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Investigating multiple-cause mortality in Poland[1]

Abstract

Progress in life expectancy and the growing number of people living to old age intensify the phenomenon of multi-morbidity, defined as the coexistence of several chronic diseases. By exploiting all the medical information in death certificates, the multiple causes of death (MCoD) approach serves to investigate complex pathological processes that lead eventually to death. This is the first MCoD analysis for Poland and its objective is twofold: to examine the quality of information on contributing causes of death, in particular in the regional dimension, and to assess the scale of multi-morbidity involving conditions that are becoming more and more frequent in ageing populations. The analysis is carried out for all deaths that took place in Poland in 2013. The results show that medical doctors issuing death certificates often define contributing causes of death, but a large part of this information includes unknown or ill-defined conditions. Several conditions favour the certification of well-defined contributing causes: when death occurs in hospital, or is due to underlying causes other than cardiovascular, the number of contributing conditions is higher. Important regional differences are observed in this regard. The analysis highlights the importance of diseases that are rarely certified as the underlying causes, but often contribute to mortal conditions, such as diseases of the blood

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and the blood-forming organs, diseases of the skin and subcutaneous tissue, diseases of the genitourinary system or mental and behavioural disorders.

Keywords: causes of death, mortality, multimorbidity, multiple causes of death, Poland

Introduction

An effective health policy can be designed only on the basis of viable and comprehensive studies of morbidity and mortality, and demographic analyses concerning causes of death contribute importantly to our knowledge in this regard. Progress in life expectancy and the growing number of people living to old age intensify the phenomenon of multi-morbidity, defined as the coexistence of several chronic diseases that may have similar determinants or result from the physiological process of individual ageing (Anderson, 2011; Marengoni, Angleman, Melis, Mangialasche, Karp, Garmen, Meinow, & Fratiglioni, 2011). The coexistence of chronic diseases translates into combinations of different disability conditions or impairments (Janssen, 1940), which has important consequences for the individuals' social and economic status and activity. Where multi-morbidity is present, "a single cause, no matter how selected, no longer adequately describes the morbid conditions responsible for a large proportion of deaths" (Dorn & Moriyama, 1964, p. 401). Consequently, the classic approach referring only to one, underlying cause of death,[2] which is a routine practice in demographic studies, is becoming increasingly insufficient for investigating complex pathological processes in ageing populations.

The multiple causes of death (MCoD) approach is an analytical solution to this problem. By exploiting all the medical information in death certificates, the MCoD approach takes into account all diseases and medical conditions that influenced one's health status, contributed to its worsening and led or potentially led to death. Generally speaking, the objectives of MCoD research are: to establish the links between chronic diseases and pathologies in order to allow investigation of the whole morbid process that leads to death, and to highlight the importance of diseases and risk factors that are rarely registered as the underlying causes of death, but significantly contribute to the deterioration of one's health status (e.g. asthma, diabetes or hepatitis). Although the first MCoD analyses were published several decades ago (Chamblee & Evans,

[2] The underlying cause of death is defined as "the disease or injury which initiated the chain of morbid events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury" (WHO, 2011, p. 31).

1982; Dorn & Moriyama, 1964; Israel, Rosneberg, & Curtin, 1986; Manton & Stallard, 1982; White, Selvin, & Merrill, 1989; Wing & Manton, 1981), this approach gained popularity only recently, mostly due to technological improvements implemented in national statistical systems used for cause-of-death data collection and publication. As accessibility of cause-of-death data improved, novel methods and measures of analysis were proposed (Désesquelles, Salvatore, Frova, Pace, Pappagallo, Meslé, & Egidi, 2010; Egidi, Salvatore, Rivellini, & D'Angelo, 2018) and scientific networks (e.g. the Multiple Causes-of-Death Network) were established.

So far, the Czech Republic is the only Central and Eastern European country for which MCoD analyses have been conducted (Pechholdová, 2014). The present study, based on unique data, is the first MCoD analysis for Poland. However, Poland is known for relatively low-quality cause-of-death data due to the frequent assignment of deaths to unknown and ill-defined causes that represent only part of a larger category of so-called 'garbage' codes (GCs), defined as causes of death that are not useful in analyses of public health and mortality (Murray & Lopez, 1996). Despite World Health Organisation (WHO) recommendations and actions implemented by public institutions in order to improve the quality of cause-of-death data in Poland (Cierniak, 2014; Stawińska-Witoszyńska, Gałęcki, Wasilewski, & Narodowy Program Zdrowia, 2019), the share of deaths assigned to unknown and ill-defined causes has remained stable since 2000 and exceeds 6%, whereas the share of all GCs exceeds 20%. Consequently, the quality of cause-of-death data is unequivocally assessed as low and Poland is regularly excluded from international mortality analyses performed by the WHO (Mathers, Fat, Inoue, Rao, & Lopez, 2005). Large differences in GC assignment are observed across regions (Fihel, Muszyńska, & Wróblewska, 2014; Wojtyniak, Jankowski, Zdrojewski, & Opolski, 2012; Wojtyniak, Rabczenko, Pokarowski, Poznańska, & Stokwiszewski, 2012), which leads to the assumption that the certification practices employed by medical doctors at the local level play an important role. This problem has also been discussed elsewhere (Jędrychowski, Mróz, Wiernikowski, & Flak, 2001; Susło, 2011).

The objective of this study is twofold. First, it aims to examine the quality of MCoD data for Poland and to identify the circumstances of death conducive to correct inclusion of information in death certificates. Second, the study assesses the scale of multi-cause mortality involving conditions that are becoming more and more frequent in ageing populations (neurological disorders, cardiovascular diseases, selected respiratory diseases) or that risk being undervalued in the classic approach based only on underlying causes (alcohol abuse, obesity, diabetes mellitus, infectious diseases).

Data and methods

The procedure of collecting and validating the cause-of-death data in Poland, concordant with WHO guidelines (WHO, 1967, 2008), regulated by law[3] and discussed thoroughly elsewhere (Fihel, 2011; GUS, 2007), can be recapitulated as follows. When a medical doctor or other medical functionary (hereinafter referred to as the certifying person) pronounces a death, they issue a death certificate in paper form consisting of two parts; in one of these parts, the so-called statistical certificate to notification of death (*karta zgonu dla celów statystycznych*), they fill in descriptive terms relating to the underlying (initial), secondary and direct causes of the death (Table 1). These causes are supposed to constitute a chain of events, with the underlying cause as its starting point and the direct cause as its end point.[4] This part of the death certificate is then delivered to a local administrative unit and, subsequently, to the regional statistical office in Olsztyn. In the regional statistical office, the medical descriptions are used to establish the 4-digit alphanumeric code of the underlying cause of death corresponding to the WHO's International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10) (WHO, 2008). This is done manually by a medical doctor, called the coder (*lekarz orzecznik* or *lekarz koder*), who is well trained in WHO recommendations and Polish regulations.[5] Importantly, the role of a coder is to verify the correctness of medical descriptions of causes of death, that is whether they do not include unknown and ill-defined codes and whether they constitute a logical chain of events leading to death. In case of doubt or misstatements, the coder is supposed to contact the certifying person for further clarifications and, potentially, attribute a given case of death to a different cause than the one initially indicated by the person pronouncing the death.

The regional statistical office replaces the paper certificates to notification of death with their scans. Once all statistical data concerning deaths that occurred in a given year have been verified by regional statistical offices, and then verified, aggregated, and validated at the national level by Statistics Poland, that is within 18 months since

[3] Public Statistics Act (Ustawa o statystyce publicznej z 1995 roku, Dz.U. 1995, nr 85, poz. 439) as amended, and Ordinance of the Minister of Health of 7 December 2001 on the death certificate specimen and the way of filling it in (Rozporządzenie Ministra Zdrowia z dnia 7 grudnia 2001 roku w sprawie wzoru karty zgonu oraz sposobu jej wypełniania) for the period 1997–2014, and the Vital Records Act (Prawo o aktach stanu cywilnego z 2014 roku. Dz.U. 2014, poz. 1741) for the period since 2015.

[4] In turn, the secondary cause is a condition that is at the origin of the direct cause. For more details, in particular examples of chains of morbid events see WHO (2008) in English or Stawińska-Witoszyńska et al. (2019) in Polish.

[5] The number of coders in Poland decreased from 35 in December 2007 to 15 in May, 2020.

the end of the year they concern, the scans are deleted. Information on secondary and direct causes of death, which for the sake of simplicity and in line with most MCoD studies is called 'contributing causes of death',[6] is destroyed as well; the official data published by Statistics Poland refer only to the code of the underlying cause of death established by the medical coders. Thus, MCoD analysis is generally not feasible for Poland. However, recently one exception was made in the procedure of cause-of-death data aggregation: for the purpose of testing the system that automatically codes the underlying causes of death (Wasilewski, Wasilewska, Bartnikowska, & Elias, 2013), the scans concerning deaths in 2013 were preserved and, later on, made available for this research.

Table 1. Excerpt from statistical certificate to notification of death valid in Poland in 1997–2014

7. Cause of death a) ..... (underlying cause or external cause of injury or poisoning) b) ..... (secondary cause) c) ..... (direct cause)	ICD-10 code of underlying cause or of external cause of injury or poisoning

7. Przyczyna zgonu a) ..... (przyczyna wyjściowa albo przyczyna zewnętrzna urazu lub zatrucia) b) ..... (przyczyna wtórna) c) ..... (przyczyna bezpośrednia)	Symbol przyczyny wyjściowej lub przyczyny zewnętrznej urazu lub zatrucia wg ICD-10

Source: Ordinance of the Minister of Health of 7th December 2001 on the death certificate specimen and the way of filling it in (Rozporządzenie Ministra Zdrowia z dnia 7 grudnia 2001 roku w sprawie wzoru karty zgonu oraz sposobu jej wypełniania, Dziennik Ustaw nr 153, poz. 1782).

The present analysis concerns 387,988 permanent residents of Poland who deceased in the territory of Poland in 2013, and includes the following information from death certificates: sex, age, region (voivodship) of death registration, place of death (hospital, other health care institution, home, other), person stating the cause of death (physician based on autopsy, physician without autopsy, other), in the case

[6] Contributing (Egidi et al., 2018) or contributory (Désesquelles et al., 2010). In turn, when the underlying and contributing causes are analysed jointly, the term 'multiple causes' is used.

of infants deceased under 1 year of age: their weight, length, pregnancy duration and type (single, twin, etc.), descriptive terms relating to the underlying (initial), secondary and direct causes of deaths originally written by the person pronouncing the death, and the ICD code of the underlying cause of death assigned by a coder. Each contributing cause of death (secondary and direct) can include descriptions of several disease entities (the Minister of Health has imposed no limits in this regard) and all of them were replaced by 3-digit alphanumeric ICD-10 codes for the purpose of further quantitative analyses.

The present study does not include one important element that remains standard in MCoD research in other countries. WHO recommendations for death certification (WHO 2008) distinguish between diseases or conditions leading to death: underlying and contributing causes (so-called part I) as presented above, and other significant conditions contributing to death, but not related to the disease causing it (part II). In Poland, the latter category was introduced only in 2015 and, consequently, the present analysis excludes multi-morbidity conditions not related to the underlying cause of death.

In terms of methods, this study is based on descriptive and econometric techniques. In order to verify which circumstances of death favour correctness of information included in death certificates and which favour registration of multiple contributing causes, logistic regressions were applied. To assess the scale of multi-cause mortality, age-standardised mortality rates were calculated for: 1) conditions registered as the underlying cause of death, and 2) the same conditions certified as underlying or contributing causes of death. The ratio of the latter to the former is the Standardized Ratio of Multiple to Underlying cause (SRMU) as defined by Désesquelles et al. (2010). For each disease or health condition, the SRMU shows how underestimated it is in overall mortality when the analysis is based exclusively on the underlying cause of death. Age standardisation was carried out based on the WHO 2013 European population standard to assure the comparability of results with other MCoD studies (ibidem).

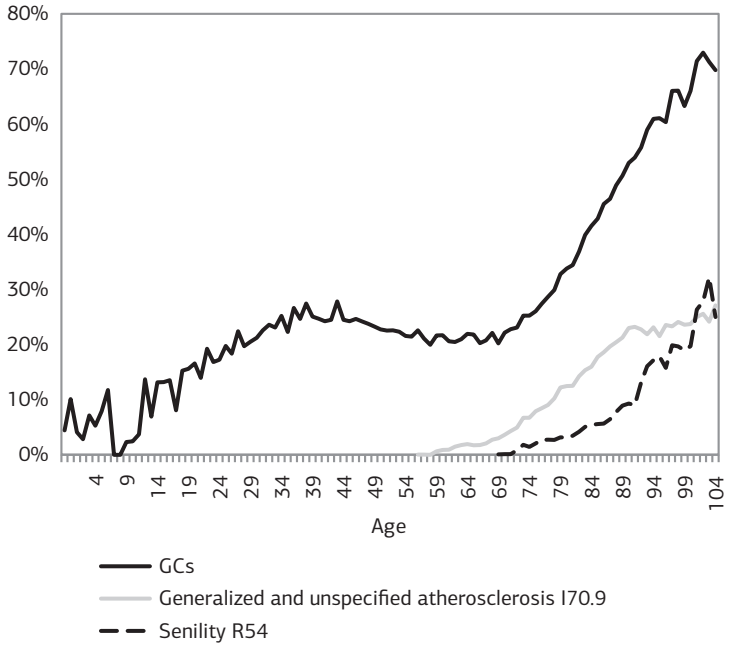
Results

Assignment of underlying causes of death

In 2013, a vast majority of death certificates were issued by physicians pronouncing the death (93%), and only a small portion were filled in by physicians performing post-mortem autopsies (7%) or other medical personnel, such as nurses or midwives

(approximately 0.3%). Deaths occurred mostly in hospitals (51%) and homes (36%), rarely in medical institutions other than hospitals (7%) or elsewhere (5%). Almost half of deaths (46%) were due to diseases of the circulatory system (9th chapter of the ICD-10 revision), whereas a quarter (26%) were due to neoplasms (2nd chapter). Three other groups of causes, each concerning approximately 6% of deaths, were: symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (18th chapter with alphanumeric codes starting with 'R', hereinafter called the R codes: these are the so-called unknown and ill-defined causes), diseases of the respiratory system (10th chapter), and external causes of morbidity and mortality (20th chapter).

Figure 1. Proportion of deaths due to all GCs and due to selected GCs as underlying causes by age, Poland 2013



Source: own elaboration based on Statistics Poland data.

Thus, the third most frequent group of underlying causes belonged to the category of unknown and ill-defined causes (the R codes mentioned above), but this is only the proverbial tip of an iceberg, as the category of GCs is much larger and also includes codes that (Murray & Lopez, 1996): are secondary causes of death (i.e. heart failure), or remain unspecified within larger groups of causes (e.g. malignant neoplasm without specification of site). The WHO regularly publishes and updates the so-called short

and long list of GCs.[7] Based on the latter, in 2013 the proportion of GCs assigned as underlying causes of death in Poland was 31%, with the most frequent GCs being generalised and unspecified atherosclerosis (ICD-10 code: I70.9) – 9% of all deaths in Poland, unspecified heart failure (I50.9) – 7%, senility (R54) – 3%, congestive heart failure (I50.0) – 2%, and other ill-defined and unspecified causes of mortality (R99) – 1%. The incidence of GCs increases with age (Figure 1); at the age of 70 and over, 37% of deaths are assigned GCs, with the most important cause being generalised and unspecified atherosclerosis (14%). Until the early 2000s, the assignment of this disease as an underlying cause of death was frequent in Central Europe, but while this practice has declined in such countries as the Czech Republic (Fihel & Meslé, 2016), it remained very frequent in Poland.

Assignment of contributing causes of death

In 2013, certifying persons readily indicated contributing causes: out of 387,988 death certificates issued in 2013, only 10% had no such additional mention, 11% had one mention, 61% had two mentions and 18% had 3 or more mentions. The record number of contributing diseases and conditions was 14, and the average was 1.9.

Unfortunately, the informative value of these mentions was low as many of them concerned ill-defined, unknown (R codes) or other garbage causes. Nearly 11% of all death certificates contained only R contributing mentions, and 49% of all death certificates contained only GC contributing mentions (Table 2). Out of all contributing causes, the five most frequently assigned codes were all GCs: other symptoms and signs involving the circulatory and respiratory systems (R09), cardiac arrest (I46), heart failure (I50), cachexia (R64), and respiratory failure, not elsewhere classified (J96). Taking into account all death certificates, the average number of non-R contributing mentions was 1.3, whereas the average number of non-GC contributing mentions was 0.5. The most frequent non-GC contributing mentions were also rather uninformative: secondary malignant neoplasm of other and unspecified sites (C79), pneumonia, unspecified (J18), chronic ischaemic heart disease (I25), and other disorders of the brain (G93). Interestingly, the average number of non-GC contributing mentions was the highest when the underlying cause was conditions originating in the perinatal

[7] The latter includes sepsis (ICD-10 codes: A40-A41), neoplasms of unspecified sites (C76, C80, C97), defibrination syndrome (D65), volume depletion (E86), primary hypertension (I10), pulmonary embolism (I26), ill-defined cardiovascular diseases (I46, I47.2, I49.0, I50, I51.4, I51.5, I51.6, I51.9, I70.9, I99), pulmonary oedema (J81), respiratory failure (J96), hepatic failure (K72), renal failure (N17-N19), respiratory failure of newborn (P28.5), unknown and ill-defined causes (R codes), events of undetermined intent (Y10-Y34, Y87.2).

period or congenital malformations, deformations, and chromosomal abnormalities (Figure 2), that is in relatively rare cases.

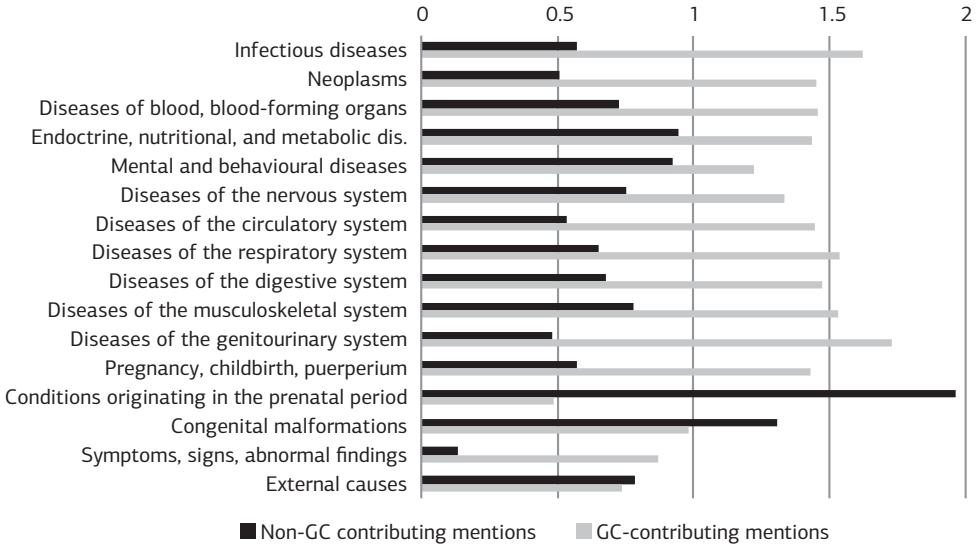
Table 2. Distribution of deaths by type of underlying cause and contributing mention in %, Poland 2013

Cause of death		Contributing mention			Total
		None	All GCs	At least one non-GC	
Underlying cause	GC	5.5	18.4	7.5	31.4
	Non-GC	4.6	30.8	33.2	68.6
Total		10.1	49.2	40.7	100.0

Cause of death		Contributing mention			Total
		None	All Rs	At least one non-R	
Underlying cause	R	3.0	1.5	1.9	6.4
	Non-R	7.1	9.3	77.2	93.6
Total		10.1	10.8	79.1	100.0

Source: own elaboration based on Statistics Poland data.

Figure 2. The average number of GC and of non-GC contributing mentions by underlying cause group,[a] Poland 2013



Notes: [a] According to the ICD-10; the following ICD chapters were excluded due to the low number of observations: diseases of the eye and adnexa, diseases of the ear and mastoid process, diseases of the skin and subcutaneous tissue.

Source: own elaboration based on Statistics Poland data.

Most probably, these deceased patients had detailed medical documentation and had been treated in highly specialised institutions, which favoured proper diagnosis and description of well-defined diseases. In turn, in the case of the most frequent underlying causes of death, neoplasms and diseases of respiratory or circulatory systems, a relatively high number of GC contributing mentions (on average 1.5) was not accompanied by a corresponding number of non-GC contributing mentions (0.5).

Table 3. Ordered logistic regression results (Odds Ratios) for the number of all, non-R and non-GC contributing mentions[a,b,c], Poland 2013

Variable	Number of all contributing mentions	Number of non-R contributing mentions	Number of non-GC contributing mentions
Sex (ref. men)	1.069***	1.067***	1.073***
Age	1.009***	1.006***	0.999***
Place of death (ref. hospital)			
Other medical institution	0.794***	0.557***	0.893***
Home	0.345***	0.342***	0.530***
Other	0.259***	0.279***	0.540***
Certifying person (ref. doctor based on post-mortem autopsy)			
Doctor without autopsy	1.500***	1.446***	0.879***
Other medical personnel	1.120***	1.282**	0.798***
Voivodship (ref. Dolnośląskie)			
Kujawsko-Pomorskie	0.687***	0.844***	1.269***
Lubelskie	0.430***	0.796***	0.659***
Lubuskie	0.471***	0.705***	0.928***
Łódzkie	0.532***	0.643***	0.715***
Małopolskie	0.905***	1.164***	1.012
Mazowieckie	0.663***	0.878***	0.671***
Opolskie	0.766***	1.146***	1.352***
Podkarpackie	0.792***	0.906***	0.960**
Podlaskie	0.980	0.791***	0.951**
Pomorskie	0.590***	0.759***	0.827***
Śląskie	1.100***	1.097***	1.359***
Świętokrzyskie	0.651***	0.995	0.877***
Warmińsko-mazurskie	0.817***	0.911***	0.947***
Wielkopolskie	0.609***	0.868***	1.239***
Zachodniopomorskie	0.818***	1.007	0.913***
Underlying cause (ref. non-GC)			
GC	0.508***	0.481***	0.336***
Underlying cause (ref. cardiov.)			
Neoplasms	0.740***	0.444***	0.631***
External causes	0.545***	0.667***	1.389***
Other	0.726***	0.642***	0.843***
Pseudo R2	0.0645	0.0565	0.0509
N	387,988		

Notes: [a] Explanatory variables take values 0, 1, 2, 3, where 3 indicates three or more contributing mentions; [b] significance levels: *** p<0.01, ** p<0.05, *p<0.1; [c] more detailed results (i.e. 95% confidence intervals) available upon request.

Source: own elaboration based on Statistics Poland data.

Some circumstances of death favour the assignment of contributing mentions; to investigate this, three ordered logistic regressions were performed:[8] estimating the number of all contributing mentions, the number of non-R and the number of non-GC mentions (Table 3). The first of them serves illustrative purposes only and provides little information. The two other models show that when death occurred in hospital, or when a non-GC was indicated as the underlying cause, the probability of each additional well-defined (non-R or non-GC) contributing mention was higher. Conversely, when death took place at home, the probability of an additional well-defined mention was almost two times lower than in hospital. Interestingly, physicians pronouncing death without a post-mortem autopsy were more likely to indicate each additional contributing mention (first model, OR 1.5) or each additional non-R mention (second model, OR 1.45), but less likely to indicate each additional non-GC contributing mention (second model, OR 0.88) as compared to physicians performing post-mortem autopsies. The chance of a higher number of non-R contributing mentions was considerable in the Małopolskie, Opolskie, and Śląskie voivodships, whereas of non-GC contributing mentions, in Kujawsko-pomorskie, Opolskie, Śląskie, and Wielkopolskie, as compared to Dolnośląskie and other regions. When the underlying cause of death was cardiovascular, the chance of each additional well-defined mention was higher than for neoplasms and other (excluding external) causes.

Factors favouring the correctness of cause-of-death mentions

As explained in the Data and methods section, a medical coder defining the ICD code of the underlying cause of death is supposed to verify and correct the descriptions of the underlying and contributing causes contained in death certificates. In practice, much depends on the expertise and involvement of both the certifying physician and the coder: if, for example, the former was not the primary care physician of the deceased person, or much time passed between the issuing of the death certificate and the coding of the underlying cause of death, the medical circumstances of the death may no longer be recalled. To some extent, however, coders do perform their checking role, and this can be investigated through a comparison of the ICD codes (of underlying causes) filled in by certifying physicians and by coders. The former are not supposed to provide these codes but, most probably due to unawareness,

[8] This form of the model was chosen because explanatory variables have specific asymmetric distributions with one dominant value (2 for all and non-R mentions and 0 for non-GC mentions). See the beginning of this section.

many of them do so: in 2013, as many as 64% of death certificates included two underlying cause codes, one provided by the physician issuing the certificate and the other defined by a coder, and obviously the latter was subsequently registered by Statistics Poland. In most certificates with double codes, coders preserved exactly the same underlying cause of death as the one chosen by the certifying person (68% of certificates with double codes), or selected a different cause from the same ICD chapter (20%). In the remaining certificates, coders relatively often replaced GCs assigned to the underlying cause of death with non-GCs; in these cases, the most frequent GCs were ill-defined cardiovascular diseases (I10, I46, I50) and unknown causes (i.e. other sudden death, cause unknown, R96), which were usually replaced with well-defined cardiovascular (I21, I25) or respiratory diseases (i.e. pneumonia, J18). These corrections most often took place in the voivodships: Pomorskie, Podlaskie, Małopolskie, and Mazowieckie.

In fact, voivodship remains one of the most important determinants of the quality of medical content in death certificates in Poland. To demonstrate this, five logistic regressions were estimated to identify circumstances that favour issuing a correct death certificate that:

1) consisted of well-defined causes of death only, that is both the underlying and contributing causes were non-GC;
2) both the underlying and contributing causes were non-GCs, with generalised and unspecified atherosclerosis (I70.9) excluded from the category of GCs;
3) only the underlying cause was non-GC;
4) only the underlying cause was non-GC or I70.9;
5) only the underlying cause was non-R code.

In models 3 to 5, no condition was imposed on the contributing cause. In model 1, the conditions of correctness of medical content are the most restrictive, in model 5, they are the least restrictive. According to all the models, in the Małopolskie, Pomorskie and Śląskie voivodships the chances of well-defined underlying and contributing causes were considerably higher than in Dolnośląskie, the region of reference, and in other regions of Poland, for which the odds ratios were below 1 (Table 4). On the other hand, death certificates issued in Lubelskie, Łódzkie, Podkarpackie, and Świętokrzyskie included well-defined causes of death less often than in Dolnośląskie in all five models, that is regardless of whether both the underlying and contributing causes were investigated, or only the former.

Three other factors determine the correctness of death certificates. First, compared to deaths occurring in hospital, the chance of well-defined underlying and contributing cause registration (model 1) was 32% lower in other medical institutions and 58% lower in homes and elsewhere. The other models show similar results.

Table 4. Logistic regressions results (Odds Ratios) for well-defined causes of death (underlying and/or contributing),[a,b,c] Poland 2013

Variable	Both underlying and contributing cause		Underlying cause		
	non-GC (model 1)	non-GC or I70.9 (model 2)	non-GC (model 3)	non-GC or I70.9 (model 4)	non-R (model 5)
Sex (ref. men)	1.002	1.008	0.916***	1.008	1.014
Age	0.992***	0.998***	0.980***	0.998***	0.994***
Place of death (ref. hospital)					
Other medical institution	0.683***	0.740***	0.531***	0.739***	0.338***
Home	0.421***	0.337***	0.302***	0.337***	0.101***
Other	0.426***	0.259***	0.234***	0.259***	0.071***
Certifying person (ref. doctor based on post-mortem autopsy)					
Doctor without autopsy	1.048***	1.401***	1.461***	1.401***	1.221***
Other medical personnel	0.903	1.193**	1.305***	1.193**	0.890
Voivodship (ref. Dolnośląskie)					
Kujawsko-Pomorskie	0.943***	0.534***	0.686***	0.534***	0.579***
Lubelskie	0.692***	0.737***	0.771***	0.737***	0.615***
Lubuskie	1.057**	0.874***	1.323***	0.874***	0.783***
Łódzkie	0.829***	0.605***	0.920***	0.605***	0.592***
Małopolskie	1.151***	2.434***	1.721***	2.434***	1.233***
Mazowieckie	0.964**	0.827***	1.995***	0.827***	2.142***
Opolskie	1.051**	0.701***	0.830***	0.701***	0.615***
Podkarpackie	0.663***	0.569***	0.661***	0.569***	0.568***
Podlaskie	1.299***	1.133***	2.393***	1.133***	0.767***
Pomorskie	1.169***	1.142***	2.967***	1.142***	28.594***
Śląskie	1.423***	1.033*	1.325***	1.033*	1.821***
Świętokrzyskie	0.716***	0.598***	0.654***	0.598***	0.609***
Warmińsko-mazurskie	1.123***	0.930***	1.400***	0.930***	1.933***
Wielkopolskie	1.269***	0.854***	1.262***	0.854***	0.672***
Zachodniopomorskie	0.950**	0.505***	0.963	0.505***	1.246***
Underlying cause (ref. cardiov.)					
Neoplasms	1.712***	11.255***	25.267***	11.256***	Not included
External causes	2.718***	7.426***	11.798***	7.426***	
Other	1.492***	0.865***	1.898***	0.866***	
Constant	0.899***	4.080***	5.105***	4.080***	88.398***
Pseudo R2	0.053	0.158	0.239	0.158	0.154
N	387,988				

Notes: [a] Explanatory variables take the value 1 when the underlying and/or contributing causes are well defined, and 0 otherwise; [b] significance levels: *** p<0.01, ** p<0.05; [c] more detailed results (i.e. 95% confidence intervals) available upon request.

Source: own elaboration based on Statistics Poland data.

Second, doctors certifying without post-mortem autopsies were more likely (by 5%) to indicate well-defined causes of death than physicians performing post-mortem autopsies. This rule is even stronger in all the other models, and may be related to the fact that post-mortem autopsies are often carried out in circumstances of death

that remain legally suspicious or unknown, that is where the death took place within 12 hours of hospital admission. Third, when the registered underlying cause was other than cardiovascular, the probability of well-defined medical content in the death certificate was considerably higher: in the case of deaths due to neoplasms this probability varied, depending on the model, from almost twofold (Odds Ratio 1.7) to 24-fold (25.3), in the case of external causes it varied from almost 3 (2.7) to 11 times higher (11.8) than for cardiovascular diseases. With the highest Odds Ratios, this variable most significantly determined the quality of medical descriptions.

The prevalence of MCoD by large groups of diseases

The Standardized Ratio of Multiple to Underlying cause (SRMU) is a ratio of the age-standardised mortality rate due to a condition recorded as the underlying or a contributing cause to the age-standardised mortality rate for the same condition recorded as the underlying cause. Consequently, whenever a disease is frequently selected as the underlying cause but not as the contributing cause, the SRMU is low. The SRMU equal to 1 represents a situation when a disease is selected exclusively as the underlying cause; the SRMU equals 2 when a disease is selected as often as the underlying and the contributing cause. In turn, when a disease is rarely assigned as the underlying cause of death, but often assigned as the contributing cause of death, the SRMU is higher than 2.

Table 5 presents the SRMUs for 16 ICD chapters and 45 more detailed cause-of-death groups. As in other MCoD studies, the SRMUs are the highest for the following ICD chapters: diseases of the blood and the blood-forming organs, which were indicated almost 17 times more often as the underlying or contributing causes than as the underlying causes only, diseases of the skin and subcutaneous tissue (almost 15 times more), diseases of the genitourinary system (5 times), mental and behavioural disorders (4.5 times), infectious and parasitic diseases (4 times). Within the more detailed groups of causes, the SRMUs are the most elevated for dementias (excluding Alzheimer's; SRMU of 20), hyperplasia of prostate (19), septicaemia (10), renal failure (9), obesity and diseases of the thyroid gland (both almost 8). For these diseases and groups of causes, loss of information is the greatest when the single-cause-of-death approach is applied. Contrary to my expectations, the SRMUs are relatively low for some diseases typical of ageing societies, such as neurological disorders (Parkinson's and Alzheimer's disease), acute and chronic respiratory diseases, other infectious and parasitic diseases, senility, and for some chronic diseases, such as cerebrovascular diseases and diabetes mellitus. But at the same time, some deaths due to these diseases are hidden in the categories of 'other' (most frequently: unknown or

unspecified) conditions within the ICD chapters. Relatively high SRMUs are noted for the following 'other' categories:

- other endocrine, nutritional and metabolic diseases: these diseases are very rarely assigned as underlying causes, and their SRMU is 22. In this category, the most frequent contributing causes are volume depletion (E86) and other disorders of fluid, electrolyte and acid-base balance (E87), that is conditions resulting from dehydration or dietary disorders typical of old age;
- other mental and behavioural disorders: these conditions are also very rarely assigned as underlying causes, and their SRMU is 117. In this category, the most important contributing causes are vascular dementia (F01), typical of old age, and unspecified organic or symptomatic mental disorder (F09);
- other diseases of the nervous system (SRMU 7), in particular other disorders of the brain (G93) and other disorders of the central nervous system (G96);
- other diseases of the respiratory system (SRMU 28), in particular the adult respiratory distress syndrome (J80), pulmonary oedema (J80) and pleural effusion, not elsewhere classified (J90);
- other diseases of the digestive system (SRMU 3), in particular hepatic failure, not elsewhere classified (K72), and other diseases of the digestive system (K92).

Table 5. Standardized mortality rates (SMR, per 100,000) and Standardized Ratio of Multiple to Underlying cause (SRMU), Poland 2013

Cause of death	ICD-10 code	SMR		SRMU
		Underlying	Underlying or contributing	
Infectious and parasitic diseases	A00-B99	4.01	16.14	4.02
Intestinal infectious diseases	A00-A09	0.55	1.38	2.5
Tuberculosis	A15-A19, B90	1.15	1.77	1.5
HIV disease	B20-B24	0.31	0.38	1.2
Viral hepatitis	B15-B19	0.51	0.67	1.3
Septicaemia	A40-A41	1.00	10.35	10.4
Other[a]	A00-B99[a]	0.49	1.58	3.2
Neoplasms	C00-D48	196.06	280.01	1.43
Malignant neoplasm of lip, oral cavity, pharynx	C00-C14	5.23	5.42	1.0
Malignant neoplasm of oesophagus	C15	3.05	3.13	1.0
Malignant neoplasm of stomach	C16	10.31	10.62	1.0
Malignant neoplasm of colon, rectum, anus	C18-C21	21.60	22.44	1.0
Malignant neoplasm of liver, intrahepatic bile ducts	C22	3.87	4.31	1.1
Malignant neoplasm of pancreas	C25	9.38	9.73	1.0

Cause of death	ICD-10 code	SMR		SRMU
		Underlying	Underlying or contributing	
Malignant neoplasm of larynx, trachea, bronchus, lung	C32-C34	49.39	51.53	1.0
Diseases of the blood (-forming organs)	D50-D89	0.62	10.37	16.7
Endocrine, nutritional and metabolic diseases	E00-E90	14.58	38.94	2.67
Diabetes mellitus	E10-E14	13.7	27.4	2.0
Malnutrition and other nutritional deficiencies	E40-E64	13.74	27.41	5.8
Obesity	E65-E69	0.30	1.74	7.8
Disorders of thyroid gland	E00-E07	0.08	0.65	7.8
Other[a]	E00-E90[a]	0.08	0.62	22.5
Mental and behavioural disorders	F00-F99	3.49	15.81	4.53
Dementias (excluding Alzheimer)	F00, F03, G31	0.27	5.47	20.3
Disorders due to alcohol abuse	F10	3.18	6.26	2.0
Drug dependence, toxicomania	F11–16, F18-9	0.01	0.03	2.9
Other[a]	F00-F99[a]	0.03	4.04	116.7
Diseases of the nervous system	G00-G99	11.06	41.10	3.72
Parkinson's disease	G20-G21	1.63	2.86	1.8
Alzheimer's disease	G30	3.73	4.99	1.3
Epilepsy	G40-G41	1.71	3.77	2.2
Other[a]	G00-G99[a]	3.99	29.49	7.4
Diseases of the circulatory system	I00-I99	300.61	615.72	2.05
Hypertensive diseases	I10-I15	7.69	21.61	2.8
Ischaemic heart diseases	I20-I25	75.16	112.76	1.5
Other heart diseases	I230-I33, I39-I45, I47-I52	86.11	265.14	3.1
Cerebrovascular diseases	I60-I69	58.45	103.77	1.8
Other[a]	I00-I99[a]	73.21	112.45	1.5
Diseases of the respiratory system	J00-J99	41.85	146.70	3.51
Influenza, pneumonia, other acute lower respiratory diseases	J00-J22	24.51	53.91	2.0
Asthma	J45-J46	0.99	1.70	1.7
Other chronic lower respiratory diseases	J40-J44	13.06	20.34	1.6
Lung diseases due to external agents	J60-J70	0.83	1.57	1.9
Other[a]	J00-J99[a]	2.47	69.18	28.1
Diseases of the digestive system	K00-K93	33.53	68.05	2.03
Ulcer of stomach, duodenum, jejunum	K25-K28	4.56	5.55	1.2
Chronic liver diseases	K70, K73-K74	13.86	17.60	1.3
Other[a]	K00-K96[a]	15.11	44.90	3.0
Diseases of the skin and subcutaneous tissue	L00-L99	0.31	4.55	14.79

Cause of death	ICD-10 code	SMR		SRMU
		Underlying	Underlying or contributing	
Diseases of the musculoskeletal system / connective tissue	M00-M99	1.25	2.57	2.06
Diseases of the genitourinary system	N00-N99	7.59	41.07	5.41
Renal failure	N17-N19	3.86	34.36	8.9
Hyperplasia of prostate	N40	0.01	0.19	19.3
Other[a]	N00-N99[a]	1.00	3.00	3.0
Complications of pregnancy, childbirth, puerperium	O00-O00	0.02	0.06	3.9
Certain conditions originating in perinatal period	P00-P96	3.33	12.90	3.9
Congenital malformations and chromosomal abnormalities	Q00-Q99	3.39	4.78	1.4
Senility	R54	18.72	23.87	1.3
Mechanisms of death[b]: cardiac arrest, shock	I46, R57	14.67	278.17	19.0
Other symptoms, signs, abnormal findings and ill-defined causes[c]	R00-R99	28.93	445.65	15.4
External causes[d]	S00-Y99	51.05	85.03	1.7

Notes: [a] The 'other' category consists of all codes within the same ICD chapter other than those mentioned; [b] cardiac arrest was excluded from diseases of the circulatory system, shock was excluded from other symptoms, signs, abnormal findings and ill-defined causes; [c] other than senility and shock; [d] as opposed to the underlying causes, the contributing causes could be denoted with S and T codes describing injury, poisoning and certain other consequences of external causes.

Source: own elaboration based on Statistics Poland data.

Three categories referring to ill-defined and unknown causes were distinguished: 1) senility (R54), 2) mechanisms of death describing the mode of dying rather than a morbid process, and including cardiac arrest (I46) and shock (R57), and 3) all other symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified (other R codes). With respect to the second category, more detailed causes (e.g. respiratory arrest – R09.2) could not be included, as contributing causes were denoted only with 3-digit alphanumeric ICD codes. Except for senility, the SRMUs for ill-defined and unknown causes are high, but such contributing causes can be informative only if the certified underlying cause was a well-defined one.

Conclusion

In line with WHO guidelines, the MCoD data in Poland are collected and used to verify medical content of death certificates and to determine ICD codes of underlying causes. Nevertheless, the procedures intended to guarantee the confidentiality of the deceased persons' medical information make MCoD analyses impossible, as all

information other than the ICD codes of underlying causes is destroyed at the final stage of data processing. Until death certificates are issued digitally on a large scale, multiple cause mortality analyses will be feasible only for 2013.

Medical doctors issuing death certificates often define contributing causes of death and, when they do so, frequently provide information on several medical conditions. Unfortunately, a large part of this information includes unknown and ill-defined codes or, more broadly, garbage codes that are useless for more detailed health policy studies. It seems that medical doctors issuing death certificates are unaware that such codes are viewed as garbage codes and unaware of the WHO's reservations about using these codes for the specification of causes of death. The most frequently assigned garbage code is generalised and unspecified atherosclerosis which, whenever a death certificate is issued by the cardiologist or primary care physician who treated the deceased person before death, could be easily replaced by a well-defined cardiovascular disease. The fact that most persons issuing death certificates fill in the ICD code of the underlying cause also proves that medical doctors do not know the rules specifying the medical content of death certificates and, more generally, are not familiar with the system established to gather, verify, and validate cause-of-death data, and in particular the role of medical coders.

Several conditions favour both the certification of well-defined underlying and contributing causes, and of a relatively high number of well-defined contributing causes. When death occurs in hospital, it is certified by a medical doctor without a post-mortem autopsy or takes place in the Małopolskie or Śląskie voivodship, it is more likely to be registered with non-R underlying and contributing causes and, at the same time, with comparatively many non-R contributing causes. Additionally, death certificates more likely include well defined (non-R) causes when registered in Pomorskie and when deaths are due to underlying causes other than cardiovascular. This shows that in each voivodship, the certification and coding practices are slightly different and depend largely on the work of medical coders, in particular their diligence in contacting the persons issuing death certificates.

The MCoD approach enables us to assess the impact of diseases that are rarely coded the underlying causes of death but contribute importantly to the overall mortality. Some results of the MCoD analysis for Poland are similar to the results obtained for other countries: for instance, the number of contributing causes is the lowest when the underlying cause is unknown, ill-defined or a neoplasm. In line with other studies, the analysis also highlights the importance of diseases that are rarely certified as the underlying cause, such as diseases of the blood and the blood-forming organs, diseases of the skin and subcutaneous tissue, diseases of the genitourinary system, non-Alzheimer dementias or mental and behavioural disorders. It also

shows that in order to investigate diseases typical of contemporary populations, it is necessary not only to focus on typical diseases of old age, but also to identify other specific causes, such as volume depletion or vascular dementia. This will be done in forthcoming detailed analyses of MCoD for Poland.

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