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Migration and cardiovascular disease: A comparative study of prevalence and risk factor profiles in resettlers from the German National Cohort (NAKO)

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ABSTRACT

Aims: Resettlers from the former Soviet Union are one of the largest migrant groups in Germany. Previous studies found lower cardiovascular disease (CVD) mortality among resettlers compared to Germans without migration background (autochthonous). Other studies have shown a higher prevalence of CVD risk factors among resettlers, suggesting a higher CVD mortality. The German National Cohort (NAKO) provides an opportunity to explore these discrepancies.

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Methods: This study used baseline data from NAKO and compared age-adjusted percentages of self-reported CVD and associated risk factors between the two groups. Logistic regression models estimated adjusted odds ratios (OR) for associations between resettler status and outcomes.
Results: Among 204,751 participants aged 19–75, 3580 were resettlers and 169,538 autochthonous Germans. Male resettlers had lower odds of risky alcohol consumption (OR: 0.55; 95 %CI: 0.49–0.63) but higher odds of ever smoking (OR: 1.26; 95 %CI: 1.13–1.41) compared to autochthonous German men. Female resettlers showed higher prevalence of hypertension, diabetes mellitus, obesity, and elevated cholesterol/triglycerides, but lower prevalence of risky alcohol consumption and smoking.
In men, the odds of peripheral artery disease (PAD) (OR: 0.46; 95 %CI: 0.21–0.97) and any CVD (OR: 0.81; 95 % CI: 0.66–0.98) were lower among resettlers. No other notable differences in clinical CVDs were observed in men.
Conclusion: Resettlers showed differences regarding CVD risk factor distribution compared to autochthonous Germans. These differences appear to balance out, leading to similar overall CVD prevalence, except for a lower prevalence of PAD and total CVD in male resettlers. Future longitudinal data will allow to explore long-term CVD trajectories.
Lay summary: We compared the prevalence of cardiovascular diseases (CVD) in a special group of migrants (resettlers from the former Soviet Union; German: (Spät-)Aussiedler) and autochthonous Germans, using data from the German National Cohort (NAKO) and investigated risk factors frequencies for these diseases in both groups. We found that male resettlers had less of risky alcohol consumption but smoked more than autochthonous German men. Female resettlers showed higher prevalence of hypertension, diabetes mellitus, obesity, and elevated cholesterol and triglyceride levels, but lower prevalence of risky alcohol consumption and smoking. The prevalence of most CVDs was similar in both groups, except of peripheral artery disease and all CVDs combined which we found less frequent in male resettlers.

Introduction

Cardiovascular diseases (CVD) are the leading cause of morbidity and mortality worldwide, accounting for an estimated 17.9 million deaths each year [1]. Thus, the burden of CVDs is not only a challenge for individual health but also for healthcare systems and global public health strategies [2]. Notably, CVDs are chronic conditions requiring long-term management, placing a major economic burden on the healthcare system and economy [3,4].

With an aging population, Germany faces substantial public health challenges and must respond to the diverse health needs of its residents [5]. However, the prevalence of cardiovascular diseases (CVDs) is not only influenced by age but also by a complex interplay of genetic factors, nutrition, health behaviour, use of healthcare services, and socioeconomic conditions. These factors are not evenly distributed across different subpopulations in Germany. Certain groups may be at higher or lower risk for CVD due to cultural, social, or economic circumstances [6,7]..

Among Germany's diverse population, resettlers are one of the largest migrant subgroups. Also known as "Aussiedler" or ethnic German repatriates, they are a group of individuals of German descent who emigrated from the former Soviet Union and Eastern Europe to Germany [8]. Following World War II, many ethnic Germans were expelled from Eastern European countries as part of post-war retribution. Those who remained often lived as minorities and faced forced resettlement and ethnic discrimination [9]. In the 1950s, the West-German government provided a legal framework for ethnic Germans to claim German citizenship. While the majority of resettlers from Poland and Romania migrated before 1990, the resettler migration from the former Soviet Union peaked in the 1990s due to the collapse of the state in 1990. Today the number of "Aussiedler", "Spätaussiedler" (official German term after 1993) and their family members, who have immigrated to Germany since 1990 from the former Soviet Union stands at about 2.5 million [10]. Given their distinct historical and socio-cultural background as well as their unique migration experience, resettlers differ in their demographic — and presumably also risk factor — profile compared to autochthonous Germans.

Previous research on CVD outcomes among resettlers from the former Soviet Union in Germany yielded conflicting results. A large cohort study in North-Rhine Westphalia, Germany, found CVD mortality to be lower among resettlers than in the general population [11]. Another cohort in the city area of Augsburg, Bavaria, Germany, also showed a lower CVD mortality in male resettlers compared to autochtonuous male Germans, but not in female resettlers [12]. However, the same study, found a higher incidence of acute myocardial infarction in male resettlers. Finally, a study combining three cohorts (from Augsburg, Saarland and North-Rhine Westphalia) with more than 90,000 resettlers confirmed a lower CVD mortality among resettlers compared with the general population, with a standardized mortality ratio for all CVD (ICD-10 codes I00-I99) of 0.84 (95 % confidence interval (CI) 0.79 – 0.89) in women and 0.80 (95 % CI 0.75 – 0.86) in men [13]. These studies were register-based so that a healthy participant bias was unlikely. A smaller study nested into the resettler cohort from North-Rhine Westphalia examined the association of CVD with different CVD risk factors and estimated their prevalence. It showed a higher prevalence of some CVD risk factors such as hypertension or lack of physical activity in resettlers compared to autochthonous Germans, and a lower prevalence for others However, the authors acknowledge several limitations to these findings [14]. A smaller Genome Wide Association Study (GWAS) on resettlers identified some Single Nucleotide Polymorphisms with a different distribution in resettlers compared to autochthonous Germans; however, these differences were unlikely to explain the observed mortality differences [15].

Thus, it remains to be confirmed whether there are differences in risk factors between these two groups. The German National Cohort (NAKO Gesundheitsstudie), as further explained below, may serve as a suitable framework for this task. Furthermore, it is of interest to investigate whether any differences between resettler and autochthonous Germans can be explained by socioeconomic or behavioural cardiovascular risk factors.

The aims of this study are (1) to analyse the prevalence of self-reported CVDs and their associated risk factors in resettlers from the former Soviet Union and autochthonous Germans using cross-sectional data from the NAKO; and (2) to investigate associations between resettler status and CVDs as well as resettler status and risk factors.

Methods

The NAKO study

This present study utilises baseline data from the NAKO, which is a large-scale, long-term cohort study designed to investigate the causes, predictive factors, (pre-)clinical markers and functional health impairments and underlying common chronic diseases, including CVD, cancer,

diabetes, neurodegenerative/-psychiatric disorders, respiratory, and infectious diseases in Germany [16,17]. Participants were randomly selected from population registries of the study regions covered by 18 study centres, located in different federal states. Baseline recruitment took place from 2014 to 2019 and included 204,751 participants with permanent residence aged between 19 and 75 years at the time of recruitment. The selectiom criteria are represented in the CONSORT Diagramm 1.

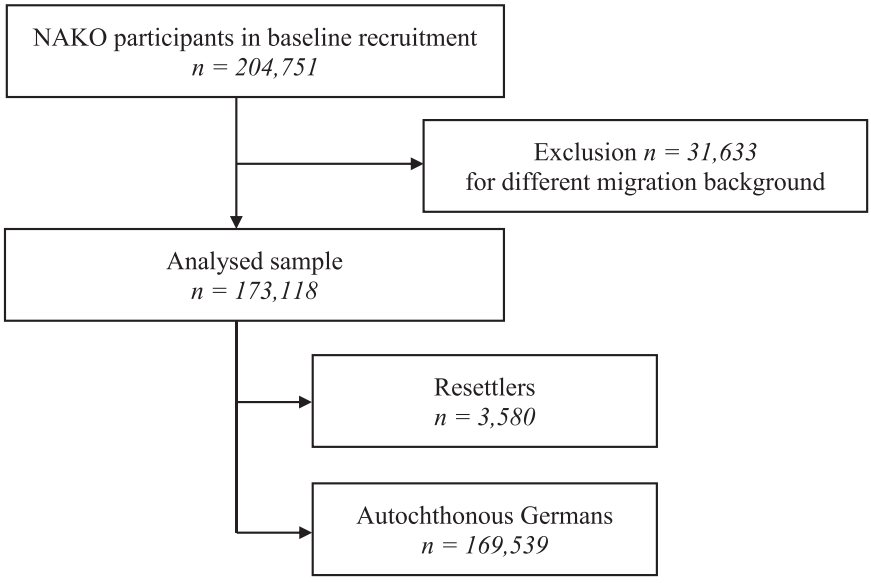

Diagramm. 1. CONSORT Diagramm representing selection criteria.

Written informed consent was obtained from all participants. The NAKO has obtained approval from the relevant ethics committees of the study centres and complies with national law and with the Declaration of Helsinki of 1975 (in the current, revised version). A detailed description of the study design and general results of the baseline examinations has been published elsewhere [18,19].

Information on sociodemographic variables, CVDs and cardiovascular risk factors was obtained through interviews, self-administered questionnaires, and physical examinations. A series of questions were included in the interview to identify migrant status. Resettlers from the former Soviet Union were defined as participants who were born in a country that was formerly part of the Soviet Union, specifically from Russia, Ukraine, Kazakhstan, and Belarus [20]. In total, the NAKO baseline comprised 169,538 autochthonous Germans and 3580 resettlers, as well as 31,633 individuals with other migrant backgrounds that were not included in the present analysis.

Variables

Covariates used in the analysis included demographic data on sex, age, marital status, education (International Standard Classification of Education (ISCED)97 educational level) and profession (ISCO – Codes). These covariates were chosen as they are important social determinants of CVD, possibly correlated with some risk factors and are therefore potential confounders. Age and sex are well-established risk factors for CVD. Marital status has been associated with differences in health behaviors Manfredini at al. [21]. Education and profession were included as they may reflect differences in lifestyle and act as an indicator of socioeconomic position Galobardes et al. [22].

For marital status, the study population was categorized into single, married living together, married living separate, divorced and widowed. The educational level is defined as the highest level of education attained, classified using the ISCED-97. We use the same classification into three categories as in Vonneilich et al. [23]. In cases where ISCED-97 data were missing, we used occupational information based on International Standard Classification of Occupations minor codes as a surrogate for educational level and assigned individuals to ISCED categories. Occupation codes 900 and higher (elementary occupations) were assigned low ISCED level, codes 100–299 (managerial and academic occupations were assigned high ISCED level, all other codes were assigned medium ISCED level. This reduced the percentage of missing values from 6.49 % to 0.4 %.

The main outcome variables in this study were self-reported CVDs and cardiovascular risk factors. CVDs were measured by self-reported information about the lifetime prevalence of CVDs according to the question: “Have you ever been diagnosed by a doctor with any of the following cardiovascular diseases: myocardial infarction, angina pectoris, heart failure, cardiac arrythmia, and peripheral artery disease.”

Additionally, the following cardiovascular risk factors were assessed based on self-reported information in the interview: hypertension, diabetes mellitus, ever smoking, risky alcohol consumption, and high cholesterol/triglyceride levels. Ever smoking was assessed using the self-reported smoking history of the participant in the self-administerd questionnaire (answers: “I have never smoked”, “I have previously smoked”, “I am currently a smoker”). Obesity was defined as a body mass index of 30 and above, calculated as the measured weight (in rare cases reported weight) in kilograms divided by the square of their measured height in meters (kg/m^2) [24]. Alcohol consumption was assessed according to the self-reported alcohol consumption of various alcoholic beverages and calculating the Alcohol Use Disorders Identification Test (AUDIT-C) score. Alcohol consumption was considered risky if the AUDIT-C score was greater than four for men and greater than three for women [25]. Risky alcohol consumption corresponds to a regular intake of more than 40–50 g of alcohol per occasion for men and 30–40 g for women.

Diabetes and high cholesterol/triglyceride levels were assessed in the personal interview with the question “Have you ever been diagnosed by a doctor with any of the following metabolic diseases?” In addition to the medical terms, the colloquial terms were also used.

Statistical analysis

Descriptive statistics included frequencies with percentages for categorical variables and means with standard deviations (SD) for

continuous variables. Prevalences for CVDs and risk factors were analysed by resettler status and sex. As in the study the resettlers were on average younger than the autochtonuous Germans, direct age standardization was used to adjust prevalences among resettlers using the age distribution of the autochthonous Germans in the study as the reference population. 95 % confidence intervals (CI) of the age-standardized prevalences were calculated according to method proposed by Consonni et al. [26]. It uses an approach based on a gamma distribution, which provides reliable estimates of the interval, especially for smaller sample sizes. Logistic regression analyses separate by sex were used to estimate the association between resettler status and each CVD, and we additionally considered the combined outcome "any CVD".

For each outcome, three regression models were set up: Model 1 adjusted for age to account for the younger average age of resettlers. In Model 2 we additionally adjusted for education to examine whether any differences between resettlers and autochthonous Germans remain after adjustment for education. Model 3 additionally included cardiovascular risk factors (hypertension, diabetes mellitus, high cholesterol and triglyceride levels, ever smoking, risky alcohol consumption) to assess whether differences in CVD between the two population groups remain after adjustment for all these established risk factors. Models 1 and 2 were also fitted with the above risk factors as dependent variables to investigate their associations with resettler status. Statistical significance was defined as $p < 0.05$.

A complete case analysis was conducted using the statistical software package Stata/SE 17.0. Percentages of missing values are reported in the descriptive tables where applicable.

Results

Descriptive statistics

Table 1 shows the sociodemographic characteristics of the study sample. The table is stratified by resettler status and sex. For both sexes, resettlers were on average younger than autochthonous Germans, and a higher proportion was married or living together with a partner (72.1 % in men and 61.8 % in women). Resettlers had lower educational attainment on average, with fewer holding university degrees or doctorates compared to autochthonous Germans at the time of recruitment. A higher number of resettlers completed lower secondary or vocational education, with a slightly higher proportion still in vocational training compared to autochthonous Germans.

The prevalence of self-reported CVDs varies across sex and resettler status. Table 2 shows the age-standardized prevalences of CVD for resettlers and autochthonous Germans. The data are visualized in Fig. 1.

For most CVDs, there were no major differences between resettlers and autochthonous Germans. However, angina pectoris was more prevalent in female resettlers (1.9; 95 % CI: 1.3 – 2.6) compared to autochtonous German women (1.3; 95 % CI: 1.2 – 1.4), while no such difference was observed for men. Additionally, for peripheral artery disease a lower prevalence was evident in male resettlers (0.9; 95 % CI: 0.4 – 1.5) compared to their autochthonous German counterparts (2.2; 95 % CI: 2.1 – 2.3). This difference was less pronounced in women. The results for "any CVD" showed similar prevalences for both sexes among resettlers and autochtonuous Germans.

Table 3 compares prevalences of CVD risk factors in resettlers and autochthonous Germans by sex. No differences were found in men for hypertension, diabetes mellitus or high cholesterol and triglyceride levels. However, male resettlers reported a higher prevalence of ever smoking (62.3 % vs. 58.3 %; $p < 0.001$) but a lower prevalence of risky alcohol consumption (24.9 % vs. 41.2 %; $p < 0.001$).

In women, differences were seen for all observed cardiovascular risk factors. Female resettlers had a higher prevalence of self-reported hypertension (30.7 % vs. 24.8 %; $p < 0.001$), diabetes mellitus (7.9 % vs. 5.2 %; $p < 0.001$), high cholesterol and triglyceride levels (26.9 % vs. 22.1 %; $p < 0.001$) and obesity (30.6 % vs. 22.5 %, $p < 0.001$). Lifestyle factors such as ever smoking and risky alcohol consumption were less prevalent in female resettlers compared to autochthonous women.

Table 1
Sociodemographic characteristics of the study sample NAKO study, Germany.

	Men (N = 85,595)		Women (N = 87,523)	
	Resettlers N = 1565 (1.8)	Autochthonous Germans N = 84,030 (98.2)	Resettlers N = 2015 (2.3)	Autochthonous Germans N = 85,508 (97.7)
Sociodemographic Characteristics				
Age (years) (mean ± SD)	46.3 ± 12.8	50.2 ± 12.8	47.5 ± 12.4	50.1 ± 12.7
Marital Status (N, (%))				
single	304 (19.4)	24,201 (28.8)	317 (15.7)	22,421 (26.2)
married / living together	1129 (72.1)	50,186 (59.7)	1245 (61.8)	47,283 (55.3)
married but living separated / divorced	120 (7.7)	8583 (10.2)	336 (16.7)	12,043 (14.1)
widowed	12 (0.8)	1041 (1.2)	117 (5.8)	3741 (4.4)
Missing values	0 (0)	19 (0)	0 (0)	20 (0)
Highest Level of Completed Education (N, (%))				
Low Education level < 10 years	108 (6.9)	1040(1.2)	115 (5.7)	2140 (2.5)
Medium Education level 10–15 years[+ #]	710 (45.4)	33,938 (40.4)	912 (45.3)	42,431 (49.6)
High Education level > 15 years[§]	739 (47.2)	48,795 (58,1)	971 (48.2)	40,664 (47.6)
Missing values	8 (0.5)	257 (0.3)	17 (0.8)	273(0.3)

Values in () are in percent
SD – standard deviation
+ e.g., apprenticeship, technical school, vocational academy
# e.g. Fachhochschulreife/Abitur + professional qualification
§ e.g. Bachelor, Master, Diploma

Table 4 presents the adjusted odds ratios (aORs) for the association between the resettler status and different self-reported clinical CVD outcomes, adjusted for age only (model 1), for age and highest attained educational level (model 2) and fully adjusted for age, highest attained educational level and CVD risk factors (model 3).

Across all three models, the regression analysis revealed no relevant associations between resettler status and CVDs, except for peripheral artery disease in men (Model 3: aOR 0.36; 95 % CI: 0.16 – 0.82) and women (Model 3: aOR 0.45; 95 % CI: 0.23 – 0.87) and for any CVD in men (Model 3: aOR 0.77; 95 % CI: 0.63 – 0.95). Generally, aORs tend towards stronger ~~risk~~ reduction from model 1 to model 3 in both men and women for most diseases. For peripheral artery disease the model 1 aOR decreased from 0.54 (95 % CI: 0.32 – 0.93) to aOR 0.36 (95 % CI: 0.16 – 0.82) in men. The same pattern was observable in women where the aOR decreased from 0.76 (95 % CI: 0.49 – 1.19) in model 1 to aOR 0.45 (95 % CI: 0.23 – 0.87) in model 3, indicating a strengthening in association for both sexes after adjusting for additional covariates.

The aOR estimates for the CVDs with risk factors considered (model 3) are shown in the appendix *Table A.1 and A.2*. We also present the results of a joint model 3 with males and females combined.

The results from the logisitc regression assessing the association between resettler status and cardiovascular risk factors are shown in Table 5.

Table 2
Lifetime prevalences of CVDs by resettler status and sex, NAKO Study, Germany.

Disease*		Men			Women		
		Resettlers *N = 1565*	Autochthonous Germans *N = 84,030*	p$	Resettlers *N = 2015*	Autochthonous Germans *N = 85,508*	p$
Myocardial Infarction	N	37	2324	0.34	13	539	0.34
	Prevalence§	3.5	2.8		0.8	0.6	
	95 %CI	2.4 – 4.5	2.7– 2.9		0.4– 1.2	0.6 – 0.7	
Angina Pectoris	N	45	3272	0.94	32	1124	0.01
	Prevalence	4.2	3.9		1.9	1.3	
	95 %CI	3.0 – 5.4	3.8 – 4.1		1.3 – 2.6	1.2 – 1.4	
Heart failure	N	31	2586	0.30	36	1861	0.94
	Prevalence§	2.7	3.1		2.3	2.2	
	95 %CI	1.7 – 3.7	3.0 – 3.2		1.5 – 3.0	2.1 – 2.3	
Cardiac Arrythmia	N	100	7633	0.09	156	8243	0.14
	Prevalence§	7.9	9.1		8.5	9.7	
	95 %CI	6.3 – 9.4	9.0 – 9.3		7.2 – 9.8	9.5 – 9.9	
Peripheral artery disease	N	14	1848	0.03	20	1332	0.23
	Prevalence§	0.9	2.2		1.2	1.6	
	95 %CI	0.4 – 1.5	2.1 – 2.3		0.7 – 1.7	1.5 – 1.7	
Any CVD	N	194	13,497	0.39	276	11,823	0.07
	Prevalence§	15.5	16.1		15.1	13.8	
	95 %CI	13.5 – 17.5	15.8 – 16.3		13.5 – 16.7	13.6 – 14.1	

* self-reported (see text)
§ in percent, in resettlers standardized to the age distribution of autochthonous Germans
$ obtained from logistic models adjusted for age

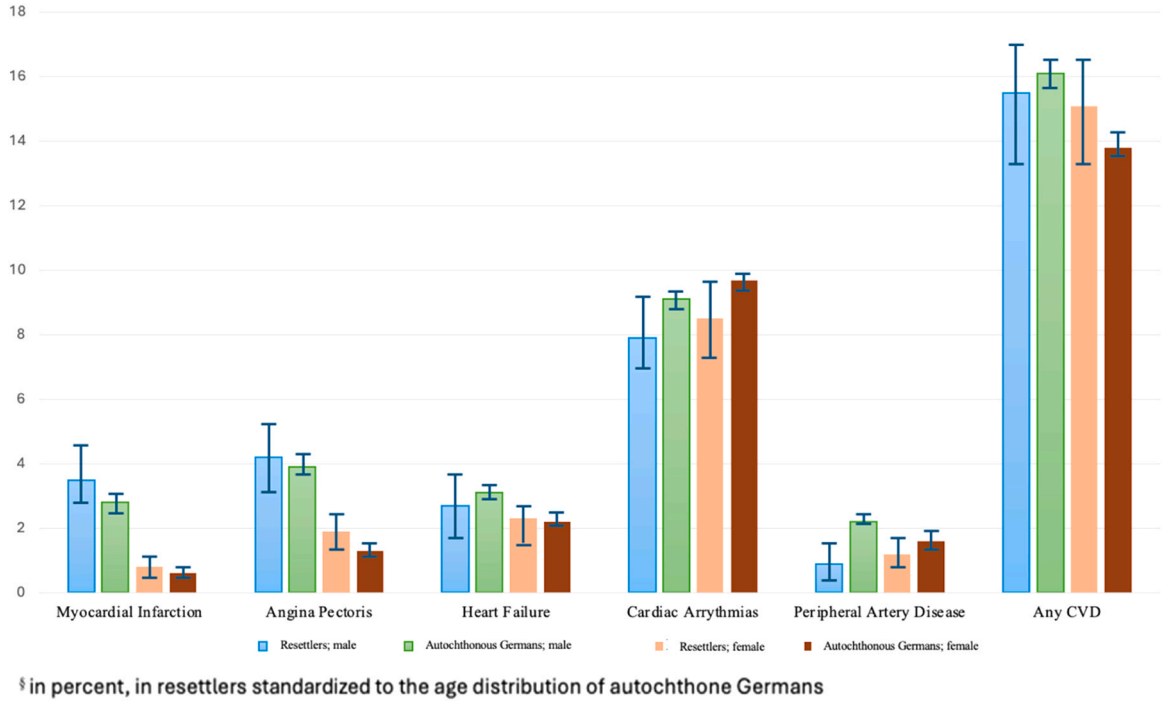

Fig. 1. Lifetime prevalence of cardiovascular diseases by resettler status and sex. Age-standardised prevalence of self-reported cardiovascular diseases (CVDs) from the NAKO study in male and female resettlers and autochthonous Germans. Diseases included in this figure: myocardial infarction, angina pectoris, heart failure, cardiac arrhythmias, peripheral artery disease and any CVD.

The results of model 1 in Table 5 parallel the prevalence patterns in Table 3, showing that female resettlers have a higher burden than autochtonous Germans for four of the six cardiovascular risk factors considered, and a lower burden for the other two. Male resettlers differ to a lesser extent from autochthonous Germans, with major differences being observed for smoking, which is more prevalent, and for risky alcohol consumption, which is less prevalent.

Comparing Model 1 and Model 2 revealed changes in adjusted odds ratios, indicating that educational differences may partly explain the observed disparities in cardiovascular risk factors.

Discussion

This study analysed the prevalence of CVDs and associated risk factors in resettlers and autochthonous Germans using NAKO data. Overall, only small differences were observed for most CVDs, with the exception of a higher prevalence of self-reported angina pectoris in female resettlers and a lower prevalence of peripheral artery disease in male resettlers. These results are not in line with previous studies suggesting lower incidence, prevalence and mortality of CVDs among resettlers compared to autochthonous Germans. Multiple large-scale retrospective cohort

Table 3
Prevalence of CVD risk factors by resettler status and sex.

Risk Factor		Men			Women		
		Resettlers *N = 1565*	Autochthonous Germans *N = 84,030*	p$	Resettlers *N = 2015*	Autochthonous Germans *N = 85,508*	p$
Hypertension	N	425	26,491	0.229	521	21,124	< 0.001
	Prevalence§	32.9	31.6		30.7	24.8	
	95 % CI	30.4 – 35.4	31.4 – 31.9		28.7 – 32.7	24.5 – 25.0	
Diabetes Mellitus	N	71	5545	0.439	142	4400	< 0.001
	Prevalence	5.8	6.6		7.9	5.2	
	95 % CI	4.5 – 7.2	6.5 – 6.8		6.6 – 9.1	5.0 – 5.3	
High cholesterol/ triglyceride levels	N	321	21,316	0.737	458	18,771	< 0.001
	Prevalence§	24.6	25.6		26.9	22.1	
	95 % CI	22.3 – 27.0	25.4 – 26.0		24.9 – 28.9	21.9 – 22.4	
Ever smoking&	N	877	47,760	< 0.001	575	41,452	< 0.001
	Prevalence§	62.3	58.3		28.1	50.1	
	95 % CI	59.4 – 65.1	58.1 – 58.7		26.1 – 30.2	49.7 – 50.4	
Risky alcohol consumption**	N	389	33,567	< 0.001	297	27,241	< 0.001
	Prevalence§	24.9	41.2		15.2	33.0	
	95 % CI	22.5 – 27.4	40.8 – 41.5		13.6 – 16.9	32.7 – 33.3	
Obesity (≥ 30 kg/m²)	N	377	20,363	0.052	564	19,252	< 0.001
	Prevalence§	26.3	24.2		30.6	22.5	
	95 % CI	23.9 – 28.7	24.0 – 24.5		28.6 – 32.7	22.2 – 22.8	

* self-reported (see text)
** AUDIT-C score > 4 (men) or > 3 (women)
§ in percent, prevalence of resettlers standardized to the age distribution of autochthonous Germans
$ As obtained from the logistic model adjusted for age
& more than 100 cigarettes lifelong

Table 4
Association of resettlers compared to autochthonous Germans with CVD based on logistic regression analysis.

Disease*	Men			Women		
	Model 1[a] aOR 95 % CI	Model 2[b] aOR 95 % CI	Model 3[c] aOR 95 % CI	Model 1[a] aOR 95 % CI	Model 2[b] aOR 95 % CI	Model 3[c] aOR 95 % CI
Myocardial Infarction	1.18 0.84 – 1.65	1.06 0.81 – 1.66	1.07 0.69 –1.67	1.31 0.75 – 2.29	1.07 0.58 – 1.97	1.30 0.66 – 2.56
Angina Pectoris	1.01 0.75 – 1.37	0.84 0.59 – 1.19	0.77 0.50 – 1.19	1.58 1.10 – 2.26	1.24 0.82 – 1.87	1.08 0.66 – 1.79
Heart Failure	0.83 0.58 – 1.19	0.69 0.46 – 1.05	0.77 0.49 – 1.21	0.99 0.71 – 1.38	0.95 0.66 – 1.37	0.71 0.44 – 1.12
Cardiac Arrythmias	0.84 0.68 – 1.03	0.79 0.63 – 1.0	0.80 0.62 – 1.02	0.88 0.75 – 1.04	0.91 0.76 – 1.10	0.88 0.72 – 1.07
Peripheral artery disease	0.54 0.32 – 0.93	0.36 0.18 – 0.69	0.36 0.16 – 0.82	0.76 0.49 – 1.19	0.61 0.37 – 1.0	0.45 0.23 – 0.87
Any CVD	0.93 0.80 – 1.09	0.82 0.69 – 0.98	0.77 0.63 – 0.95	1.13 0.99 – 1.29	1.06 0.92 – 1.23	0.95 0.80 – 1.12

* self-reported (see text)
[a] adjusted for age
[b] adjusted for age and ISCED 97 level (3 categories)
[c] adjusted for age, ISCED 97 level, hypertension, diabetes mellitus, high cholesterol and triglyceride levels, ever smoking, risky alcohol consumption, and obesity

Table 5
Association between resettler status and cardiovascular risk factors in the NAKO study-baseline assessment.

Risk factor*	Men		Women	
	Model 1[a] aOR 95 % CI	Model 2[b] aOR 95 % CI	Model 1[a] aOR 95 % CI	Model 2[b] aOR 95 % CI
Hypertension	1.08 0.95 – 1.22	0.99 0.87 – 1.13	1.37 1.23 – 1.53	1.23 1.09 – 1.39
Diabetes mellitus	0.91 0.71 – 1.16	0.82 0.63 – 1.07	1.61 1.35 – 1.92	1.34 1.10 – 1.62
High cholesterol/ triglyceride levels	0.98 0.86 – 1.11	0.97 0.85 – 1.12	1.30 1.17 – 1.46	1.26 1.11 – 1.43
Ever smoking	1.32 1.19 – 1.48	1.16 1.03 – 1.31	0.48 0.43 – 0.53	0.45 0.41 – 0.51
Risky alcohol consumption	0.55 0.48 – 0.61	0.54 0.48 – 0.62	0.39 0.34 – 0.44	0.40 0.34 – 0.45
Obesity	1.12 1.00 – 1.27	1.04 0.91 – 1.18	1.46 1.32 – 1.62	1.28 1.15 – 1.43

* self-reported (see text)
[a] adjusted for age
[b] adjusted for age and education (ISCED-97 level)

studies have found standardized mortality ratios (SMRs) consistently below 1.0 for both sexes in resettlers (inlcuding Ronellenfitsch et al., 2006: SMR 0.79; Winkler et al., 2019: women SMR 0.84, men SMR 0.80) [13,12,11].

However, the sex differences observed underscore unique patterns that have not been fully explored in the existing literature.

Male resettlers reported a higher prevalence of ever smoking, but lower risky alcohol consumption, compared to autochthonous German men. The former aligns with reported behaviours in the former Soviet Union populations, where smoking was particularly prevalent among men [27,28]. This risk profile may suggest that some pre-migration health behaviours persist after migration and influence long-term health outcomes, but available data from the former Soviet Union do not report by population groups.

In contrast, female resettlers had a higher odds of self-reported CVD risk factors such as hypertension, diabetes mellitus and high cholesterol and triglyceride levels and obesity, but lower odds of ever smoking compared to German women. The dietary and lifestyle changes associated with migration, including acculturation to a new diet, may play a significant role in these differences [29]. Our findings in female

resettlers are consistent with those of Morbach et al. [30] who found individuals with a migration background in Germany to exhibit a higher prevalence of metabolic syndrome, compared to the general German population. Accordingly, female resettlers had higher aORs for multiple cardiovascular risk factors, suggesting that metabolic risks disproportionately affect them.

These sex-specific health and risk factor profiles reflect the complex interplay of migration, acculturation and cultural inequities. While the "healthy migrant effect" [31] has been widely discussed, its relevance to resettlers might be limited due to their protected migration experience. Rather than benefiting from a strong health advantage upon arrival, resettlers, particularly women, appear to face increased metabolic risks post-migration. In contrast, male resettlers seem to retain some protective pre-migration behaviours, such as lower alcohol consumption. Social determinants, including healthcare access, political and social inequalities, and cultural barriers, likely contribute to the increased health risks observed in women [32].

Adjustment for highest attained educational level in our models substantially altered the observed associations between resettler status and CVDs or cardiovascular risk factors. This suggests that differences in educational attainment, as a key component of socioeconomic status, may partly explain the higher burden of cardiovascular conditions observed among resettlers compared to autochthonous Germans.

Strengths and limitations

This study has several strengths. The NAKO is the largest study to date to compare the prevalence of risk factors and CVD between resettlers and autochthonous Germans. This study benefits from high-quality data. The proportion of resettlers from the Soviet Union in the study population is similar to its proportion in the total German population. Therefore, differential response between both groups seems unlikely. The methodological approach with direct standardization and multivariable regression models allowed for important comparisons between resettlers and autochthonous Germans while controlling for potential confounders. Sex-specific analyses of this study provide insights into differences in health outcomes and risk factors, addressing an important gap in the literature. The focus on the resettler population, a migrant subgroup with unique demographic and health characteristics, adds valuable information about the cardiovascular health of this underresearched population.

However, several limitations should be acknowledged. The NAKO study population may not fully represent the broader population due to differences between those who chose to participate and those who did not [33]. Individuals who opted to join the NAKO might have specific characteristics, such as better overall health and higher SES, compared to non-participants. This introduces the potential for selection bias, where healthier individuals are overrepresented. As a result, the actual prevalence of certain risk factors within the general population might be higher than what the study findings suggest. It is important to note, however, that this limitation is probably not unique to one group and applies to both resettlers and autochthonous Germans included in the study.

The reliance on self-reported data for key variables, such as CVDs and behavioural risk factors is an important limitation as it introduces the potential for reporting bias. Furthermore, the self-reported data on smoking behaviour and alcohol consumption is prone to recall bias and a social desirability bias, which can result in inaccurate reporting of health behaviours and conditions, leading to a distortion of the study results if there is a differential bias between resettlers and autochthonous Germans.

It is also important to acknowledge that most CVD diagnoses rely on healthcare utilisation and doctor visits, which may introduce bias into self-reported prevalence estimates. Access to healthcare, health literacy, and cultural perceptions of illness may influence whether individuals seek medical attention and receive a formal diagnosis. If resettlers experience barriers to healthcare or differences in symptom recognition, certain conditions may be under- or over-reported. Consequently, the observed prevalence patterns may reflect not only the true disease burden but also differences in healthcare engagement between resettlers and autochthonous Germans.

Although we adjusted for several confounders in the regression model, there may be other confounding or mediating factors that we could not account for. These include genetic predisposition, psychological stressors, environmental conditions and access to healthcare, which were not available in the dataset.

Furthermore, the classification of migration background in broad categories (resettlers; autochthonous Germans) might overlook heterogeneity within these groups. Differences in country of origin, migration history and duration of stay may lead to different health outcomes, which could shape specific health behaviours and lifestyle choices. These are not limited to migration background, but could also be shaped by living conditions and place of residence.

Another methodological limitation is the use of occupational information for assigning ISCED-97 level in cases of missing data. This can introduce misclassification, as occupation is not always a reliable indicator of educational attainment.As for the multivariate logistic regression models, collinearity between included variables was not formally assessed. This may lead to a destabilized model, especially for models including all risk factors simultaneously and thus make the interpretation of individual risk factors less reliable.

Given the cross-sectional nature of the data, we cannot make any statements on the temporal sequence of risk factors and disease and certainly not about causality.

Finally, future longitudinal investigations will be necessary to validate our findings and explore the long-term cardiovascular health outcomes for resettlers.

Conclusion

This study addresses critical gaps in the literature on the cardiovascular health of resettlers in Germany and highlights important sex-specific differences. Both male and female resettlers exhibited distinct patterns of cardiovascular risk factors compared to autochthonous Germans. Overall, the various differences in the risk factor distributions roughly balance each other out, resulting in similar frequencies of most CVDs, except for a lower prevalence of peripheral artery disease and any CVD in male resettlers. These findings suggest that the previously reported lower CVD mortality among resettlers may not be fully explained by differences in the analyzed risk factors.

CRediT authorship contribution statement

Marvin Reuter: Writing – review & editing. **Ilais Moreno Velásquez:** Writing – review & editing. **Börge Schmidt:** Writing – review & editing, Investigation. **Kerstin Wirkner:** Writing – review & editing, Investigation. **Henry Völzke:** Writing – review & editing, Investigation. **Till Bärnighausen:** Writing – review & editing. **Glenna Walther:** Writing – review & editing, Writing – original draft, Visualization, Software, Investigation, Formal analysis, Data curation. **Hajo Zeeb:** Writing – review & editing, Investigation. **Lena Koch-Gallenkamp:** Writing – review & editing, Investigation. **Nico Dragano:** Writing – review & editing. **Beate Fischer:** Writing – review & editing, Investigation. **Tilman Brand:** Writing – review & editing. **Amand Führer:** Writing – review & editing. **Volker Harth:** Writing – review & editing. **Claudia Meinke-Franze:** Writing – review & editing, Investigation. **Karin Halina Greiser:** Writing – review & editing, Investigation. **Volker Winkler:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Heiko Becher:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Kiekert Jasmin:** Writing – review & editing. **Olga**

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendices

Table A.1
Results of the logistic regression with CVDs as dependent variables, full model (model 3), men

	aOR (95 % CI)					
	Acute myocardial infarction	Angina Pectoris	Heart Failure	Cardiac Arrythmias	Vascular disease	Any CVD
Resettler status	1.08 (0.69 – 1.67)	0.77 (0.50 – 1.19)	0.77 (0.49 – 1.21)	0.80 (0.62 – 1.03)	0.36 (0.16– 0.82)	0.77 (0.63 – 0.95)
Age (in years/10)	2.22 (2.08 – 2.36)	2.30 (2.18 – 2.43)	1.59 (1.51 – 1.68)	1.51 (1.47 – 1.54)	2.15 (2.01 – 2.31)	1.65 (1.61 – 1.69)
ISCED Educational Level	1.33	1.41	1.33	0.83	3.17	1.11
Low vs. high	(1.01– 1.74)	(1.12 – 1.78)	(1.04 – 1.70)	(0.71 – 0.98)	(2.47 – 4.08)	(0.98 – 1.25)
Medium vs. high	1.22 (1.1 – 1.35)	1.28 (1.17 – 1.40)	1.17 (1.06 – 1.29)	0.94 (0.89 – 1.0)	1.76 (1.55 – 1.99)	1.09 (1.05 – 1.15)
Hypertension	1.75 (1.57 – 1.94)	2.41 (2.20 – 2.66)	2.33 (2.11 – 2.59)	1.70 (1.61 – 1.80)	1.47 (1.30 – 1.66)	1.86 (1.78 – 1.95)
Ever smoking	2.12 (1.89 – 2.38)	1.75 (1.59 – 1.93)	1.19 (1.08 – 1.32)	1.12 (1.06 – 1.18)	2.39 (2.08 – 2.75)	1.31 (1.25 – 1.37)
Obesity (BMI > 30)	1.37 (1.23 – 1.51)	1.18 (1.08 – 1.28)	1.40 (1.27 – 1.54)	1.15 (1.08 – 1.22)	1.42 (1.27 – 1.59)	1.20 (1.14–1.26)
Risky alcohol consumption	0.61 (0.55 – 0.68)	0.68 (0.63 – 0.74)	0.71 (0.65 – 0.78)	0.91 (0.86 – 0.96)	0.91 (0.82 – 1.02)	0.85 (0.82 – 0.89)
High cholesterol and triglyceride levels	3.40 (3.07–3.77)	3.53 (3.24 – 3.86)	1.83 (1.66 – 2.01)	1.32 (1.25 – 1.40)	1.68 (1.50 – 1.88)	1.74 (1.67 – 1.82)
Diabetes mellitus	1.50 (1.33 – 1.69)	1.52 (1.37 – 1.69)	1.54 (1.37 – 1.74)	1.11 (1.02 – 1.21)	2.15 (1.88 – 2.45)	1.44 (1.34 – 1.54)

Table A.2
Results of the logistic regression with CVDs as dependent variables full model (model 3), women

	OR (95 % CI)					
	Acute myocardial infarction	Angina pectoris	Heart failure	Cardiac Arrythmias	Vascular Diseases	Any CVD
Resettler status	1.30 (0.66 – 2.56)	1.08 (0.66 – 1.79)	0.71 (0.44 – 1.12)	0.88 (0.72 – 1.07)	0.45 (0.23 – 0.87)	0.95 (0.80 – 1.12)
Age (in years/10)	2.05 (1.79 – 2.34)	1.96 (1.79 – 2.15)	1.54 (1.45 – 1.63)	1.32 (1.29 – 1.36)	1.62 (1.51 – 1.73)	1.39 (1.36 – 1.42)
ISCED Education level	2.25	1.77	1.07	1.01	2.28	1.18
- Low vs. high	(1.48 – 3.42)	(1.32 – 2.82)	(0.83 – 1.38)	(0.87 – 1.16)	(1.74 – 2. 99))	(1.05– 1.33)
-Medium vs. high	1.46 (1.13 – 1.90)	1.19 (1.01 – 1.41)	1.02 (0.90 – 1.15)	1.02 (0.96 – 1.07)	1.44 (1.23 – 1.68)	1.05 (1.0 – 1. 10)
Hypertension	2.48 (1.98 – 3.12)	3.19 (2.72 – 3.74)	2.51 (2.23 – 2.82)	1.68 (1.58 – 1.78)	1.61 (1.41 – 1.85)	1.86 (1.77 – 1.95)
Ever smoking	2.06 (1.67 – 2.53)	1.50 (1.30 – 1.72)	1.14 (1.03 – 1.27)	1.15 (1.09 – 1.21)	1.51 (1.33 – 1.71)	1.22 (1.17 – 1.28)
Obesity (BMI > 30)	1.46 (1.18 – 1.79)	1.17 (1.01 – 1.35)	1.30 (1.16 – 1.46)	1.01 (0.96 – 1.08)	1.74 (1.52 – 1.99)	1.10 (1.04 – 1.16)
Risky alcohol consumption	0.68 (0.53 – 0.87)	0.72 (0.61–0.85)	0.78 (0.69 – 0.88)	0.90 (0.85 – 0.95)	0.88 (0.76 – 1.01)	0.88 (0.84 – 0.92)
High cholesterol and triglyceride levels	3.04 (2.46–3.75)	2.75 (2.38 – 3.17)	1.72 (1.54 – 1.92)	1.37 (1.30 – 1.45)	1.36 (1.19 – 1.55)	1.48 (1.41 – 1.55)
Diabetes mellitus	2.0 (1.57 – 2.58)	2.02 (1.70 – 2.41)	1.80 (1.55 – 2.09)	1.21 (1.10 – 1.34)	1.74 (1.45 – 2.09)	1.39 (1.28 – 1.51)

Table A.3
Results of the logistic regression with CVDs as dependent variables (men and women combined, full model (model 3))

	OR (95 % CI)					
	Acute myocardial infarction	Angina pectoris	Heart failure	Cardiac Arrythmias	Vascular Diseases	Any CVD
Resettler status	1.15	0.91	0.74	0.85	0.43	0.88
	(0.80–1.67)	(0.65 – 1.27)	(0.54 – 1.01)	(0.73 – 0.99)	(0.25 – 0.71)	(0.77–1.0)
Sex	0.24	0.35	0.80	1.15	0.82	0.92
(men vs. women)	(0.21 – 0.27)	(0.32 – 0.37)	(0.74 – 0.85)	(1.11 – 1.19)	(0.75 – 0.89)	(0.89 – 0.94)
Age	2.18	2.20	1.57	1.41	1.88	1.52
(in years/10)	(2.06 – 2.31)	(2.10 – 2.29)	(1.51 – 1.63)	(1.38 – 1.43)	(1.79 – 1.98)	(1.49–1.54)
ISCED Education level	1.54	1.57	1.21	0.91	2.70	1.13
Low	(1.23 – 1.92)	(1.31 – 1.88)	(1.01 – 1.44)	(0.82 – 1.01)	(2.25 – 3. 24)	(1.03 – 1.22)
Medium	1.25	1.25	1.11	0.97	1.62	1.07
	(1.13 – 1.37)	(1.16 – 1.36)	(1.03 – 1. 19)	(0.93 – 1.01)	(1.47 – 1. 79)	(1.03 – 1.10)
Hypertension	1.87	2.61	2.41	1.69	1.53	1.86
	(1.70 – 2.06)	(2.40 – 2.83)	(2.23 – 2.60)	(1.62– 1.76)	(1.40–1.68)	(1.80 – 1.92)
Ever smoking	2.10	1.67	1.17	1.14	1.90	1.28
	(1.89 – 2.32)	(1.54 – 1.81)	(1.09 – 1.26)	(1.10 – 1.19)	(1.73 – 2.09)	(1.24 – 1.32)
Obesity (BMI > 30)	1.39	1.18	1.36	1.08	1.55	1.15
	(1.27 – 1.52)	(1.10 – 1.27)	(1.26 – 1.46)	(1.04 – 1.12)	(1.42 – 1.69)	(1.11 – 1.19)
Risky alcohol consumption	0.62	0.69	0.74	0.91	0.90	0.87
	(0.57 – 0.68)	(0.64 – 0.75)	(0.69 – 0.80)	(0.87 – 0.94)	(0.83 – 0.98)	(0.84 – 0.90)
High cholesterol and triglyceride levels	3.32	3.29	1.78	1.35	1.52	1.61
	(3.03– 3.64)	(3.05 – 3.54)	(1.66 – 1.91)	(1.29 – 1.40)	(1.40 – 1.65)	(1.55 – 1.66)
Diabetes mellitus	1.59	1.65	1.64	1.17	2.05	1.45
	(1.42 – 1.77)	(1.51 – 1.80)	(1.50 – 1.81)	(1.10 – 1.25)	(1.84 – 2.28)	(1.38– 1.53)

Data availability

The data underlying this article were accessed from the German National Cohort (NAKO Gesundheitsstudie). Data can be provided by the NAKO data transfer site (https://transfer.nako.de) based on a written request. Requests should be submitted to the German National Cohort data transfer site.

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