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Descriptive Finding

Using multiple cause of death information to eliminate garbage codes

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Contents

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Abstract

BACKGROUND
International comparisons of mortality largely depend on the quality of data. With more than 20% of deaths annually assigned to ill-defined cardiovascular conditions, the mortality level due to well-defined causes of death is under-registered in Poland.

OBJECTIVE
We aim to reclassify cardiovascular garbage codes (GCs) into well-defined causes based on multiple causes of death (MCoD) data and to approximate mortality levels due to well-defined causes of death in Poland. We examine the usefulness of the MCoD approach for correcting low-quality data on causes of death.

METHODS
Based on the unique MCoD dataset for Poland, death counts due to cardiovascular GCs were reassigned to well-defined underlying causes in two steps: (1) manually for death records that included MCoD information constituting a logical chain of conditions leading to death and (2) with coarsened exact matching for the remaining death records. Age-specific and age-standardised death rates for large groups of causes were calculated before and after redistribution and compared to those of other Eastern European countries with relatively good data quality.

RESULTS
Of deaths originally assigned to cardiovascular GCs, 86,856 were reclassified, mostly to well-defined cardiovascular diseases, cancers, endocrine, nutritional and metabolic diseases, and respiratory diseases. The age-standardised death rate due to well-defined ischaemic heart diseases increased by 43%, and the rate due to cerebrovascular diseases by 22%. Cardiovascular mortality structure by large groups of causes became similar to

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the structure registered in other Eastern European countries characterised by a low prevalence of GCs.

CONCLUSION

Coarsened exact matching performs relatively well when abundant MCoD information is available and enhances the comparability of cause-of-death data between countries.

1. Introduction

International studies of mortality rely on the comparability of cause-of-death data between countries. European countries follow the guidelines from the World Health Organization (WHO) on registering deaths and, to this end, adopt the same classification of causes of death, that is, the WHO's International Statistical Classification of Diseases and Related Health Problems (ICD). Despite the implementation of concordant rules and the ICD, important differences in the quality of cause-of-death data hinder international comparisons; in Europe, the main problem stems from the assignment of so-called garbage codes (GCs), that is, causes of death that are not useful in analyses of public health and mortality (Murray and Lopez 1996). GCs include not only the symptoms, signs, and ill-defined conditions, which are denoted with ICD codes starting with 'R', but also several other conditions of low informative value. The prevalence of GCs considerably varies in Europe (Figure 1), and countries with more than 20% deaths registered due to GCs are systematically excluded from the WHO's international comparisons of mortality (Mathers et al. 2005; Naghavi et al. 2010).

In demographic research, the common and widely accepted practice is to deal only with R codes and to redistribute age- and sex-specific death counts (or seldom, death rates) assigned to R codes proportionally across all other causes. This practice, however, neglects other GCs and imposes a strong, unrealistic assumption that the difficulty in recognising the appropriate diagnosis is the same for each cause of death. Moreover, proportional redistribution favours the most prevalent causes of death, even though pathophysiologic links between those causes and R codes may not exist at all. Such a method, finally, does not allow for local differences; for instance, in Russia and Ukraine ill-defined conditions are more often assigned in place of well-defined cardiovascular diseases than of other diseases (Meslé and Vallin 2003, 2012).

Figure 1: **Deaths due to R codes and other garbage codes in all deaths, selected European countries (average for 2005–2018), in %**
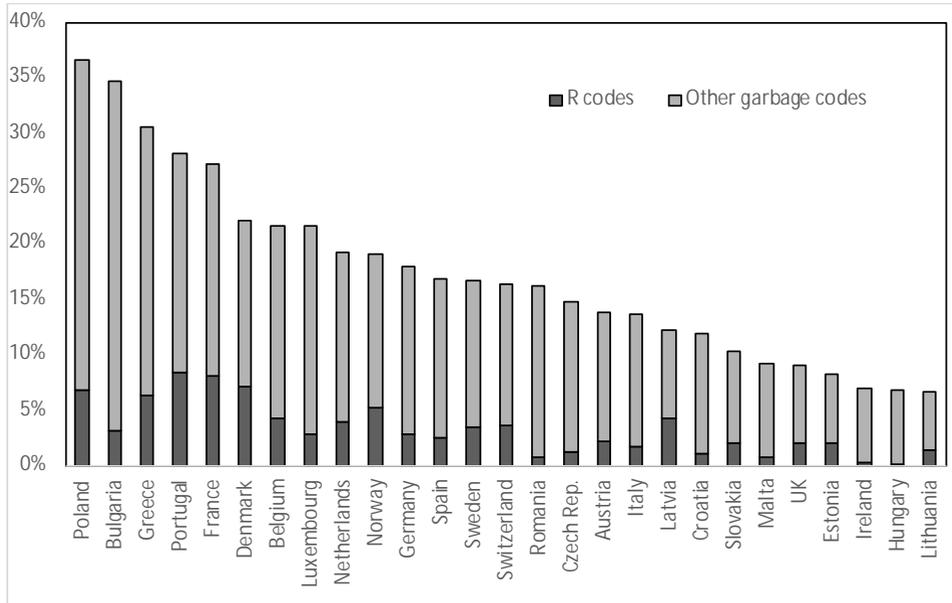
Source: Own elaboration based on WHO (2020).

One solution to the problem of GCs can be found in the multiple causes of death (MCoD) approach, which consists in analysing all morbid conditions mentioned in death certificates: underlying causes of death (UCoD) and so-called contributing mentions (i.e., medical conditions accompanying or induced by the UCoD). This line of research is usually used to investigate the prevalence of morbid conditions that coexist with the underlying causes of death, but MCoD information has another, seldom explored application: When the underlying causes of death are GCs, contributing mentions may provide useful information allowing verification and, potentially, correction of the former (D'Amico et al. 1999; Fink et al. 2012; Foreman, Naghavi, and Ezzati 2016). Such revisions of underlying causes of death have been carried out for the group of R codes (D'Amico et al. 1999) and for heart failure (Foreman, Naghavi, and Ezzati 2016; Snyder et al. 2014; Stevens, King and Shibuya 2010) but not for other problematic conditions.

In this study, we focus on the largest group of GCs (cardiovascular GCs) and on Poland, where almost 27% of deaths (approximately 100,000) are annually assigned to GCs. In absolute terms, this is the highest number of GCs registered at the national level in the European Union. The shares of GCs and cardiovascular GCS have remained stable

in Poland since the early 2000s. A study comparing medical documentation and assigned causes of death of persons deceased in hospitals evidenced an important role of medical doctors' habits in reporting unknown and ill-defined conditions (Jędrychowski et al. 2001). An analysis for the largest cities of Poland revealed considerable and unjustified differences in cardiovascular mortality levels due to distinct local certification practices (Wojtyniak et al. 2012). At the regional level, the prevalence of some well-defined causes of death correlates negatively with GC prevalence, which suggests that the former tend to be replaced by the latter (Bijak 2003; Fihel and Meslé 2016).

Our objective is twofold: First, we aim to reclassify cardiovascular GCs into well-defined (that is, non-GC) causes of death and to recalculate mortality levels from well-defined cardiovascular diseases, which due to high prevalence of GCs remain under-registered in Poland. Second, more generally, we attempt to test the plausibility of the redistribution method based on the MCoD data and, thus, to verify the usefulness of the MCoD approach for correcting underlying causes of death.

2. Data and method

The study concerns all conditions recognised by the WHO (2013) as cardiovascular GCs (Table 1). The reclassification is based on a unique dataset including all original MCoD mentions in death certificates, which in Poland are usually destroyed for the sake of confidentiality as soon as a medical coder has defined and validated the code of the underlying cause of death. However, the scans of death certificates for 2013 were preserved and made available for this research. The dataset concerns 387,988 permanent residents of Poland deceased in 2013 in the territory of Poland. The contents of scanned death certificates, including the deceased's demographic characteristics, circumstances of death, all MCoD mentions made by medical doctors pronouncing the death, and the ICD code of the UCoD defined by medical coders, were digitalised. For the purpose of quantitative analysis, we assigned ICD codes to all contributing mentions. Importantly, in Poland no restrictions are imposed on the number of contributing mentions, so the amount of MCoD information for cardiovascular GCs is abundant and provides grounds for establishing specific aetiologic associations between causes of death. This, however, does not apply to deaths due to symptoms, signs, and ill-defined conditions (R codes), for the vast majority of which the only MCoD mentions included other ill-defined categories. Therefore, this study does not contain an in-depth investigation of deaths due to symptoms, signs, and ill-defined conditions.

Table 1: **Number of death counts due to cardiovascular garbage codes under study, before and after first-step correction, Poland 2013**

| Cardiovascular GC and its ICD-10 code	Original death counts	Death counts after manual correction
Essential (primary) hypertension, I10	978	978
Pulmonary embolism without mention of acute cor. pulmonale, I26.9	1,643	1,643
Cardiac arrest, I46	6,939	5,539
Ventricular tachycardia, I47.2	14	12
Ventricular fibrillation and flutter, I49.0	84	17
Heart failure, I50.0,1,9	38,372	29,167
Complications, ill-defined descriptions of heart disease, I51.4,5,6,8	4,342	3,309
Generalised and unspecified atherosclerosis, I70.9	34,407	20,507
Other and unspecified disorders of circulatory system, I99	77	77
Total	86,856	61,249

Source: Own elaboration based on the MCoD data from Statistics Poland.

The analysis consisted of three steps. First, all cardiovascular GC individual records (N = 86,856) were verified; where a detailed description of well-defined medical conditions was provided and constituted a logical chain of events leading to death, the code of the UCoD was manually replaced with a well-defined one from the given death certificate. If a well-defined condition was mentioned both as a secondary and a direct cause of death, the former was prioritised over the latter, and if several mentions were listed in the relevant section, the first of them was selected.

Second, coarsened exact matching (Snyder et al. 2014; Stevens, King, and Shibuya 2010) was applied to death counts that had not been reclassified in the previous step. This method consists of matching each cardiovascular GC death record with all death records that had been registered due to both a well-defined UCoD and a contributing mention including the same GC (Figure 2). Each cardiovascular GC death count can be linked – through what we call 'associations' – to several well-defined death counts. Next, cardiovascular GC death records have their UCoD replaced by well-defined causes of death they were matched with proportionally to the number of established associations. In this study, a large number of associations was created; for instance, 29,167 death counts due to heart failure (code I50) as the UCoD were matched with 60,480 death counts, including a well-defined UCoD and heart failure as a contributing mention. Based on these associations, for each GC we calculated transition coefficients that proportionally redistribute GCs across well-defined UCoD. For the above-mentioned example of heart failure, 60,480 well-defined death counts included 2,070 deaths due to cardiomyopathy (I42) as the UCoD. As a result, 3% (2,070) of deaths originally assigned to heart failure were reclassified as due to cardiomyopathy. All operations were done separately for males and females, divided into five-year age groups. Both the first and the

second step of the analysis were conducted at the accuracy level of four-digit ICD codes (e.g., I70.9 instead of I70).

Figure 2: **Two step procedure of correcting cardiovascular GC (manual correction and coarsened exact matching) and its results**
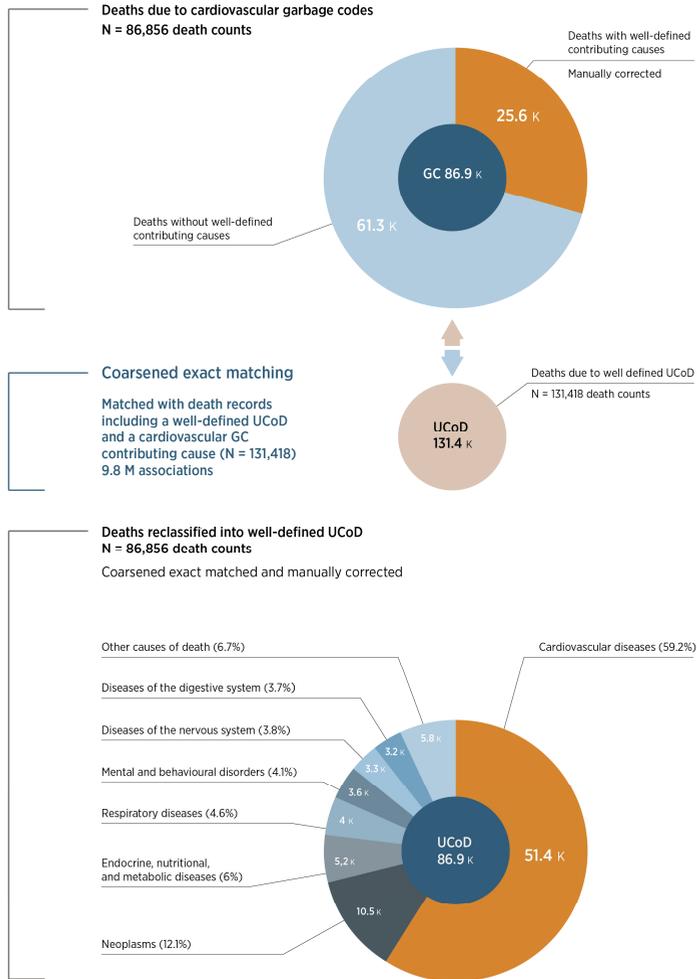
Source: Own elaboration based on the MCoD data from Statistics Poland.

Third, we evaluated the external plausibility of coarsened exact matching using a group of death records (N = 118,626) that were originally registered due to a well-defined UCoD and, as a contributing mention, one of three most prevalent cardiovascular GCs: cardiac arrest (I46), heart failure (I50), or generalised and unspecified atherosclerosis (I70.9). Once the UCoD were removed and replaced by one of the three above-mentioned GCs, we applied the transition coefficients calculated previously and redistributed these death counts across well-defined UCoD. Finally, we compared the number of deaths originally registered due to well-defined UCoD and redistributed deaths into these causes with the use of coarsened exact matching.

The results of redistribution were compared to mortality levels observed in three other Eastern European countries: the Czech Republic, Hungary, and Slovakia. These countries were selected for two reasons: a relatively low level of cardiovascular GCs (in 2013, 6% of deaths in the Czech Republic, 5% in Hungary, and 2% in Slovakia) and an epidemiologic situation similar to Poland's, given the phase of health transition (Meslé 2004, OECD and European Union 2018). Death counts by cause and population estimates for these countries were both derived from the WHO Mortality Database (2020). Age-specific death rates and age-standardised death rates (ASDRs) were compared, the latter being based on the European standard population for 2013. To assure comparability, deaths due to symptoms, signs, and ill-defined conditions (R codes) and cardiovascular GCs for these three countries were redistributed proportionally across all other causes.

3. Results

In 2013, 86,856 deaths, which constituted 22% of all deaths in Poland, were assigned to 14 cardiovascular GCs. The most prevalent GCs were heart failure (I50) and generalised and unspecified atherosclerosis (I70.9, Table 1). These two GCs were also most frequently corrected in the first step of the reclassification. Heart failure was frequently recorded as an UCoD despite the coexistence of well-defined mentions such as chronic ischaemic heart disease (I25), atrial fibrillation and flutter (I48), and vascular dementia (F01). Generalised and unspecified atherosclerosis, in turn, was often registered despite well-defined contributing mentions of atherosclerotic heart disease (I25.1), atherosclerosis of well-defined arteries (I70.0–170.8), and cerebrovascular diseases (I60–I69). The first step of redistribution included 25,607 death counts (29% of all cardiovascular GCs) and involved replacing the underlying cause with a well-defined disease, mostly cardiovascular (62% of all corrections in this step), mental and behavioural (8%), respiratory (5%), or nervous (5%).

The second step of the reclassification, coarsened exact matching, covered 61,249 GC deaths that were combined with 131,418 death records due to well-defined UCoD;

9.8 million associations were established. Redistributions were made predominantly to well-defined cardiovascular diseases (58%), in particular ischaemic heart diseases (chronic heart disease, I25, and acute myocardial infarction, I21), hypertensive heart disease (I11), and cerebrovascular diseases (cerebral infarction, I63, and stroke, not specified as haemorrhage or infarction, I64). Deaths originally registered as cardiovascular GCs were also reclassified to other groups of diseases, mostly cancers (17%), such as malignant neoplasm of bronchus and lung (C34), colon (C18), and breast (C50), and endocrine, nutritional, and metabolic diseases (7%), in particular diabetes mellitus type 2 (E11).

Altogether, in both manual correction and coarsened exact matching, death records were reclassified to well-defined cardiovascular diseases (59%); cancers (12%); endocrine, nutritional, and metabolic diseases (6%); and respiratory diseases (5%) (Figure 2).

As a result of the redistribution, mortality due to well-defined cardiovascular diseases increased considerably (Table 2, Figure 3): The ASDR for ischaemic heart diseases rose from 224 to 308 per 100,000 for men and from 120 to 179 per 100,000 for women. For cerebrovascular diseases, the ASDR rose from to 148 to 178 per 100,000 for men and from 118 to 147 per 100,000 for women. In contrast, the unusually elevated mortality due to diseases of arteries, arterioles, and capillaries, driven mostly by generalised and unspecified atherosclerosis, decreased almost fourfold for men and fivefold for women. Mortality due to other forms of heart disease, with cardiac arrest and heart failure as the most important causes, decreased threefold for both sexes. After redistribution, cardiovascular mortality structure by large groups of causes in Poland became similar to the structure observed in other countries, with ischaemic heart diseases and cerebrovascular diseases dominating. As cardiovascular GCs were redistributed to all chapters of ICD classification, overall cardiovascular mortality decreased by 12% for men and 15% for women and became lower than in other countries (Table 4). Concurrently, mortality levels due to other large groups of diseases, notably cancers and respiratory diseases, increased but remained similar to levels registered in other countries.

Coarsened exact matching appears to have been relatively accurate. In the test performed for death counts that had been originally attributed to a well-defined UCoD and a cardiovascular GC contributing mention, as many as 84.8% of death records were reassigned to the same well-defined UCoD as the original one (accuracy level: three-digit ICD codes).

Table 2: **Age-standardised death rates by large groups of causes of death[1,2] in selected countries, 2013 (per 100,000)**

Group of causes[1]	Czech Rep.	Hungary	Slovakia	Poland	Poland reclassified
Males					
Cancers	408	502	484	448	498
Nervous	17	43	26	17	22
Cardiovascular	675	852	787	730	620
(*therein*:)					
(Ischaemic heart dis.)	(440)	(497)	(513)	(224)	(308)
(Other forms heart dis.)	(31)	(60)	(30)	(215)	(63)
(Cerebrovascular dis.)	(144)	(184)	(168)	(148)	(178)
(Diseases of arteries)	(16)	(20)	(16)	(122)	(34)
Respiratory	120	124	132	135	153
Digestive	66	98	94	74	84
External	94	103	115	113	123
All other	137	91	108	116	133
Total	1,517	1,813	1,746	1,633	1,633
Females					
Cancers	236	278	239	239	265
Nervous system	15	37	21	11	15
Cardiovascular	485	596	575	485	415
(*therein*:)					
(Ischaemic heart dis.)	(294)	(329)	(374)	(120)	(179)
(Other forms heart dis.)	(20)	(33)	(14)	(136)	(41)
(Cerebrovascular dis.)	(122)	(139)	(129)	(118)	(147)
(Diseases of arteries)	(8)	(10)	(8)	(88)	(18)
Respiratory	60	59	61	58	64
Digestive	40	49	49	43	49
External	35	41	39	30	36
All other	109	77	83	90	112
Total	980	1,137	1,067	956	956

Notes: [1]Cancers ICD-10 codes C00–D48; diseases of nervous system G00–G99; cardiovascular diseases I00–I99, therein ischaemic heart diseases I20–I25, other forms of heart disease I30–I52, cerebrovascular diseases I60–I69, and diseases of arteries, arterioles, and capillaries I70–I79; diseases of respiratory system J00–J99; diseases of digestive system K00–K93; and external causes of death V01–Y98. [2]Symptoms, signs, and ill-defined conditions (R codes) are redistributed proportionally across all causes of death in all countries; cardiovascular GCs are redistributed proportionally across all causes of death in the Czech Republic, Hungary, and Slovakia.
Source: Own elaboration based on the MCoD data from Statistics Poland and WHO (2020).

Figure 3: **Age-specific death rates due to selected groups of cardiovascular diseases[1] in selected countries, 2013, by sex (per 100,000)**
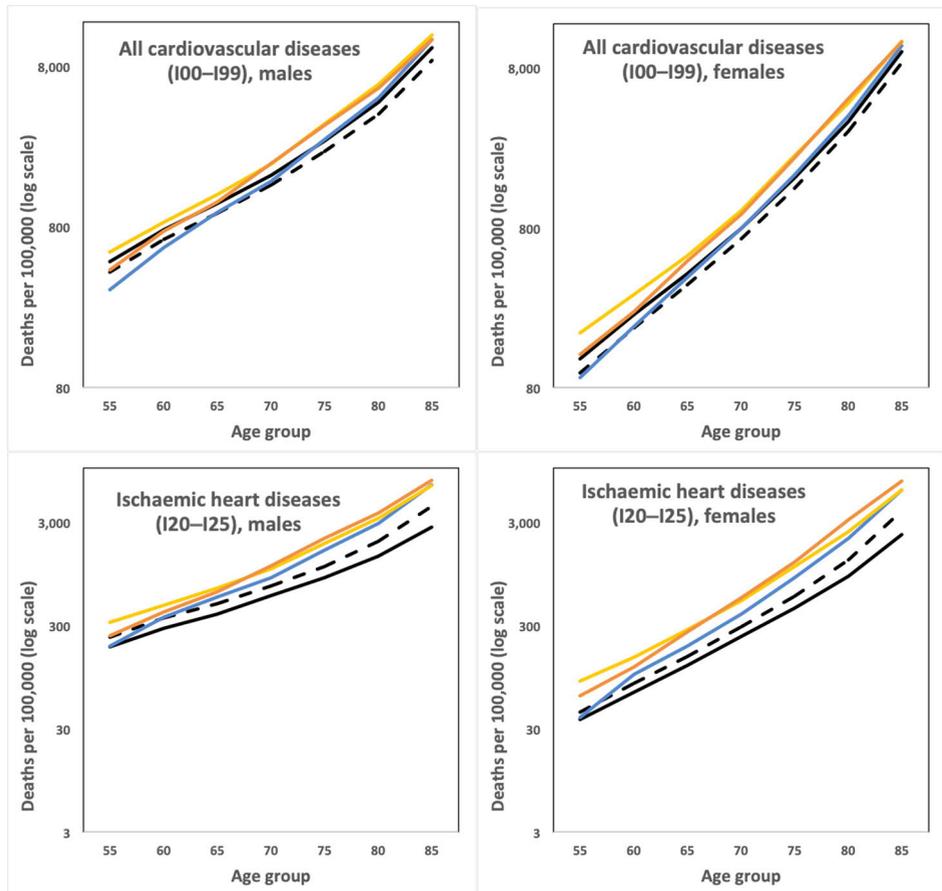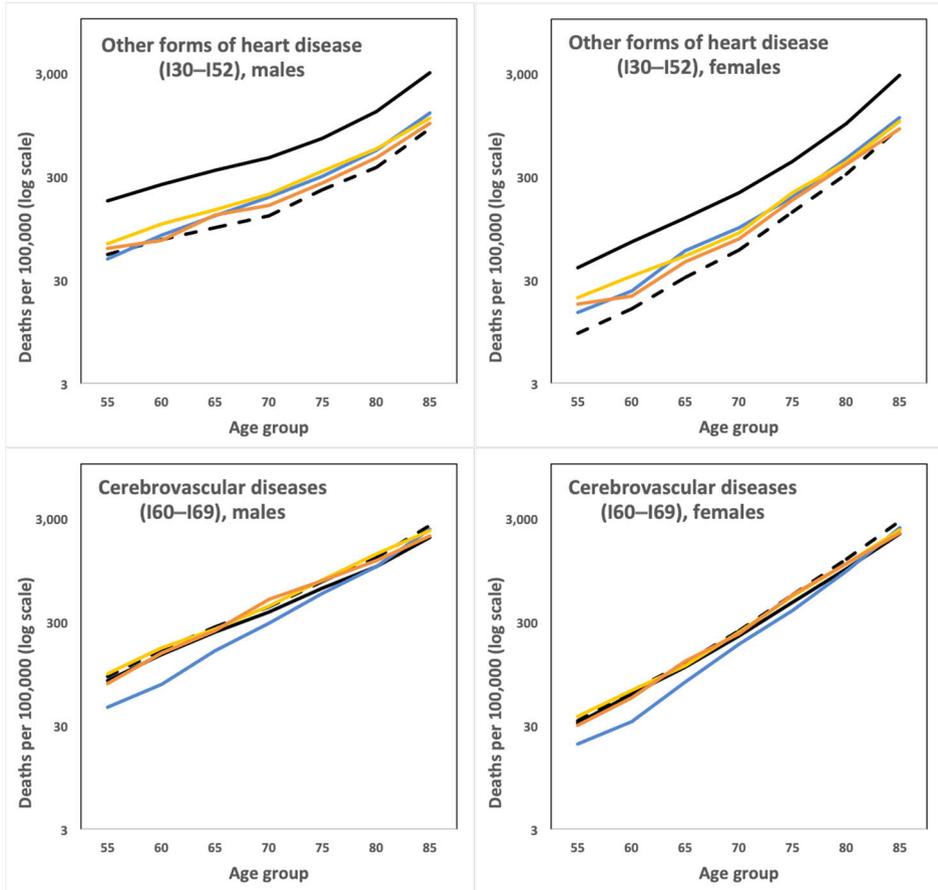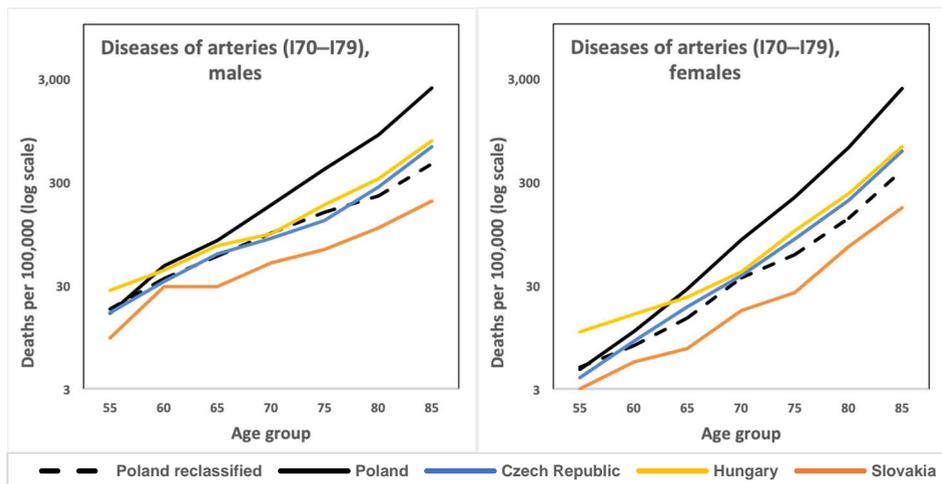
Figure 3: **(Continued)**

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Notes: [1]Symptoms, signs, and ill-defined conditions (R codes) are redistributed proportionally across all causes of death in all countries; cardiovascular GCs are redistributed proportionally across all causes of death in the Czech Republic, Hungary, and Slovakia.
Source: Own elaboration based on the MCoD data from Statistics Poland.

4. Conclusions and discussion

When prevalence of GCs is considerable, the standard approach to mortality accounting for only well-defined causes with proportionally redistributed R codes yields questionable results. To conduct international comparisons of cause-of-death mortality, more and more complex methodologies for GCs are being developed (Vos et al. 2020), most often based on stochastic models (Ahern et al. 2011; Fink et al. 2012; Foreman, Naghavi and Ezzati 2016; Murray et al. 2008; Murray, Kulkarni and Ezzati 2006) and hence imposing a priori assumptions on the functional form of redistribution (Stevens, King and Shibuya 2010). Other studies first employ expert judgement to establish possible medical associations between causes of deaths and then verify these associations on the basis of empirical data (Ahern et al. 2011; Naghavi et al. 2010). In contrast, the coarsened exact matching approach using MCoD is relatively simple, makes use of source information concerning the death counts in question and, as a non-parametric method, leaves little room for arbitrary operations. It has its limitations, however.

First, this approach can be applied only if abundant and informative MCoD data is available. In most cases, however, when information on underlying causes is of low quality, the same goes for contributing mentions. For this reason, this method has

previously been applied only to Brazil, Mexico, and the United States (Snyder et al. 2014; Stevens, King, and Shibuya 2010). Second, since one death certificate can include several contributing mentions that in the coarsened exact matching partially replace one underlying cause of death, this approach increases the dispersion of mortality by causes. In this study, the recalculated overall cardiovascular mortality remained lower in Poland than in other Eastern European countries because the death counts were reassigned also to other well-defined causes.

Notwithstanding this effect, we demonstrated that coarsened exact matching improves the comparability of cause-of-death data between countries at the same stage of the health transition but where these data are of different quality. Altogether, 22% of deaths in Poland in 2013 – those originally registered due to cardiovascular GCs – were reassigned to a well-known coexisting disease. As a result, the level of well-defined cardiovascular mortality increased, and the structure of cardiovascular mortality by groups of diseases became similar to the structures observed in Eastern European countries with a low prevalence of GCs. As mortality structure by well-defined causes of death and the prevalence of GCs remain relatively stable in Poland, the transition coefficients obtained in this study could potentially be applied to the whole period covered by the ICD-10 and the same organisation of statistical system dedicated to the cause-of-deaths coding, which covers 1997–2019. This would result in a considerable increase in mortality due to malignant neoplasms, ischaemic heart diseases, and cerebrovascular diseases.

5. Acknowledgements

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