant groups were linked to indicators of the health policy field rather than medical intervention. This reflected trends in mortality rates associated with behavior or lifestyle such as alcohol consumption, smoking, and socio-economic status (e.g. working vs. non-working population) for which outreach and prevention activities are potentially effective combat tools. Variations in the distribution of diseases in different population groups could be caused by high exposure risks, unhealthy life style, insufficient medical care or unequal access to health care services. Thus, a better understanding of premature mortality patterns in populations may be useful for various aspects of health improvements in populations, including improving access to health care services.

In this study, we made use of the exceptional data sources available in the federal state of Bremen, Germany to investigate premature mortality of immigrants from Turkey and the former Soviet Union (FSU) for the period 2004-2010 in a population based approach. Turkish and FSU immigrants form the two largest immigrant populations in Germany, each comprising nearly 3 million people. Our main objective is to explore premature mortality to help identify specific diseases and health needs among immigrants from FSU and Turkey, which will be important for setting priorities in medical health care provision and prevention activities.

METHODS

Determination of denominator populations

We obtained population figures for the general population living in the federal state of Bremen during the period 2004-2010 from the German Federal Health Monitoring System.[26] The federal health monitoring system however does not provide data on immigrant populations by country of origin; instead, it contains numbers of all foreigners by nationality for every federal state and in 5-year age groups.[27] To avoid relying on nationality only, we searched the full population file for 2010 in the Residents' Registration office in Bremen using (i) nationality as well as country and place of birth to identify immigrants from the FSU (n=33,497, 5.1 percent of the general population in the state of Bremen)[9] and (ii) the name-based algorithm developed by Razum and colleagues to identify immigrants from Turkey (n=49,518, 7.5 percent of the general population in the state of Bremen).[9,28,29] Detailed descriptions of these two applied approaches can be found in Makarova et al.[9] We then used the figures for FSU and Turkish immigrants obtained for 2010 to estimate the missing denominators for 2004 – 2009. To this end, we initially calculated the percentage increase or decrease in the foreign population in the federal state of Bremen[27] between each consecutive year from 2004 – 2010, going backwards from 2010. In other words, we calculated the development of the foreign population in the state of Bremen in percent between 2010 and 2009, 2009 and 2008, 2008 and 2007 etc. Thereafter, we used the obtained percentage changes to project figures for FSU and Turkish immigrants for 2004 – 2009, based on the figures for 2010 obtained from the Bremen Residents' Registration office for each of the population groups (see online supplementary figure S1).

The denominator population for the full study period was thus stratified into the general population (all residents living in the federal state Bremen, including the two migrant populations) and the population with migrant background from Turkey and from the FSU. The data were available differentiated by sex and categorized in five-year age groups.

Mortality data and linkage

For the mortality analysis of each of the three population groups of interest, we used data from the Bremen Mortality Index (BreMI). The BreMI is an electronic database providing all information recorded on death certificates of Bremen citizens who died since 1998 including ICD-10 Code of

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underlying cause of death. Data from the Bremen Residents' Registration office were linked with the BreMI using only the death registration number.

Statistical analyses

Based on the methodological approach of health monitoring used in Germany and following the recommendations of the Robert Koch-Institute, we selected the age of 65 years as upper limit for the calculation of premature mortality.[15]

We calculated age-standardized death rates (SDRs)/100,000, using the European Standard Population (ESP) for ages 0-64 for both sexes in the different populations, and years of potential life lost (YPLL) for premature deaths. To determine YPLL, we added the age-specific deaths occurring at each age and weighted them by the number of remaining lost years up to the selected age limit of < 65. For example, a death occurring at five years of age is counted as 60 YPLL.[14,15] The indicator is expressed per 100,000 persons. Data were standardized to the ESP.[15] We considered more detailed age-specific death rates (ASDR) per 100,000 person years and calculated ratios of the age-specific death rates in every age- and population group for men and women. Furthermore standardized mortality ratios (SMR) were calculated. Precision was estimated using 95% confidence intervals (CIs). We also descriptively analyzed leading causes of death contributing to premature mortality based on the main groups of the ICD 10th version. We focused on the ten leading causes of death for premature mortality.

RESULTS

According to our population based calculations, we estimated the proportion of Turkish and FSU immigrants living in Bremen as measured by the number of general population between 2004 and 2010: 5.1% were from the FSU and 7.5% originated from Turkey (see online supplementary table S1). Over the study period 2004-2010, a total of 774 deaths among Turkish immigrants, 1,288 deaths among immigrants from the FSU (see online supplementary table S1) and 52,258 deaths in the general population were identified in the data of the residents' registration office. After record linkage with the BreMI, useful mortality information was retrieved for 706 deaths (8.9% missings) among Turkish immigrants and for 1,258 deaths (2.4% missings) among immigrants from the FSU. 51% (N=360) of all deaths among Turkish immigrants, 28% (N=350) of those among immigrants from the FSU, and 18% (N=9,759) of those in the general population occurred prematurely. Note that for the general population no missings could be determined, as only the BreMI database was used. Regarding sex specific percentage points of premature mortality increased values were found among men from the FSU compared to every other sex and population group (table 1).

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Table 1 Mortality parameters 2004-2010 by sex, population and age group

Mortality parameters	FSU immigrants			Turkish immigrants			General population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
n of all cases of death	656	602	1,258	461	245	706	24,688	27,570	52,258
n of premature death	251	99	350	233	127	360	6,432	3,327	9,759
% of premature mortality in relation to the (n) of all cases of death, both sexes	28		-	51		-	18		-
Sex specific percentage points of 28%, 51%, 18% of premature death	71	29	-	65	35	-	67	33	-
Age-standardized death rates for all premature cases of death /100,000 with 95% CI	214 [187; 241]	76 [60; 91]	140 [125; 155]	178 [154; 203]	94 [77; 111]	136 [121; 150]	273 [266; 279]	142 [137; 147]	207 [203; 211]
Standardized mortality ratios with 95% CI	0.79 [0.69; 0.89]	0.53 [0.43; 0.64]	0.67 [0.61; 0.75]	0.63 [0.55; 0.72]	0.66 [0.55; 0.79]	0.64 [0.58; 0.71]	General population = 1		
YPLL age-standardized with 95% CI	4,238 [4,119; 4,358]	1,710 [1,631; 1,789]	5,949 [5,808; 6,089]	2,560 [2,430; 2,581]	1,631 [1,569; 1,693]	4,137 [4,042; 4,233]	3,880 [3,854; 3,907]	2,163 [2,142; 2,184]	6,043 [6,011; 6,076]

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We further calculated age-standardized death rates/100,000, using the ESP for ages 0–64 for both sexes in the different populations. The SDR for premature deaths of the two immigrant population groups were lower compared to the general population. Among Turkish immigrants, the SDR was 136/100,000, 95% CI [121; 150] versus 140/100,000, 95% CI [125; 155] among FSU immigrants, and 207/100,000, 95% CI [203; 211] in the general population. Regarding sex specific SDRs, men in every population group had higher SDRs as compared to women. Among Turkish immigrants men showed the SDR of 178/100,000, 95% CI [154; 203] as compared to women with SDR of 94/100,000, 95% CI [77; 111]. Men from the FSU demonstrated the SDR of 214/100,000, 95% CI [187; 241] as compared to the women in this population group with the SDR of 76/100,000, 95% CI [60; 91]. In the general population group the SDR among males was 273/100,000, 95% CI [266; 279] vs. 142/100,000, 95% CI [137; 147] among females. Sex and age-specific death rates (ASDRs) comparing the three populations are provided in Table 2.

Table 2 Age-specific death rates 2004-2010 by sex, population group, per 100,000 person years, up to age 64

Age at death	FSU immigrants		Turkish immigrants		General population	
	Male	Female	Male	Female	Male	Female
	Rate (n, cases of death)					
0-4	129 (9)	43 (3)	126 (22)	151 (25)	136 (133)	111 (101)
5-19	35 (5)	23 (3)	35 (17)	9 (4)	23 (74)	16 (49)
20-34	110 (42)	27 (12)	28 (13)	15 (7)	65 (299)	27 (124)
35-49	346 (75)	130 (33)	117 (52)	40 (14)	269 (1,459)	142 (721)
50-64	560 (120)	192 (48)	725 (129)	382 (77)	1,038 (4,469)	523 (2,332)
n = total	245 (251)	87 (99)	133 (233)	79 (127)	347 (6,434)	184 (3,327)

Comparing males and females, we observed generally higher age-specific death rates among males than among females in all population groups. Detailed analyses of ASDRs in age groups comparing immigrant groups to the general population as well as within immigrant groups showed a general trend towards higher premature mortality among men from the FSU in the age group 20-49 years compared to men from the general population. In the younger age groups, there were increased ASDRs among females from the FSU aged 5-19 years compared to the two other groups. The highest under-five mortality was found among children with Turkish migrant background. We also calculated ratios for age specific death rates, with the general population as reference (see figure 1). The figure clearly shows the differences as outlined above, but also the similarities mainly regarding under-five child mortality.

Similar to the observations we made for SDRs, the SMRs in both immigrant groups remained significantly below 1, indicating lower premature mortality risks than in the general population: the SMR for FSU immigrants was 0.67, 95% CI [0.61; 0.75] and for Turkish immigrants – 0.64, 95% CI [0.58; 0.71]. Differentiating between men and women in every immigrant group, the SMR ranged from 0.53, 95% CI [0.43; 0.64] for women from the FSU to 0.79, 95% CI [0.69; 0.89] for FSU males, with estimates for Turkish migrants between 0.63, 95% CI [0.55, 0.72] (males) and 0.66, 95% CI [0.55, 0.79] (females).

In terms of YPLL, FSU males had the highest age-standardized YPLL rate (4,238 per 100,000 with 95% CI [4,119; 4,358]), while Turkish females had the lowest age-standardized YPLL rate (1,631 per 100,000 with 95% CI [1,569; 1,693]) (table 1). In contrast, the age-specific YPLL were the highest among female Turkish migrant children in the age group 0-4 compared to every other sex and population group (table 3).

Insert figure 1 about here

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Table 3 Age-specific YPLL per 100,000 for all cases of death for the age at death < 65, between 2004 and 2010 by sex, immigrant- and age group

Age at death	FSU immigrants		Turkish immigrants		General population	
	Male	Female	Male	Female	Male	Female
0-4	8,344	2,800	8,177	9,286	8,831	6,697
5-19	1,734	1,111	1,784	429	1,131	770
20-34	4,138	1,204	975	566	2,373	1,003
35-49	7,018	2,986	2,642	653	5,705	2,797
50-64	4,799	2,073	3,987	3,014	6,888	3,710
Total	4,840	1,859	2,647	1,667	4,516	2,414

Main causes of death

In each of the population groups, neoplasms and diseases of the circulatory system accounted for over 40% of premature deaths. Generally, the proportions of these two major causes of death contributing to premature mortality in all three population groups were higher among men than women (table 4). We however observed differences in specific causes of death in the three population groups. For example, infant mortality and diseases of the respiratory system were higher among Turkish than among FSU immigrants, and injuries and poisonings as well as mental and behavioral disorders were considerably higher among immigrants from the FSU than in the other two groups. Using the BreMI, we were able to ascertain that the premature deaths coded as injuries and poisonings among men from the FSU were often due to alcoholism, alcohol abuse, smoking, and intoxication.

Table 4 Causes of death contributing to premature mortality between 2004 and 2010 for three population groups; Percentage in relation to the total number of premature death cases

Cause of death *(main groups of the ICD 10)**	FSU immigrants		Turkish immigrants		General population	
	Male	Female	Male	Female	Male	Female
	(%)					
Neoplasms *(C00-D48)*	19.1	10.6	14.2	10.8	19.6	15.1
Diseases of the circulatory system *(I00-I99)*	13.7	4.9	15.6	7.8	14.8	5.6
Mental and behavioral disorders *(F00-F99)*	11.4	1.7	3.3	0.3	7.9	2.1
Injuries, poisonings *(S00-T98)*	12.3	2.0	6.7	0.6	5.3	1.6
Diseases of the digestive system *(K00-K93)*	0.9	2.0	2.2	0.6	3.6	1.9
Diseases of the respiratory system *(J00-J99)*	2.0	0.3	5.3	1.7	3.2	1.9
Certain conditions originating in the perinatal period *(P00-P96)*	2.0	0.9	4.2	3.9	-	-
Certain infectious and parasitic diseases *(A00-B99)*	1.7	1.1	1.7	2.2	2.2	1.2
Endocrine, nutritional and metabolic diseases *(E00-E90)*	0.9	0.9	-	-	1.7	0.6
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified *(R00-R99)*	2.6	0.6	-	-	-	-

* ICD, 10th version

DISCUSSION

In this study, we examined and compared patterns of premature/avoidable mortality among immigrants from Turkey and the FSU to the host population in the federal state of Bremen, Germany. Through the exploration of premature mortality, we aimed to identify specific health problems contributing to premature death, and derive information to identify priority areas in medical care or prevention for migrant populations. We combined different methodological approaches for analyzing premature/avoidable mortality: we selected the age of <65 for analyzing premature deaths and calculated different mortality indicators including years of potential life lost. Additionally, to gain further insight into mortality patterns, we documented the leading causes of death based on the main groups of the ICD 10th version.

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When using standardized death rates and mortality ratios to assess premature mortality, we found lower mortality rates of the two immigrant groups compared to in the general population. We did not observe differences in the distribution of the two leading causes of premature mortality: neoplasms and diseases of the circulatory system accounted for over 40% of premature deaths in each of the three population groups.

The lower mortality among Turkish immigrants compared to the general population could be explained, for example, by the "healthy migrant effect"[5]. Migrant workers are generally said to represent a healthier and younger population and consequently, based on the selection effect, a conditional relatively lower mortality compared to the general population. Moreover, based on data we obtained from the Bremen Residents' Registration office, we assume a certain degree of re-migration of elderly Turkish immigrants in Turkey, possibly leading to reduced premature mortality in this population group.

The "healthy migrant" effect could not be applied to the group of migrants from the FSU as they did not primarily come to Germany as young workers, but rather as repatriates. The overall lower premature mortality in this population group can possibly be explained by the "social support"[30] provided by the comprehensive social security and insurance systems in Germany, which is better than compared to the countries of FSU. In addition, the immigrants from the FSU benefited from better access to high-quality health care leading to better health.[31,32] The reason for better health and thus lower mortality compared for example to migrant workers was because immigrants from the FSU were included in the system as ethnic Germans and in large part spoke fluent German.

Only with the indicator of YPLL and when looking at specific causes of death and analyses conducted in specific age groups, were we able to demonstrate that certain subgroups among immigrant groups had higher premature mortality compared to the general population. The indicator of YPLL provides a common denominator for judging the priority to be given with regard to planning and organization of health care or prevention to each cause of mortality in identified risk age groups.[33,34] For instance, we observed increased years of life lost among Turkish children, especially females, for death at ages between 0-4 years of age. Further analyses showed increased mortality in relation to pregnancy and infant mortality, especially due to extreme immaturity among Turkish immigrants. In terms of setting priorities and thinking about developing migrant-sensitive health systems, one focus could be on strengthening health literacy of mothers. Patients with Turkish migrant background should be informed that for example consanguineous marriages can lead to an increased risk for genetic disorders and infant mortality,[35] and the obstetricians should be able to give qualified information to support early diagnosis to prevent deaths. The setting of health development strategies relating to avoidable mortality and evaluation of their achievement also provides a powerful means of audit.[36]

We observed that compared to Turkish men and those in the general population, men from the FSU lost more years of life if the death occurred between 20 and 50 years. Premature deaths in this population group coded as injuries and poisonings as well as mental and behavioral disorders were often noted as being associated with alcoholism, alcohol abuse, smoking, and intoxication. Our results are, in general, in line with those reported in studies conducted in European countries,[23-25] which highlight life-style related mortality attributable to alcohol consumption, smoking and intoxication. Explicitly focusing on Germany, Deckert et al., suggest that the higher YPLL in middle-aged men could reflect detrimental drinking patterns, which are popular in blue-collar working men in Russia.[37] These drinking patterns are associated with cardiomyopathy in young men.[31] The composition of the group of German repatriates changed dramatically between 1990 and 1999, with the majority of the German repatriates being of Russian ethnicity at the end of this period. Theoretically, a large proportion of the German repatriates residing in Bremen from 2004 could also be of Russian ethnicity. There are some theories that the lifestyle of the ethnic Germans in the FSU was completely different to the autochthonous population, hence, in Germany, the higher YPLL might mainly affect the ethnic Russian immigrants.[31,38] Furthermore, studies originating from the Russian Federation link premature mortality to hazardous alcohol- and nicotine consumption.[39-41] Such findings raise two important

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questions: (1) whether immigrants from the FSU bring their lifestyle habits along to Germany[32] and keep them over the time after migration; and (2) whether this group can be reached through better health care integration and support for the adoption of a healthier lifestyle?

With regard to setting priorities in the group of FSU immigrants, sex-specific interventions in this population group to reduce alcohol, nicotine and substance consumption appear to be of importance and individual and community-based interventions need to be explored.

We also observed slightly higher age specific death rates among women from the FSU aged 5 to 19 years compared to other women in this age group. Explanations for this unique mortality reverse: lower overall premature mortality and increased age specific mortality in this population group could include factors associated with transition from childhood to adulthood: alcohol, smoking, violence, drugs, transport accidents etc.[42] Pregnancy and childbirth in adolescence could also pose higher risks for premature mortality.[43]

Our study has several strengths and limitations. To our knowledge, this is the first study that contemporaneously analyzed premature/avoidable mortality among two large immigrant population groups living in Germany. This is also the first study that tested different approaches as well as their combination to identify both immigrant groups in the Residents' Registration office and after that to link personal data to the electronically database BreMI - the unique form to document and monitor mortality on the federal state level.

In this study we touched on the important issue of the availability of data. Mortality data are widely available and easy to obtain in many European countries. The coding of the underlying cause of death according to ICD-10 offers a standardized methodological basis. The epidemiological concept of avoidable mortality has been studied among immigrants in some European studies, e.g. Sweden, the Netherlands and Estonia, using registry linkage.[23-25] For Estonia, Baburin et al. documented the most important preventable causes of death among men as being accidental poisonings, suicide and alcohol-related diseases.[25] For Sweden, Westerling et al. also assumed that observed variations in mortality reflected differences in smoking and alcohol habits.[23] Stirbu et al. assessed mortality in a number of immigrant groups in the Netherlands, including immigrants from Turkey. The study population comprised mainly women and Turkish immigrants had a higher risk of death from maternity-related conditions compared to the native Dutch population.[24] Our own investigations highlight the need for a differentiated epidemiological assessment of premature mortality, and indicate specific risks for particular groups, most notably young and middle-aged men from the FSU. We believe that further investigations in premature mortality for immigrant and ethnic minority groups in Germany and the European region will be useful and informative for epidemiological surveillance and for evidence based interventions. More standardization of methodological approaches will enhance the opportunities for comparisons within and across countries.

Several limitations merit consideration. The population-group specific denominator data for the years 2004–2009 were missing. To calculate them, we used an imputation procedure based on available data for 2010 and data on changes in foreign population numbers. Although this procedure introduces some imprecision, we believe that it does not invalidate the overall findings. Further, the numbers of deaths in specific age-bands and subgroups were small, and thus need to be interpreted with caution. Missing data – ie. missing death certificates were higher among Turkish immigrants (8.9% compared to 2.4% among FSU immigrants) after record linkage with the Bremen Mortality Index. We argue that this is due to higher re-migration of elderly Turkish immigrants.

A further limitation of this study is the inconsistent usage of methodology for defining of our cohort. We used name-based algorithm for determination of Turkish immigrants developed by Razum and collegues.[28,29] Onomatology, the science of the origin of names, is a well-established discipline. Humpert and Schneiderheinze[44] described name-based algorithms to identify immigrants in German residence registries in case the place of origin is not available. The Bayesian approach using the Bayes' theorem was also applied for inferring geographical origins of immigrants through surnames.[45] The

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name-based algorithm, proposed by Razum and colleagues, achieves a specificity of > 99.9%[29] and was successfully applied in our dataset resulting in the identification of about 90% of Turkish immigrants.[9]

For the identification of immigrants from the FSU we did not have an existing good applicable algorithm. Therefore, we used the available information of country of birth, nationality and, were necessary, place of birth as well as the combination of all three approaches. Currently, this information seems to be sufficient to identify first generation persons from the FSU. Children born in Germany as from the early 1990s already have German citizenship/nationality and hence could not be identified using our search methods. Prospectively, the creation of an identical name-based algorithm in this population group will be of interest. A comprehensive work will be needed to make these individuals recognizable in the national statistics.[9]

The most pronounced limitation in this analysis is the small number of premature deaths: 360 among Turkish immigrants and 350 for those originating from the FSU. This fact may affect the transferability of the results to other federal states. To improve the transferability, some similar analyses should be performed, for example, in other federal state in Germany. It would be possible in the federal state of Rheinland-Pfalz, where the Data Management System Mortality is well implemented and similar to the BreMI.

The other problem is the representativeness of the sample. The federal state of Bremen with around 600,000 inhabitants is the smallest federal state in Germany. Due to the political and economic situation in Bremen representativeness in many other issues is also difficult to establish. However, we could test and validate the usage of previously disregarded data sources for health research in vulnerable population groups.

Comparing the results obtained in this study, for example, the age-standardized mortality rates for premature deaths before the age of 65, with those from the health monitoring system for the Bremen's population, the results are consistent (207 per 100,000 for the 2004 - 2010 period compared to 241 per 100,000 in 2004 and 209 per 100,000 in 2010). The consistency of the results in the general population may provide indications for the validity and transferability to immigrant populations.

CONCLUSION

Our analyses of premature mortality demonstrated differences and similarities between the immigrant and the general population in Bremen, Germany. While the overall trends surprisingly favour the immigrant populations, age and cause-specific results indicate areas where the health care system's responsiveness may need to be improved, including preventive services. Further work with broader databases providing a similar level of differentiation is necessary to substantiate the findings.

CONTRIBUTORS

NM conceptualized the study, its design and methods. She conducted the analyses and presented the results. TB and HP were involved in the conceptualization of methods and statistical analyses. SL was involved in the acquisition, management and interpretation of data. CBK carried out the linkage approach and was partly involved in the data management as well as data interpretation. TB, HP, SL and CBK revised critically the manuscript and approved the final version of the manuscript.

COMPETING INTERESTS

There are no competing interests.

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ETHICAL APPROVAL

All research work with the BreMI follows a specific set of rules and requires clearance by the Bremen Senator for Health. All linkage procedures were done by authorized personnel only, and the study center received an anonymized data set. Under these conditions, no ethical approval was required.

DATA SHARING

No additional data available.

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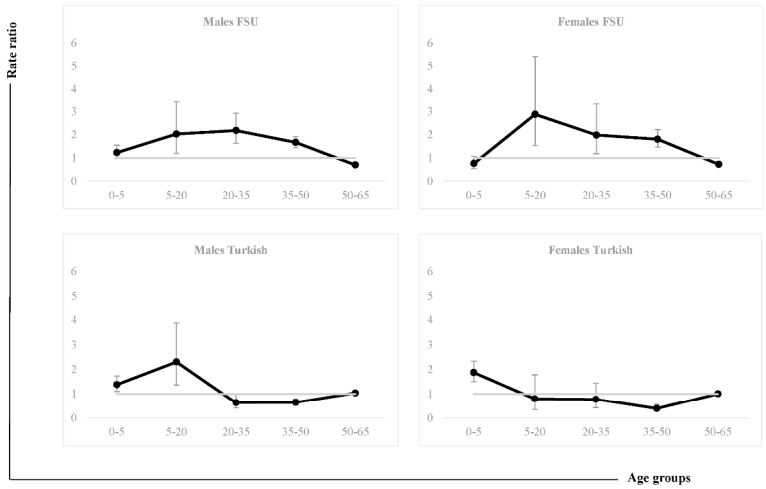
Figure 1 Rate ratios for age-specific death rates 2004-2010 by sex, immigrant group. General population = 1. Error bars denote 95% CI



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Supplementary material

A comparative analysis of premature mortality among urban immigrants in Bremen, Germany: a retrospective register-based linkage study

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Table S1 Population figures among both immigrant groups: from Turkey and the FSU in the federal state of Bremen

Population figures and mortality parameters	Turkish immigrants females	Turkish immigrants males	Turkish immigrants total	FSU immigrants females	FSU immigrants males	FSU immigrants total
n population (% per year measured by general population)						
2004	23,781 (6.95)	27,145 (8.45)	50,887 (7.67)	18,216 (5.33)	16,131 (5.62)	34,423 (5.19)
2005	23,996 (7.02)	26,902 (8.37)	50,874 (7.67)	18,381 (5.37)	15,987 (4.57)	34,414 (5.19)
2006	23,924 (7.0)	26,705 (8.29)	50,609 (7.62)	18,326 (5.36)	15,870 (4.52)	34,235 (5.16)
2007	24,035 (7.04)	26,547 (8.25)	50,571 (7.63)	18,411 (5.40)	15,776 (4.50)	34,209 (5.16)
2008	23,905 (7.03)	26,322 (8.18)	50,218 (7.59)	18,311 (5.38)	15,642 (4.46)	33,971 (5.13)
2009	23,841 (7.02)	26,250 (8.15)	50,082 (7.57)	18,262 (5.38)	15,599 (4.44)	33,879 (5.12)
2010	23,701 (7.0)	25,817 (8.02)	49,518 (7.49)	18,155 (5.36)	15,342 (4.37)	33,497 (5.07)
n death per year						
2004	34	60	94	95	88	183
2005	33	54	87	77	92	169
2006	33	60	93	92	105	197
2007	28	71	99	91	85	176
2008	46	81	127	80	110	190
2009	41	77	118	93	95	188
2010	32	63	95	76	88	164
Not available death certificates		**n=61**			**n=21**	
n premature death per year						
2004	18	31	49	17	37	54
2005	19	32	51	14	40	54
2006	17	43	60	10	38	48
2007	12	34	46	21	33	54
2008	26	39	65	10	33	43
2009	23	27	50	17	38	55
2010	12	27	39	10	32	42

Population figures of the living persons in the federal state of Bremen were extracted from the Residents' Registration office. Figures for the years 2004-2009 are truncated.

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Figure S1: Age pyramid for the population living in the federal state of Bremen divided in immigrants from Turkey, the FSU and the general population

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A comparative analysis of premature mortality among urban immigrants in Bremen, Germany: a retrospective register-based linkage study

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TITLE PAGE

A comparative analysis of premature mortality among urban immigrants in Bremen, Germany: a retrospective register-based linkage study

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ABSTRACT

Objectives

The main object of this study was to explore differences in mortality patterns among two large immigrant groups in Germany: from Turkey and from the former Soviet Union (FSU). To this end, we investigated indicators of premature mortality.

Design

This study was conducted as a retrospective population-based study based on mortality register linkage. Using mortality data for the period 2004-2010, we calculated age-standardized death rates (SDR) and standardized mortality ratios (SMR) for premature deaths (< age 65). We computed years of potential life lost (YPLL) and analyzed the underlying causes of death contributing to premature mortality.

Setting and participants

In this study we made use of the unique possibilities of register-based research in relation to migration and health. Analyses were performed in three population groups in the federal state of Bremen, Germany: immigrants from Turkey, from the FSU, and the general population.

Results

The SDRs for premature deaths of the two immigrant groups were lower compared to those of the general population. The SMRs remained under 1. Using the indicator of YPLL, we observed higher age-standardized YPLL rates among immigrant populations, particularly among males from the FSU compared to other sex and population groups 4,238/100,000, 95% confidence interval (CI) [4,119; 4,358]. Regarding main causes of premature death, we found larger contributions of infant mortality and diseases of the respiratory system among Turkish immigrants, and of injuries and poisonings and mental and behavioral disorders among immigrants from the FSU.

Conclusion

While the overall trends favour the immigrant populations, the indicator of YPLL and cause-specific results indicate areas where the health care system´s responsiveness may need to be improved, including preventive services. Further work with broader databases providing a similar level of differentiation is necessary to substantiate these findings.

ARTICLE SUMMARY

Strengths and limitation of this study

- We used a name-based algorithm as well as a combination of different methods for the

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determination of migrant background, i.e. country of birth, birthplace and nationality to get a more accurate estimation of the immigrant populations.

- We successfully implemented the record linkage method to link registry data with Bremen Mortality Index data.
- Using the concept of premature mortality and indicator of years of potential life lost, we were able to indicate areas where health care provision needs to be improved.
- In this study we touched on the important issue of data availability.
- Limitations of the current study include the absence of population-group specific denominator data for the years 2004–2009, for which we used an imputation procedure based on available data for 2010 and data on changes in population numbers per nationality group.

Methods

- Usage of mortality data for the period 2004-2010.
- Calculation of age-standardized death rates (SDR) and standardized mortality ratios (SMR) for premature deaths (< age 65).
- Computation years of potential life lost (YPLL).
- Analyses of the underlying causes of death contributing to premature mortality.

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INTRODUCTION

Immigrant populations, which typically have a higher concentration of socio-economic and health disadvantages[1] compared to host populations, are of growing social, demographic and political importance in many countries. Among the potential adverse factors affecting migrant health, inequalities in health care access and sub-optimal services in host countries are among those amenable by public health measures and thus of particular concern. There is however also evidence that immigrant populations often show a better health status compared to the general population of the host-country (healthy migrant effect; selective migration etc.).[2-5] Despite this evidence, reviewing the topic of migration, an expert commission recently came to the conclusion that the health status of migrants is on average lower than that of non-migrants.[6] The combination of the selection mechanisms towards healthy migrants and the potential adverse factors in the host country makes it particularly difficult to assess the health situation of migrants. Up to now comparative research that captures the complexity and heterogeneity of immigrants and at the same time identifies their shared risks is still scarce.[7] Reliable and comparable quantitative data on the patterns of diseases, access to health care, overall mortality, as well as specific mortality causes amongst immigrants are rarely available. This is mainly due to the fact that most data sources do not provide consistent information on the origin of immigrants. In Germany for example, the Federal Health Monitoring System provides information on foreign populations based on their nationality. This indicator however excludes immigrants who have taken up German citizenship, although this group now constitutes a non-negligible part of the immigrant population in Germany.[8] Overall, almost 20% of the population of Germany has a migration background.[9] A recent comprehensive investigation into migrant morbidity and mortality in Germany confirmed the problem of insufficient characterization of migrant status in official data.[10] They used nationality as the only indicator and found lower mortality among foreign adult population aged 20 to 60 years compared to Germans. However, there was some evidence that further differences in mortality among immigrant groups were present.[10]

In epidemiology, the study of mortality patterns is central to the goal of assessing the overall health situation, taking the status and accessibility of the healthcare system of one or more demographic groups into account.[11] Population-based mortality data are a continuous and accessible source of health information in most industrialized countries. With higher life expectancy, most deaths occur among the older aged people (75 +), such that classic mortality and cause of death investigations are strongly influenced by this age group. From a public health perspective, it is even more interesting to pay attention to premature mortality (also referred to as amenable mortality), i.e. mortality occurring before the age of the average life expectancy. Premature deaths occurring in young ages refer to *"all those deaths that, given current medical knowledge and technology, could be avoided by the healthcare system through either prevention or treatment"*.[12] Evidence derived from the study of premature mortality can be used in public health planning to compare the relative importance of different causes of premature deaths, to set priorities for prevention or health care activities, and to compare the premature mortality between different populations.[13]

The use of indicators of premature mortality such as years of potential life lost (YPLL) to quantify health status in population groups is gaining importance.[12, 14, 15] YPLL offers a method to measure the impact of premature mortality in the population.[16, 17]

Previous international comprehensive studies[18] indicate a reduction of premature mortality by more than half since 1970 and outline general trends by sex and underlying causes of death contributing to premature mortality, but do not provide information on vulnerable population groups.[14, 19-22]

Only few European studies have investigated premature or avoidable mortality among immigrants[21]. These studies, which originate from Sweden,[23] the Netherlands,[24] and Estonia[25] reported heterogeneous premature mortality results for the selected immigrant groups. Components of avoidable mortality used in these studies were chosen from the classical approach of the concept.[12, 17] In this respect, studies from Sweden and the Netherlands included indicators of medical intervention

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and national health policy in their analysis. The study from Estonia on the other hand linked the causes of death to preventable versus treatable conditions. In studies from Sweden and the Netherlands, the most common causes of death found among immigrant groups were linked to indicators of the health policy field rather than medical intervention. This reflected trends in mortality rates associated with behavior or lifestyle such as alcohol consumption, smoking, and socio-economic status (e.g. working vs. non-working population) for which outreach and prevention activities are potentially effective combat tools. Variations in the distribution of diseases in different population groups could be caused by high exposure risks, unhealthy life style, insufficient medical care or unequal access to health care services. Thus, a better understanding of premature mortality patterns in populations may be useful for various aspects of health improvements in populations, including improving access to health care services.

In this study, we made use of the exceptional data sources available in the federal state of Bremen, Germany to investigate premature mortality of immigrants from Turkey and the former Soviet Union (FSU) for the period 2004-2010 in a population based approach. Turkish and FSU immigrants form the two largest immigrant populations in Germany, each comprising nearly 3 million people. Our main objective is to explore premature mortality to help identify specific diseases and health needs among immigrants from FSU and Turkey, which will be important for setting priorities in medical health care provision and prevention activities.

METHODS

Determination of denominator populations

We obtained population figures for the general population living in the federal state of Bremen during the period 2004-2010 from the German Federal Health Monitoring System.[26] The federal health monitoring system however does not provide data on immigrant populations by country of origin; instead, it contains numbers of all foreigners by nationality for every federal state and in 5-year age groups.[27] To avoid relying on nationality only, we searched the full population file for 2010 in the Residents' Registration office in Bremen using (i) nationality as well as country and place of birth to identify immigrants from the FSU (n=33,497, 5.1 percent of the general population in the state of Bremen)[9] and (ii) the name-based algorithm developed by Razum and colleagues as well as a combination of different methods, i.e. country of birth and nationality to identify immigrants from Turkey (n=49,518, 7.5 percent of the general population in the state of Bremen).[9, 28, 29] Detailed descriptions of these two applied approaches can be found in Makarova et al.[9] We then used the figures for FSU and Turkish immigrants obtained for 2010 to estimate the missing denominators for 2004 – 2009. To this end, we initially calculated the percentage increase or decrease in the foreign population in the federal state of Bremen[27] between each consecutive year from 2004 – 2010, going backwards from 2010. In other words, we calculated the development of the foreign population in the state of Bremen in percent between 2010 and 2009, 2009 and 2008, 2008 and 2007 etc. Thereafter, we used the obtained percentage changes to project figures for FSU and Turkish immigrants for 2004 – 2009, based on the figures for 2010 obtained from the Bremen Residents' Registration office for each of the population groups (see online supplementary figure S1). We used figures at the end of the year. The extraction of data from Residents' Registration office was at the end of the year 2010. No mid-year figures were available for the immigrant groups. For comparability, we used also end-year figures for the reference population.

The denominator population for the full study period was thus stratified into the general population (all residents living in the federal state Bremen, including the two migrant populations) and the population with migrant background from Turkey and from the FSU. The data were available differentiated by sex and categorized in five-year age groups.

Mortality data and linkage

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For the mortality analysis of each of the three population groups of interest, we used data from the Bremen Mortality Index (BreMI). The BreMI is an electronic database providing all information recorded on death certificates of Bremen citizens who died since 1998 including ICD-10 Code of underlying cause of death. Data from the Bremen Residents' Registration office were linked with the BreMI using only the death registration number.

Statistical analyses

Based on the methodological approach of health monitoring used in Germany and following the recommendations of the Robert Koch-Institute, we selected the age of 65 years as upper limit for the calculation of premature mortality.[15]

We calculated age-standardized death rates (SDRs)/100,000, using the European Standard Population (ESP) for ages 0-64 for both sexes in the different populations, and years of potential life lost (YPLL) for premature deaths. To determine YPLL, we added the age-specific deaths occurring at each age and weighted them by the number of remaining lost years up to the selected age limit of < 65. For example, a death occurring at five years of age is counted as 60 YPLL.[14, 15] The indicator is expressed per 100,000 persons. Data were standardized to the ESP.[15] We considered more detailed age-specific death rates (ASDR) per 100,000 person years and calculated ratios of the age-specific death rates in every age- and population group for men and women. Furthermore standardized mortality ratios (SMR) were calculated. Precision was estimated using 95% confidence intervals (CIs). We also descriptively analyzed leading causes of death contributing to premature mortality based on the main groups of the ICD 10th version. We focused on the ten leading causes of death for premature mortality.

RESULTS

According to our population based calculations, we estimated the proportion of Turkish and FSU immigrants living in Bremen as measured by the number of general population between 2004 and 2010: 5.1% were from the FSU and 7.5% originated from Turkey (see online supplementary table S1). Over the study period 2004-2010, a total of 774 deaths among Turkish immigrants, 1,288 deaths among immigrants from the FSU (see online supplementary table S1) and 52,258 deaths in the general population were identified in the data of the residents' registration office. After record linkage with the BreMI, death certificates were available for 713 deaths among Turkish immigrants and for 1,267 deaths among immigrants from the FSU (see online supplementary table S1) Useful mortality information was retrieved for 706 deaths among Turkish immigrants and for 1,258 immigrants from the FSU. About 50% (N=360) of all deaths among Turkish immigrants, about 25% (N=350) of those among immigrants from the FSU, and about 15% (N=9,759) of those in the general population occurred prematurely. Note that for the general population no missings could be determined, as only the BreMI database was used. Regarding sex specific percentage of prematurely occurred death cases, the relation between males and females is conspicuously in the group of FSU immigrants and of general population compared to Turkish immigrants. (table 1).

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Table 1 Mortality parameters 2004-2010 by sex, population and age group

Mortality parameters	FSU immigrants			Turkish immigrants			General population		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
n overall deaths	656	602	1,258	461	245	706	24,688	27,570	52,258
n premature deaths (%)	251 (38.3)	99 (16.4)	350 (27.8)	233 (50.5)	127 (51.8)	360 (51.0)	6,432 (26.1)	3,327 (12.1)	9,759 (18.7)
Age-standardized premature death rates per 100,000 [95% CI]	214 [187; 241]	76 [60; 91]	140 [125; 155]	178 [154; 203]	94 [77; 111]	136 [121; 150]	273 [266; 279]	142 [137; 147]	207 [203; 211]
Standardized mortality ratios [95% CI]	0.79 [0.69; 0.89]	0.53 [0.43; 0.64]	0.67 [0.61; 0.75]	0.63 [0.55; 0.72]	0.66 [0.55; 0.79]	0.64 [0.58; 0.71]	**General population = 1**		
Age-standardized YPLL rates per 100,000 [95% CI]	4,238 [4,119; 4,358]	1,710 [1,631; 1,789]	5,949 [5,808; 6,089]	2,560 [2,430; 2,581]	1,631 [1,569; 1,693]	4,137 [4,042; 4,233]	3,880 [3,854; 3,907]	2,163 [2,142; 2,184]	6,043 [6,011; 6,076]

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We further calculated age-standardized death rates/100,000, using the ESP for ages 0–64 for both sexes in the different populations. The SDR for premature deaths of the two immigrant population groups were lower compared to the general population. The general population's SDR of 207/100,000, 95% CI [203; 211] was considerably higher compared to those of the immigrants (from Turkey 136/100,000, 95% CI [121; 150] and from the FSU 140/100,000, 95% CI [125; 155]). Regarding sex specific SDRs, men in every population group had higher SDRs as compared to women (table 1). Sex and age-specific death rates (ASDRs) comparing the three populations are provided in Table 2.

Table 2 Age-specific death rates 2004-2010 by sex, population group, per 100,000 person years, up to age 64

Age at death	FSU immigrants		Turkish immigrants		General population	
	Male	Female	Male	Female	Male	Female
	Rate (n, cases of death)					
0-4	129 (9)	43 (3)	126 (22)	151 (25)	136 (133)	111 (101)
5-19	35 (5)	23 (3)	35 (17)	9 (4)	23 (74)	16 (49)
20-34	110 (42)	27 (12)	28 (13)	15 (7)	65 (299)	27 (124)
35-49	346 (75)	130 (33)	117 (52)	40 (14)	269 (1,459)	142 (721)
50-64	560 (120)	192 (48)	725 (129)	382 (77)	1,038 (4,469)	523 (2,332)
n = total	245 (251)	87 (99)	133 (233)	79 (127)	347 (6,434)	184 (3,327)

Comparing males and females, we observed generally higher age-specific death rates among males than among females in all population groups. Detailed analyses of ASDRs in age groups comparing immigrant groups to the general population as well as within immigrant groups showed a general trend towards higher premature mortality among men from the FSU in the age group 20-49 years compared to men from the general population. In the younger age groups, there were increased ASDRs among females from the FSU aged 5-19 years compared to the two other groups. The highest under-five mortality was found among children with Turkish migrant background (table 2) We also calculated ratios for age specific death rates, with the general population as reference (see figure 1). The figure clearly shows the differences as outlined above, but also the similarities mainly regarding under-five child mortality.

Similar to the observations we made for SDRs, the SMRs in both immigrant groups remained significantly below 1, indicating lower premature mortality risks than in the general population (table 1). Differentiating between men and women in every immigrant group, the SMR ranged from 0.53, 95% CI [0.43; 0.64] for women from the FSU to 0.79, 95% CI [0.69; 0.89] for FSU males, with estimates for Turkish migrants between 0.63, 95% CI [0.55, 0.72] (males) and 0.66, 95% CI [0.55, 0.79] (females).

In terms of YPLL, FSU males had the highest age-standardized YPLL rate, while Turkish females had the lowest age-standardized YPLL rate (table 1). In contrast, the age-specific YPLL were the highest among female Turkish migrant children in the age group 0-4 compared to every other sex and population group (table 3).

Insert figure 1 about here

Table 3 Age-specific YPLL per 100,000 for all cases of death for the age at death < 65, between 2004 and 2010 by sex, immigrant- and age group

Age at death	FSU immigrants		Turkish immigrants		General population	
	Male	Female	Male	Female	Male	Female
0-4	8,344	2,800	8,177	9,286	8,831	6,697
5-19	1,734	1,111	1,784	429	1,131	770

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20-34	4,138	1,204	975	566	2,373	1,003
35-49	7,018	2,986	2,642	653	5,705	2,797
50-64	4,799	2,073	3,987	3,014	6,888	3,710
Total	4,840	1,859	2,647	1,667	4,516	2,414

Main causes of death

In each of the population groups, neoplasms and diseases of the circulatory system accounted for over 40% of premature deaths. Generally, the proportions of these two major causes of death contributing to premature mortality in all three population groups were higher among men than women (table 4). We however observed differences in specific causes of death in the three population groups. For example, infant mortality and diseases of the respiratory system were higher among Turkish than among FSU immigrants, and injuries and poisonings as well as mental and behavioral disorders were considerably higher among immigrants from the FSU than in the other two groups. Using the BreMI, we were able to ascertain that the premature deaths coded as injuries and poisonings among men from the FSU were often due to alcoholism, alcohol abuse, smoking, and intoxication.

Table 4 Causes of death contributing to premature mortality between 2004 and 2010 for three population groups; Percentage in relation to the total number of premature death cases

Cause of death *(main groups of the ICD 10)**	FSU immigrants		Turkish immigrants		General population	
	Male	Female	Male	Female	Male	Female
	(%)					
Neoplasms *(C00-D48)*	19.1	10.6	14.2	10.8	19.6	15.1
Diseases of the circulatory system *(I00-I99)*	13.7	4.9	15.6	7.8	14.8	5.6
Mental and behavioral disorders *(F00-F99)*	11.4	1.7	3.3	0.3	7.9	2.1
Injuries, poisonings *(S00-T98)*	12.3	2.0	6.7	0.6	5.3	1.6
Diseases of the digestive system *(K00-K93)*	0.9	2.0	2.2	0.6	3.6	1.9
Diseases of the respiratory system *(J00-J99)*	2.0	0.3	5.3	1.7	3.2	1.9
Certain conditions originating in the perinatal period *(P00-P96)*	2.0	0.9	4.2	3.9	-	-
Certain infectious and parasitic diseases *(A00-B99)*	1.7	1.1	1.7	2.2	2.2	1.2
Endocrine, nutritional and metabolic diseases *(E00-E90)*	0.9	0.9	-	-	1.7	0.6
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified *(R00-R99)*	2.6	0.6	-	-	-	-

* ICD, 10th version

DISCUSSION

In this study, we examined and compared patterns of premature/avoidable mortality among immigrants from Turkey and the FSU to the host population in the federal state of Bremen, Germany. Through the exploration of premature mortality, we aimed to identify specific health problems contributing to premature death, and derive information to identify priority areas in medical care or prevention for migrant populations. We combined different methodological approaches for analyzing premature/avoidable mortality: we selected the age of <65 for analyzing premature deaths and calculated different mortality indicators including years of potential life lost. Additionally, to gain further insight into mortality patterns, we documented the leading causes of death based on the main groups of the ICD 10th version.

When using standardized death rates and mortality ratios to assess premature mortality, we found lower mortality rates of the two immigrant groups compared to in the general population. We did not observe differences in the distribution of the two leading causes of premature mortality: neoplasms and diseases of the circulatory system accounted for over 40% of premature deaths in each of the three population groups.

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The lower mortality among Turkish immigrants compared to the general population could be explained, for example, by the "healthy migrant effect"[5]. Migrant workers tended generally to represent a healthier and younger population and consequently, based on the selection effect, a conditional relatively lower mortality compared to the general population. Moreover, based on data we obtained from the Bremen Residents' Registration office, we assume a certain degree of re-migration of elderly Turkish immigrants in Turkey, possibly leading to reduced premature mortality in this population group.

The "healthy migrant" effect was probably not present among immigrants from the FSU as they did not primarily come to Germany as young workers, but rather as repatriates. The overall lower premature mortality in this population group can possibly be explained by the "social support"[30] provided by the comprehensive social security and insurance system in Germany, which is better compared to the countries of FSU[31-33]. In addition, the immigrants from the FSU benefited from better access to high-quality health care leading to better health.[34, 35] The reason for better health and thus lower mortality compared for example to migrant workers was because immigrants from the FSU were included in the system as ethnic Germans and not as a formerly temporary accepted population.

Only with the indicator of YPLL and when looking at specific causes of death and analyses conducted in specific age groups, were we able to demonstrate that certain subgroups among immigrant groups had higher premature mortality compared to the general population. The indicator of YPLL provides a common denominator for judging the priority to be given with regard to planning and organization of health care or prevention to each cause of mortality in identified risk age groups.[36, 37] For instance, we observed increased years of life lost among Turkish children, especially females, for death at ages between 0-4 years of age. Further analyses showed increased mortality in relation to pregnancy and infant mortality, especially due to extreme immaturity among Turkish immigrants. In terms of setting priorities and thinking about developing migrant-sensitive health systems, one focus could be on strengthening health literacy of mothers. Patients with Turkish migrant background should be informed that for example consanguineous marriages can lead to an increased risk for genetic disorders and infant mortality,[38] and the obstetricians should be able to give qualified information to support early diagnosis to prevent deaths. The setting of health development strategies relating to avoidable mortality and evaluation of their achievement also provides a powerful means of audit.[39]

We observed that compared to Turkish men and those in the general population, men from the FSU lost more years of life if the death occurred between 20 and 50 years. Premature deaths in this population group coded as injuries and poisonings as well as mental and behavioral disorders were often noted as being associated with alcoholism, alcohol abuse, smoking, and intoxication. Our results are, in general, in line with those reported in studies conducted in European countries,[23-25] which highlight life-style related mortality attributable to alcohol consumption, smoking and intoxication. Explicitly focusing on Germany, Deckert et al., suggest that the increased mortality from cardiovascular diseases, external causes of death and suicides and in middle-aged men could reflect detrimental drinking patterns, which are popular in blue-collar working men in Russia.[40, 41] These drinking patterns are associated with cardiomyopathy in young men.[34] The composition of the group of German repatriates changed dramatically between 1990 and 1999, with the majority of the German repatriates being of Russian ethnicity at the end of this period. Theoretically, a large proportion of the German repatriates residing in Bremen from 2004 could also be of Russian ethnicity. There are some theories that the lifestyle of the ethnic Germans in the FSU was completely different to the autochthonous population, hence, in Germany, the higher YPLL might mainly affect the ethnic Russian immigrants.[34, 41] Furthermore, studies originating from the Russian Federation link premature mortality to hazardous alcohol- and nicotine consumption.[42-44] Such findings raise two important questions: (1) whether immigrants from the FSU bring their lifestyle habits along to Germany[35] and keep them over the time after migration; and (2) whether this group can be reached through better health care integration and support for the adoption of a healthier lifestyle?

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With regard to setting priorities in the group of FSU immigrants, sex-specific interventions in this population group to reduce alcohol, nicotine and substance consumption appear to be of importance and individual and community-based interventions need to be explored.

We also observed slightly higher age specific death rates among women from the FSU aged 5 to 19 years compared to other women in this age group. Explanations for this unique mortality reverse: lower overall premature mortality and increased age specific mortality in this population group could include factors associated with transition from childhood to adulthood: alcohol, smoking, violence, drugs, transport accidents etc.[45] Pregnancy and childbirth in adolescence could also pose higher risks for premature mortality.[46]

Our study has several strengths and limitations. To our knowledge, this is the first study that contemporaneously analyzed premature/avoidable mortality among two large immigrant population groups living in Germany. This is also the first study that tested different approaches as well as their combination to identify both immigrant groups in the Residents' Registration office and after that to link personal data to the electronically database BreMI - the unique form to document and monitor mortality on the federal state level.

In this study we touched on the important issue of the availability of data. Mortality data are widely available and easy to obtain in many European countries. The coding of the underlying cause of death according to ICD-10 offers a standardized methodological basis. The epidemiological concept of avoidable mortality has been studied among immigrants in some European studies, e.g. Sweden, the Netherlands and Estonia, using registry linkage.[23-25] For Estonia, Baburin et al. documented the most important preventable causes of death among men as being accidental poisonings, suicide and alcohol-related diseases.[25] For Sweden, Westerling et al. also assumed that observed variations in mortality reflected differences in smoking and alcohol habits.[23] Stirbu et al. assessed mortality in a number of immigrant groups in the Netherlands, including immigrants from Turkey. The study population comprised mainly women and Turkish immigrants had a higher risk of death from maternity-related conditions compared to the native Dutch population.[24] Our own investigations highlight the need for a differentiated epidemiological assessment of premature mortality, and indicate specific risks for particular groups, most notably young and middle-aged men from the FSU. We believe that further investigations in premature mortality for immigrant and ethnic minority groups in Germany and the European region will be useful and informative for epidemiological surveillance and for evidence based interventions. More standardization of methodological approaches will enhance the opportunities for comparisons within and across countries.

Several limitations merit consideration. The population-group specific denominator data for the years 2004–2009 were missing. To calculate them, we used an imputation procedure based on available data for 2010 and data on changes in foreign population numbers. Although this procedure introduces some imprecision, we believe that it does not invalidate the overall findings. Further, the numbers of deaths in specific age-bands and subgroups were small, and thus need to be interpreted with caution. Missing data – ie. missing death certificates were higher among Turkish immigrants (see online supplementary table S1) after record linkage with the Bremen Mortality Index. We argue that this is due to higher re-migration of elderly Turkish immigrants.

A further limitation of this study is the inconsistent usage of methodology for defining of our cohort. We used a name-based algorithm, as developed by Razum and colleagues[28, 29] as well as a combination of different methods, i.e. country of birth and nationality for determination of Turkish immigrants. Onomatology, the science of the origin of names, is a well-established discipline. Humpert and Schneiderheinze[47] described name-based algorithms to identify immigrants in German residence registries in case the place of origin is not available. Degioanni and Darlu used the Bayesian approach for inferring geographical origins of immigrants through surnames.[48] The name-based algorithm, proposed by Razum and colleagues, achieves a specificity of > 99.9%[29] and was successfully applied in our dataset resulting in the identification of about 90% of Turkish immigrants.[9]

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For various reasons, the name-based algorithms do not yield satisfactory results if applied to immigrants from the FSU. Therefore, we used the available information of country of birth, nationality and, place of birth as well as the combination of all three approaches. Currently, this information seems to be sufficient to identify first generation immigrants from the FSU.

Children born in Germany from the early 1990s onward have German citizenship/nationality and hence could not be identified using our search methods. Prospectively, the creation of an identical name-based algorithm in this population group will be of interest. A comprehensive work will be needed to make these individuals recognizable in the national statistics.[9]

The most pronounced limitation in this analysis is the small number of premature deaths: 360 among Turkish immigrants and 350 for those originating from the FSU. This fact may affect the transferability of the results to other federal states. To improve the transferability, similar analyses should be performed in other federal states in Germany. It would be possible in the federal state of Rheinland-Pfalz, where the Data Management System Mortality is well implemented and similar to the BreMI.

Another limitation is the representativeness of the sample. The federal state of Bremen with around 600,000 inhabitants is the smallest federal state in Germany. Due to the political and economic situation in Bremen representativeness for many other issues is also difficult to establish. However, we were able to test and validate the usage of previously disregarded data sources for health research in vulnerable population groups.

Comparing the results obtained in this study, for example, the age-standardized mortality rates for premature deaths before the age of 65, with those from the health monitoring system for population of Bremen, the results are consistent (207 per 100,000 for the 2004 - 2010 period compared to 241 per 100,000 in 2004 and 209 per 100,000 in 2010). The consistency of the results in the general population may provide indications for the validity and transferability to immigrant populations.

CONCLUSION

Our analyses of premature mortality demonstrated differences and similarities between the immigrant and the general population in Bremen, Germany. While the overall trends surprisingly favour the immigrant populations, age and cause-specific results indicate areas where the health care system's responsiveness may need to be improved, including preventive services. Further work with broader databases providing a similar level of differentiation is necessary to substantiate the findings.

CONTRIBUTORS

NM conceptualized the study, its design and methods. She conducted the analyses and presented the results. TB and HP were involved in the conceptualization of methods and statistical analyses. SL was involved in the acquisition, management and interpretation of data. CBK carried out the linkage approach and was partly involved in the data management as well as data interpretation. TB, HP, SL and CBK revised critically the manuscript and approved the final version of the manuscript.

COMPETING INTERESTS

There are no competing interests.

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ETHICAL APPROVAL

All research work with the BreMI follows a specific set of rules and requires clearance by the Bremen Senator for Health. All linkage procedures were done by authorized personnel only, and the study center received an anonymized data set. Under these conditions, no ethical approval was required.

DATA SHARING

No additional data available.

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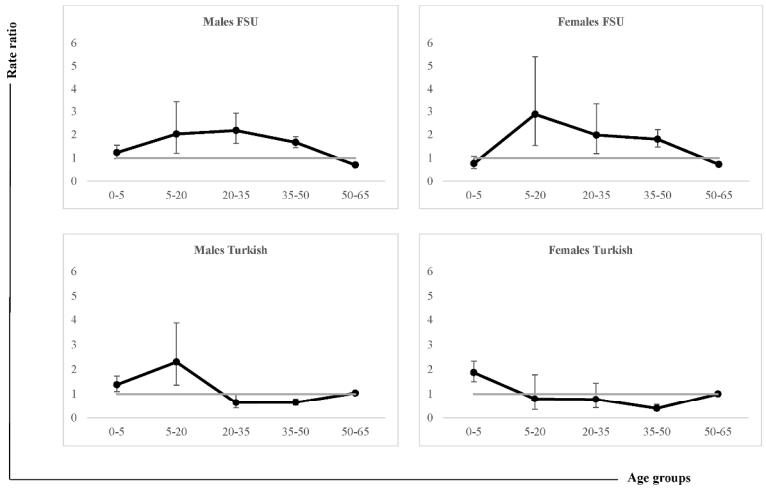
Figure 1 Rate ratios for age-specific death rates 2004-2010 by sex, immigrant group. General population = 1. Error bars denote 95% CI



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Supplementary material

A comparative analysis of premature mortality among urban immigrants in Bremen, Germany: a retrospective register-based linkage study

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Table S1 Population figures among both immigrant groups: from Turkey and the FSU in the federal state of Bremen

Population figures and mortality parameters	Turkish immigrants females	Turkish immigrants males	Turkish immigrants total	FSU immigrants females	FSU immigrants males	FSU immigrants total
n population (% per year measured by general population)						
2004	23,781 (6.95)	27,145 (8.45)	50,887 (7.67)	18,216 (5.33)	16,131 (4.02)	34,423 (5.19)
2005	23,996 (7.02)	26,902 (8.37)	50,874 (7.67)	18,381 (5.37)	15,987 (3.97)	34,414 (5.19)
2006	23,924 (7.0)	26,705 (8.29)	50,609 (7.62)	18,326 (5.36)	15,870 (3.92)	34,235 (5.16)
2007	24,035 (7.04)	26,547 (8.25)	50,571 (7.63)	18,411 (5.40)	15,776 (3.90)	34,209 (5.16)
2008	23,905 (7.03)	26,322 (8.18)	50,218 (7.59)	18,311 (5.38)	15,642 (3.86)	33,971 (5.13)
2009	23,841 (7.02)	26,250 (8.15)	50,082 (7.57)	18,262 (5.38)	15,599 (3.84)	33,879 (5.12)
2010	23,701 (7.0)	25,817 (8.02)	49,518 (7.49)	18,155 (5.36)	15,342 (3.77)	33,497 (5.07)
n deaths per year						
2004	34	60	94	95	88	183
2005	33	54	87	77	92	169
2006	33	60	93	92	105	197
2007	28	71	99	91	85	176
2008	46	81	127	80	110	190
2009	41	77	118	93	95	188
2010	32	63	95	76	88	164
n missing death certificates (%)		**n=61 (8.6)**			**n=21 (1.7)**	
2004		20 (21.3)			10 (5.5)	
2005		12 (13.8)			1 (0.6)	
2006		9 (9.7)			2 (1.0)	
2007		14 (14.1)			8 (4.5)	
2008		2 (1.6)			0	
2009		2 (1.7)			0	
2010		2 (2.1)			0	
n premature deaths per year						
2004	18	31	49	17	37	54
2005	19	32	51	14	40	54
2006	17	43	60	10	38	48
2007	12	34	46	21	33	54
2008	26	39	65	10	33	43
2009	23	27	50	17	38	55
2010	12	27	39	10	32	42

Population figures of the living persons in the federal state of Bremen were extracted from the Residents' Registration office. Figures for the years 2004-2009 are truncated.

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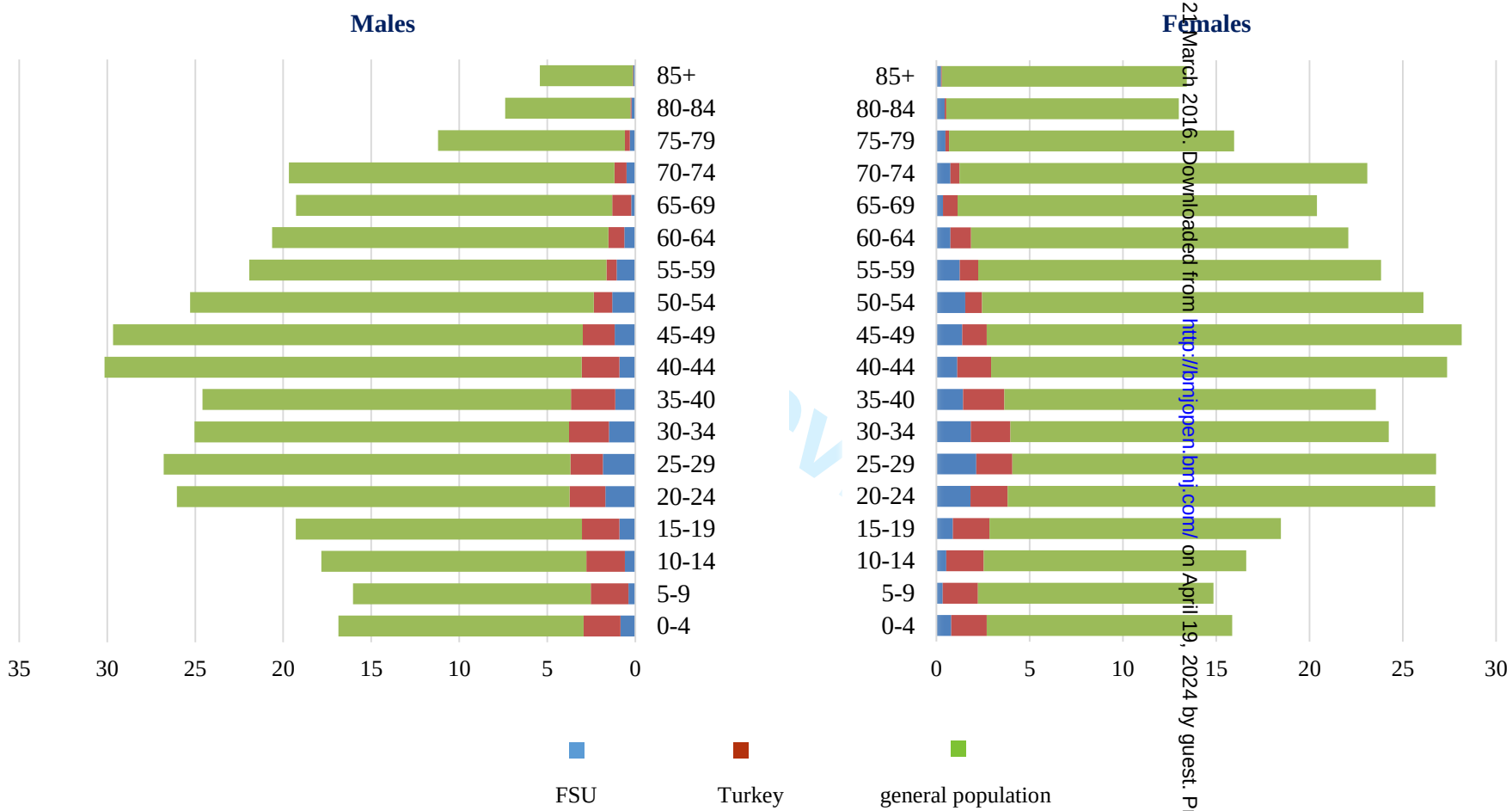
Figure S1: Age pyramid for the population living in the federal state of Bremen divided in immigrants from Turkey, the FSU and the general population



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