Chapter 5

Assessment of Avoidable Mortality Concepts in the European Union Countries, Their Benefits and Limitations

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Additional information is available at the end of the chapter

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Abstract

The concept of avoidable mortality is intended to assessing health care system performance. It is defined as premature deaths from selected disease groups that are considered either treatable through the timely and effective health care (amenable mortality), or preventable by public health interventions (preventable mortality). The purpose of study is to analyse the impact of four lists of causes of death created by researchers on amenable mortality by country, sex and cause of death. Data on deaths were obtained from the WHO database for 20 European Union countries in 2014. We applied the method of direct standardisation using the European Standard Population, Spearman rank-order correlation with statistical significance tests and confidence intervals. We found that the selection of diseases considered as amenable has not significantly impact on the cross-country comparison, but the weight of selected list of causes of death is significant at the national level. The concept has several limitations relating to selection of diseases and setting age threshold over time, availability of health care resources, prevalence of diseases or variation of causes of death coding among countries. However, indicator of avoidable mortality offers a way of the evaluating effectiveness of health systems in maintaining and improving population health.

Keywords: avoidable mortality, amenable mortality, preventable mortality, health care system performance, health policy

1. Introduction

Health systems play an important role in improving population health what closely relates to assessing the effectiveness of health care systems as one of the main dimensions of health

system performance. Evaluating the effectiveness of health care systems requires pre-defined objectives or the expected health outcomes that are usually measured by mortality and morbidity. More specifically, length of life and quality of life are examined. These aggregate indicators are not able to capture a clear impact of health care activities, especially quality of health care, on the health status of population. Therefore, more specific health outcome indicators were developed, e.g. avoidable mortality by selected causes of death, infant mortality, prevalence or incidence of chronic diseases, avoidable hospitalisations, and others [1].

The question of how much health care contributes to the health of populations has been discussed for several decades. Although there is no indicator that would comprehensively reflect the performance of health care system, nevertheless, the suitable measurement seems to be a concept of avoidable mortality. The concept of avoidable mortality, as an indicator for the quality of health care services, defines premature deaths from selected disease groups that are considered either treatable through the medical services or preventable by influencing the population characteristics [2].

From the beginning 1970s, many researchers have tried to renew the list of causes of death considered as amenable by health care or preventable by health interventions (see Chapter 2). Unfortunately, many studies did not demonstrate the selection process of avoidable causes of death. This is a bias that raises a question if this concept is not influenced by subjective approach of the given researchers. Has this concept a potential to be applied both at national and international levels?

The main objective of this study is to analyse the impact of the four lists of causes of death on amenable mortality by country, sex and cause of death. By application of several methods of avoidable mortality, we have an ambition to point out possible fluctuations in their results and limitations of international comparison. These raise an appeal for confrontation of the scientific teams at national and international levels and for the development of comparative international baseline. The most innovative part of the study is disputation whether the concept of avoidable mortality is reliable for international health systems comparison or not.

This chapter consists of six sections. Theoretical background of avoidable, amenable and preventable mortality, together with a literature review follows Section 1. Section 3 presents the description of the two recent modifications of the concept including cause of death structure. Section 4 deals with the empirical analyses of amenable mortality differentials across the European Union countries and describes the data and methods used. Section 5 provides a discussion about the potentials or limitations of the concept applied. The most meaningful conclusions are summarised at the end of the chapter.

2. Development of the concept of avoidable mortality

The concept of avoidable mortality was developed by Rutstein et al. [3]. They suggested that several diseases at certain ages should not occur in the presence of timely and effective health care. Additionally, they distinguished the diseases that should be amenable by the quality

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of health care (e.g. diabetes mellitus treated with insulin) and those that were influenced by public health policy interventions (e.g. lung cancer prevented by smoking elimination). Their list of causes of death included more than 90 diseases considered as unnecessary, untimely causes of death and disabilities. Many research studies have tried to renew the list over time adjusting to the new medical and technological advances. In 1983, Charlton et al. [4] modified the number of conditions on 14 disease groups and excluded deaths that were not directly associated with health care, for example, deaths avoided by public health prevention programs comprising alcohol or tobacco consumption. At the end of the 1980s, the concept was proceeded by several researchers [5, 6], but the highest progress was achieved by Holland [7] who created a European Community atlas of avoidable mortality modifying the previous authors. As for a main benefit of the atlas, strict distinguishing between types of health care services on primary care, hospital care and collective health services was interpreted. In 1993 and 1997, second and third editions of atlas adjusting the number of diseases were created by Holland [8, 9] again, and further developed by other authors [10–13]. In spite of changing list of causes of death, age limit was mostly set at 65 years, what was about the average life expectancy in developed countries in those years. According to experts, above this age, the treatment of selected diseases is less obvious and appearance of co-morbidities becomes problematic.

In 2001, Tobias and Jackson [14] derived the weights for primary, secondary and tertiary health interventions on the basis of a medical expert consensus. For example, avoidability of deaths from HIV/AIDS was distributed according to the primary level with weights 0.9, the secondary level with weights 0.05 and the tertiary level weighted 0.05. To compare, deaths from hypertensive disease were avoidable first by secondary interventions with weights 0.65, second by tertiary interventions with weights 0.3 and finally by primary interventions weighted 0.05. Unfortunately, all above-mentioned proposals of the concept of avoidable mortality did not consider the availability of health care resources such as current technology, medical skills, human resources or health expenditures in a certain country.

A new perspective view on the concept was presented by Nolte and McKee [15] in 2004. They conducted a broad review of randomised controlled trials providing the evidence of impact of health services on survival taking into account advances in medical knowledge and technology across the European Union countries during the 1980s and 1990s. The previous lists of causes of death created by Mackenbach et al. [6] or Charlton et al. [4] were changed on 34 groups of diseases comprising amenable, preventable conditions and ischaemic heart disease separately. Ischaemic heart disease was represented as a separate group because the highest number of these deaths could bias the influence of health services on other diseases. Additionally, the concept considers only 50% of deaths from ischaemic heart disease. Another reason was that ischaemic heart disease could be understood partially as amenable but also as preventable cause of death. Some causes of death were added to the list and some were removed. For example, malignant neoplasm of prostate was not included because an available time trends analysis of cancer mortality showed a small decrease of mortality from prostate cancer, together with the uncertain impact of screening. On the other hand, they included colorectal cancer on the basis of randomised controlled trials providing that curative resection had a significant impact on survival. Establishing an upper

age limit varied across diseases. The vast majority were set at 75 years, with the exception of diabetes mellitus (lower than 50 years), some infectious and respiratory diseases (lower than 15 years), malignant neoplasm of cervix uteri and body uterus, as well as leukaemia (lower than 45 years). This was the result of studies that reported substantial improvements in mortality from these diseases relating to advances in treatment before mentioned age limits.

The concept was further renewed analysing European and non-European countries due to the works by Nolte and McKee [16] in 2008 and Tobias and Yeh [17] in 2009. Nolte and McKee closely followed up their last list of causes of death from 2004, while Tobias and Yeh discussed some new inclusion and exclusion criteria. Infectious diseases varied significantly. While Nolte and McKee concentrated on infectious disease of children before the age of 15, Tobias and Yeh focused on selective invasive bacterial infections such as scarlet fever, meningococcal infection, etc. They argued that early detection and treatment by antibiotic therapy decrease mortality substantially. Moreover, only half of the mortality from cerebrovascular diseases, ischaemic heart disease and diabetes mellitus are considered as amenable by appropriate health care according to Tobias and Yeh, because the second half can be preventable by health behaviours (e.g. healthy lifestyle, obesity prevention). The authors of mentioned lists of diseases have different opinions on setting age limit for some causes of death; however, there are more similarities than discrepancies between these two lists of diseases (**Table 1**).

Cause of death	Nolte and McKee [16] ICD-10	Tobias and Yeh [17] ICD-10
Infectious disease		
Tuberculosis	A15–A19, B90	A15–A19, B90
Selected invasive infections:		
Intestinal infectious diseases	A00–A09 (age 0–14)	Non-classified
Whooping cough	A37 (age 0–14)	Non-classified
Measles	B05 (age 1–14)	Non-classified
Tetanus and Diphtheria	A35–A36	Non-classified
Sepsis	A40–A41	A40–A41
Scarlet fever	Non-classified	A38
Meningococcal infection	Non-classified	A39
Acute poliomyelitis	A80	Non-classified
Influenza	J10–J11	Non-classified
Pneumonia	J12–J18	J13–J15, J18
Erysipelas	Non-classified	A46
Legionnaires disease	Non-classified	A481
Malaria	Non-classified	B50–B54

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Cause of death	Nolte and McKee [16] ICD-10	Tobias and Yeh [17] ICD-10
Meningitis	Non-classified	G00, G03
Cellulitis	Non-classified	L03
Neoplasms		
Colorectal cancer	C18–C21	C18–C21
Malignant neoplasms of skin	C44	C43–C44
Breast cancer	C50	C50
Cervical cancer	C53	C53
Uterine cancer	C54–C55 (age 0–44)	C54–C55
Testis cancer	C62	Non-classified
Bladder cancer	Non-classified	C67
Thyroid cancer	Non-classified	C73
Hodgkin's disease	C81	C81
Leukaemia	C91–C95 (age 0–44)	C91–C95 (age 0–44)
Benign neoplasms	Non-classified	D10–D36
Diabetes mellitus (type 2)	E10–E14 (age 0–49)	E10–E14 (50% of deaths)
Ischaemic heart disease	I20–I25 (50% of deaths)	I20–I25 (50% of deaths)
Other circulatory disease		
Rheumatic and other valvular heart disease	I05–I09	I01–I09
Hypertensive heart disease	I10–I13, I15	I11
Cerebrovascular diseases	I60–I69	I60–I69 (50% of deaths)
Respiratory diseases (excl. pneumonia, influenza) (age 1–14)	J00–J09, J20–J99	Non-classified
Chronic obstructive pulmonary disease	Non-classified	J40–J44 (age >45)
Asthma	Non-classified	J45–J46 (age 0–44)
Surgical conditions		
Peptic ulcer disease	K25–K27	K25–K28
Appendicitis	K35–K38	K35–K38
Hernia	K40–K46	K40–K46
Cholelithiasis, cholecystitis	K80–K81	K80–K83
Pancreatitis	Non-classified	K85–K86
Postcholecystectomy syndrome	Non-classified	K915
Nephritis and nephrosis	N00–N07, N17–N19, N25–N27	I12–I13, N00–N09,N17–N19
Obstructive uropathy and prostatic hyperplasia	N40	N13, N20–N21, N35, N40, N991

Cause of death	Nolte and McKee [16] ICD-10	Tobias and Yeh [17] ICD-10
Misadventures to patients during surgical and medical care	Y60–Y69, Y83–Y84	Non-classified
Maternal, congenital and perinatal conditions		
Maternal deaths	O00–O99	Non-classified
Perinatal deaths, all causes (excl. stillbirths)	P00–P96	H311, P00, P03–P95
Congenital malformations	Q20–Q28	Q00–Q99
Other conditions		
Thyroid disorders	E00–E07	E00–E07
Epilepsy	G40–G41	G40–G41

Note: Age group used for calculation is 0–74 except if otherwise mentioned.
Source: Own processing based on Nolte and McKee [16] and Tobias and Yeh [17].

Table 1. Causes of death selected in the amenable mortality list of Nolte and McKee [16] and Tobias and Yeh [17].

The second latest study 'Amenable mortality in the European Union: toward better indicators for the effectiveness of health systems' (AMIEHS) [18] in 2011 introduced an empirical evidence of selecting diseases into the lists of causes of death. Finally, a recent project has referred to the avoidable mortality indicators defined according to the Eurostat 'Satellite List' Task Force [19] in 2013. A common objective of these studies is to reach a consensus by countries of the European Community about the definition and selection of causes of avoidable deaths. Both studies are further described in Section 3 more specifically for the purposes of our analysis.

3. Conceptual methods

3.1. AMIEHS project from 2011

The AMIEHS project (Amenable mortality in the European Union: toward better indicators for the effectiveness of health systems) was introduced in 2011 by researchers representing prestigious universities from seven EU countries: the Netherland, the United Kingdom, Sweden, France, Estonia, Germany and Spain.

The main aim of this project is to develop an agreed definition of amenable mortality for Europe and introduce a renewed way of selecting diseases into the lists of causes of death that are amenable by health care which can be used in assessing effectiveness of health systems. They applied strict selection process of diseases based on the consecutively conducted analyses. First, they identified 54 diseases for which mortality declined more than 30% between 1979 and 2000, and for which the number of deaths in 2000 exceeded 100 in England or Wales. These countries were selected because they disposed the most consistent data over

this period. Second, they conducted a systematic review of the literature in order to identify health care interventions, which were introduced in 1970–2000 and shown as effective in reducing mortality.

Evidence of effectiveness of interventions was evaluated on a four-point scale. The highest grade was denoted as (4)—evidence from systematic reviews or meta-analysis; (3)—randomised controlled trial; (2)—observational studies; and (1)—consensus statements or expert opinions. Grade of evidence of the decrease in mortality of 30% or more due to effective impact of health care interventions was evaluated on a three-point scale: (3)—evidence from population-based registers (e.g. cancer registries) of reduction in mortality; (2)—published studies describing decline in mortality at population level where investigation has identified health care interventions as the most likely explanation; and (1)—published studies describing decline in mortality at population level where investigation has identified health care interventions as one among several explanations.

However, the strength of the evidence was variable, only few interventions had the highest grade and many interventions were supported by evidence from observational studies only. The highest levels of evidence were observed, for example, in HIV-related mortality that between 1996 and 1998 fell by 60% in the United States due to the key intervention attributable to the azidothymidine and zidovudine applied in the late 1980s. Evidence of patient-level studies reflected a major influence of treatment on mortality during the early 1990s. The result of these efforts was the list of 16 causes of death for which a review of the literature indicated the appropriate level of evidence of treatment (**Table 2**). Those causes of death, in which successful health care interventions were introduced before 1970, e.g. infectious diseases treated successfully with antibiotics or diabetes by insulin were eliminated from the list of amenable causes of death.

Cause of death	AMIEHS (2011) ICD-10	EUROSTAT (2013) ICD-10
Infectious disease		
Tuberculosis	Non-classified	A15–A19, B90
Selected invasive bacterial and protozoal infections	Non-classified	A38–A41, A46, A481,B50–B54, G00, G03, J02, L03
Hepatitis C	Non-classified	B171, B182
HIV	B20–B24	B20–B24 (all ages)
Neoplasms		
Colorectal cancer	C18–C21	C18–C21
Malignant neoplasms of skin	Non-classified	C43
Breast cancer	C50	C50
Cervical cancer	C53	C53
Testis cancer	C62	Non-classified
Bladder cancer	Non-classified	C67

Cause of death	AMIEHS (2011) ICD-10	EUROSTAT (2013) ICD-10
Thyroid cancer	Non-classified	C73
Hodgkin's disease	C81	C81
Leukaemia	C91	C91, C920 (age 0–44)
Benign neoplasms	Non-classified	D10–D36
Diabetes mellitus (type 2)	Non-classified	E10–E14 (age 0–49)
Ischaemic heart disease	I20–I25	I20–I25
Other circulatory disease		
Rheumatic and other valvular heart disease	I00–I09	I01–I09
Hypertensive heart disease	I10–I13	I10–I15
Heart failure	I50–I51	Non-classified
Cerebrovascular diseases	I60–I69	I60–I69
Respiratory diseases		
Influenza (including swine flu)	Non-classified	J09–J11
Pneumonia	Non-classified	J12–J18
Asthma	Non-classified	J45–J46
Surgical conditions		
Gastric and duodenal ulcer	K25–K26	K25–K28
Acute abdomen, appendicitis, intestinal obstruction, cholecystitis/ lithiasis, pancreatitis, hernia	Non-classified	K35–K38, K40–K46, K80–K83, K85, K861–K869, K915
Nephritis and nephrosis	N17–N19	N00–N07, N17–N19, N25–N27
Obstructive uropathy and prostatic hyperplasia	Non-classified	N13, N20–N21, N35, N40, N991
Congenital and perinatal conditions		
Complications of perinatal period	P00–P96	P00–P96, A33 (all ages)
Congenital malformations, deformations and chromosomal anomalies	Q20–Q24	Q00–99
Other condition		
Epilepsy and status epilepticus	Non-classified	G40–G41
Misadventures to patients during surgical and medical care	Non-classified	Y60–Y69, Y83–Y84 (all ages)

Note: Age group used for calculation is 0–74 except if otherwise mentioned.

Source: Own processing based on AMIEHS and EUROSTAT's proposals.

Table 2. Comparison of the AMIEHS and the EUROSTAT's list of causes of death considered amenable to health care.

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For each selected cause of death, mortality trends were analysed using regression analyses to specify points in time at which the mortality trend changed significantly. They applied age limit 75 years of age. The trend analyses examined the validation of amenable mortality indicators. The results were also validated by a Delphi method where experts assessed the likelihood that variations in mortality from the pre-selected conditions reflect variations in the effectiveness of health care. Surprisingly, the experts reached consensus on only three diseases: colorectal cancer, cervical cancer and cerebrovascular disease. These results raise doubts about availability of amenable mortality as a valid indicator of effectiveness of health systems in international comparisons. Their analyses showed that although the treatment for surgical emergencies has been known for decades, mortality has continued to decline, reflecting a combination of some other factors, for example, increasing skill in treatment or better treatment of complications. However, the AMIEHS project has proved that amenable mortality partially reflects the impact of health care innovations but must be interpreted with other analyses examining such as quality of health care utilisation or access to health care resources.

Finally, an electronic atlas of amenable mortality was prepared that provides trends of standardised mortality rates in European countries according to the list of causes of death over the period 2001–2009 [20].

3.2. Eurostat task force on satellite lists of causes of death from 2013

At the request of European member states, policy makers and experts in the field of public health to enhance information on specific groups of causes of death, Eurostat established a Task Force for revising a Satellite Lists of causes of death information on major public health issues. These public health themes also include the two concepts of avoidable mortality: amenable and preventable deaths. This satellite list should serve as a comprehensive information platform on at-risk groups of population in the European countries. The Task Force had some meetings were decided to consider the list of avoidable causes of death based on the three publications by the Office for National Statistics of the United Kingdom.

First of them, the consultation document [21] from February 2011 consists of the literature review, comparative analyses of existing selections of causes and consultations with experts to agree or disagree with the proposed disease classification. A public consultation was running between February and April 2011. The second one was the 'Responses to the public consultation on definitions of avoidable mortality' [22] from August 2011. This document contains 20 responses to the consultation document from various medical experts on five key questions of revising the definition of avoidable mortality concept. These questions related to the proposed causes of death to be included in amenable or preventable mortality, agreement or disagreement with the proposals on age limits, and how they would change them. Third, the final definition of avoidable mortality was presented in a document 'Definition of avoidable mortality' [23] at the end of 2011.

The Members of Eurostat's Working Group of Public Health Statistics approved the list of diseases and age groups proposed by the Office for National Statistics of the United Kingdom. Hence, the Eurostat 'satellite lists' Task Force tested this proposed selection of causes of death

by Delphi method; unfortunately, those results are not disseminated. The final EUROSTAT Satellite List defining causes of death considered as amenable or preventable is available at Eurostat web page [24]. We present the list of causes considered to be amenable in **Table 2**.

As one should notice, the development of concept of avoidable mortality has been considerably influenced by the evidence from clinical research studies or consultation that has confirmed the impact of health care or public health interventions on declining mortality. However, a considered time period has played an important role in creating the unique list of selected diseases, because medical knowledge and technology have advanced over time what subsequently has an impact on inclusion or exclusion criteria by which a list of amenable or preventable causes of death is made. Therefore, the lists of causes of death amenable to health care need to be regularly updated in relation to current medical practice.

3.3. Office for national statistics in England

Although avoidable mortality has been investigated for the last four decades, there is still small consensus among researchers about how to define it. Last precise definitions of the concept are presented by the Office for National Statistics in England [25]. Following definitions were developed through an iterative public consultation running in 2015.

3.3.1. Avoidable mortality

Avoidable deaths are all those defined as preventable, amenable (treatable) or both, where each death is counted only once; where a cause of death is both preventable and amenable, all deaths from that cause are counted in both categories when they are presented separately.

3.3.2. Amenable mortality

A death is amenable (treatable) if, in the light of medical knowledge and technology at the time of death, all or most deaths from that cause (subject to age limits if appropriate) could be avoided through good quality healthcare.

3.3.3. Preventable mortality

A death is preventable if, in the light of understanding of the determinants of health at time of death, all or most deaths from that cause (subject to age limits if appropriate) could be avoided by public health interventions in the broadest sense.

4. Analysis

In our analysis, we examine the impact of the lists of causes of death on amenable mortality by country, sex and cause of death. We compare the results of amenable mortality across the European Union (EU) countries calculated by the four lists of causes of death. Then, we are

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interested whether the two latest developed lists (AMIEHS and EUROSTAT) have a statistically significant impact on amenable mortality in Slovakia identifying the most influential group of diseases.

4.1. Data and methods

This section introduces what kind of dataset and methods are applied on the estimation of age-standardised amenable death rates when comparing the EU countries. It also includes information how significances of the results have been tested.

4.1.1. Data

Our main source of mortality data is the raw data files of the WHO Mortality Database, where the causes of death are coded using the ICD-10 classification at fourth digit level by five-year age groups. We conduct analysis on data from 2014, as it is the latest available time point. The data in the required structure for calculation of amenable mortality are available for 19 EU countries, while other EU countries do not meet the requirements of this analysis due to data incompleteness at some age groups. We select causes of death that are proposed by the Nolte and McKee, Tobias and Yeh, AMIEHS, EUROSTAT's list regardless to the age limit. Statistical database of the United Nations Economic Commission for Europe is the main source for data on mid-year population at the age groups. For comparison of mortality across EU countries, we adopt the European standard population by age groups according to the last revision in 2012, proceeding in 2013 [26].

4.1.2. Methods

We estimate age-standardised amenable death rates per 100,000 population by the direct method of standardisation to overcome an effect from variations in the age and sex structure across countries. First, the age and sex-specific death rates for the given causes of death are calculated in each examined country. Second, the age-specific death rate and the European standard population for each age interval are multiplied, and these results are summed. Finally, this sum is divided by the total standard population, in our case 100,000, to calculate the age-standardised death rate [27].

Two directly standardised rates calculated by the same standard population can be compared, and differences tested for statistical significance. To determine an association of countries' rank order according to the standardised death rates between the lists each other, we run a Spearman rank-order correlation with statistical significance tests. Probability values are computed from a *t*-distribution with N-2 degrees of freedom.

To find out whether age-standardised rates of amenable mortality based on the two lists are significantly different by sex and causes of death in Slovakia, we calculate 95% confidence intervals that are equivalent to statistical tests. As a general rule, a difference is statistically significance if a confidence interval around rate non-overlap with the interval around another [28]. Calculations are made using statistical software R Studio.

4.2. Between-list differences of amenable mortality across the European Union countries

This section compares the results of age standardised death rates across the European Union countries based on data from 2014 using the four evolutionarily most recent selections of amenable diagnoses. We tested the six null hypothesis statements (H_0) against the six alternative hypotheses (H_1):

- H_0: There is no association between the standardised death rates calculated by Nolte and McKee's list and the standardised death rates calculated by Tobias and Yeh's list.
- H_1: There is an association between the standardised death rates calculated by Nolte and McKee's list and the standardised death rates calculated by Tobias and Yeh's list.
- H_0: There is no association between the standardised death rates calculated by Nolte and McKee's list and the standardised death rates calculated by AMIEHS's list.
- H_1: There is an association between the standardised death rates calculated by Nolte and McKee's list and the standardised death rates calculated by AMIEHS's list.
- H_0: There is no association between the standardised death rates calculated by Nolte and McKee's list and the standardised death rates calculated by EUROSTAT's list.
- H_1: There is an association between the standardised death rates calculated by Nolte and McKee's list and the standardised death rates calculated by EUROSTAT's list.
- H_0: There is no association between the standardised death rates calculated by Tobias and Yeh's list and the standardised death rates calculated by AMIEHS's list.
- H_1: There is an association between the standardised death rates calculated by Tobias and Yeh's list and the standardised death rates calculated by AMIEHS's list.
- H_0: There is no association between the standardised death rates calculated by Tobias and Yeh's list and the standardised death rates calculated by EUROSTAT's list.
- H_1: There is an association between the standardised death rates calculated by Tobias and Yeh's list and the standardised death rates calculated by EUROSTAT's list.
- H_0: There is no association between the standardised death rates calculated by AMIEHS's list and the standardised death rates calculated by EUROSTAT's list.
- H_1: There is an association between the standardised death rates calculated by AMIEHS's list and the standardised death rates calculated by EUROSTAT's list.

Table 3 reports the Spearman's rank correlation matrix with a statistical significance of correlation coefficients. All calculated probability values achieved a value of $p < 0.001$, what means that we can reject the null hypothesis. In other words, despite any concept of amenable mortality applied, there is a significant very strong positive correlation of the standardised death rates. Generally, the Spearman's correlation test calculated on standardised death rates of amenable causes using the Nolte and McKee, Tobias and Yeh, AMIEHS or EUROSTAT's concepts, shows that the *rank order of countries does not change significantly*.

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	sdr_NOLTE & McKEE	sdr_TOBIAS & YEH	sdr_AMIEHS	sdr_EUROSTAT
sdr_NOLTE & McKEE	1.0000000	0.9403509	0.9877193	0.9807018
p-value	*8.377e-06*	*4.836e-06*	*8.402e-06*	*8.267e-06*
sdr_TOBIAS & YEH	0.9403509	1.0000000	0.9333333	0.9456140
p-value	*4.836e-06*	*8.377e-06*	*3.74e-06*	*5.562e-06*
sdr_AMIEHS	0.9877193	0.9333333	1.0000000	0.9894737
p-value	*8.402e-06*	*3.74e-06*	*8.377e-06*	*8.418e-06*
sdr_EUROSTAT	0.9807018	0.9456140	0.9894737	1.0000000
p-value	*8.267e-06*	*5.562e-06*	*8.418e-06*	*8.377e-06*

Note: Probability values computed from a t distribution with N-2 degrees of freedom. *N* = 19.
Source: Own calculation using R Studio.

Table 3. Spearman's rank correlation matrix with *p*-values calculated for standardised death rates (sdr) by country based on the four lists of amenable causes, 2014.

These results are depicted in **Figure 1**. The four lists provide different levels of amenable mortality rates for countries; however, the rank order of countries is very similar. In 2014, France accounted for the best results of amenable mortality obtained from the all examined lists, ranged from 61 to 79 deaths per 100,000 population. On the other hand, the worst rate was recorded in Romania, 275 per 100,000 calculated by Nolte and McKee's list, as well as an average of 309 deaths per 100,000 in Latvia estimated by three remaining lists.

Generally, the standardised death rates for EU-19 calculated by Eurostat's list were 40.5% higher than rates calculated by Nolte and McKee's list. On the other hand, the rates calculated according to the lists of Tobias and Yeh or AMIEHS were nearly the same, 161 per 100,000, 162 per 100,000, respectively. Using the Nolte and McKee's list, the amenable mortality rates for EU-19 reached the lowest value, 128 deaths per 100,000 population. The standard deviations (not shown in this document) expressing the rate of variability of standardised amenable death rates between lists, gained the highest values in Eastern European countries (Latvia, Lithuania, Slovakia, Hungary, Romania, the Czech Republic, Poland), along with Denmark, Estonia, the United Kingdom, Croatia, had still standard deviations above the average of EU-19. A gradual decline of the variation in amenable mortality rates, below an average of EU-19, was demonstrated in the Netherlands, Germany, Luxembourg, Malta, Sweden, Finland, Spain and France.

Observed between-list differences of the level of standardised amenable death rates in the EU countries are due to discrepancies in selected diseases and age limits. However, when assessing the effectiveness of health systems in examined countries, it has not changed significantly.

4.3. The impact of AMIEHS and EUROSTAT's list on amenable mortality by cause of death in Slovakia

The analysis examines whether age-standardised rates of amenable mortality based on AMIEHS or EUROSTAT's list are significantly different by sex and causes of death in Slovakia. We apply both lists on data for 2014.

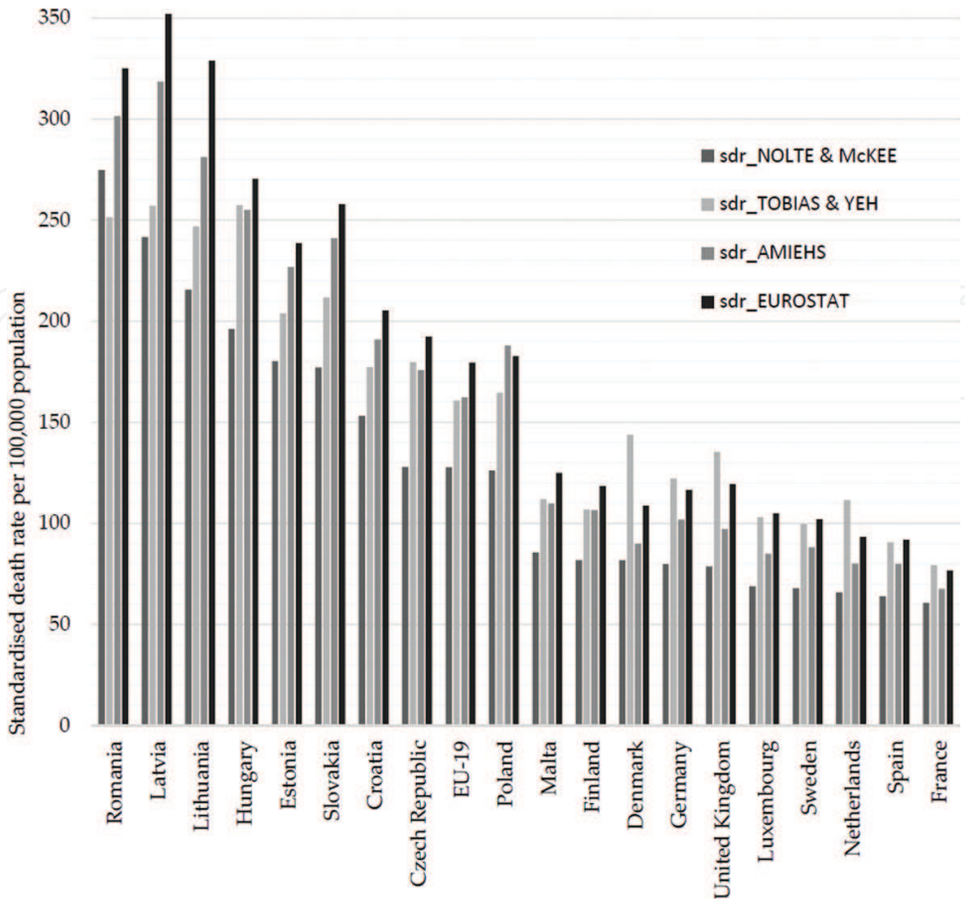

Figure 1. Amenable mortality across the European Union countries by the four lists of causes of death, 2014. *Source*: Own calculation based on the data from WHO mortality database.

In Slovakia, there was a considerable increase in the number of deaths considered amenable, from 9325 by the AMIEHS's list to 10,451 under the EUROSTAT's list. Of the additional 1126 deaths, 753 were for men and 373 for women. The increase occurred in all age groups, mostly after 55 years of age, and also not negligibly in the children aged from 0 to 4 years. The majority of the increase was due to the inclusion of respiratory diseases in the EUROSTAT's list that contributed 585 deaths of the 1126 deaths. The increase in the number of amenable deaths revealed that the total amenable mortality rates, as well as the rates for men and women, calculated by EUROSTAT's list were *significantly higher* (by 14.2% for men and 11.3% for women) than the rates under the AMIEHS's list. Generally, a difference is statistically significance if a confidence interval around rate non-overlap with the interval around another (**Table 4**).

Table 5 reflects the age-standardised amenable mortality rates, based on the AMIEHS and EUROSTAT's list (with 95% confidence intervals) by broad cause group in Slovakia, 2014.

Besides the inclusion of respiratory diseases in the EUROSTAT's list, the increases in the number of deaths were also due to the inclusions of epilepsy contributing 96 deaths, diabetes with 37 deaths and misadventures to patients during surgical and medical care adding 15 deaths. Thus,

	AMIEHS's list				EUROSTAT's list			
Sex	**Number of deaths**	**Rate per 100,000 population**	**Lower 95% CI**	**Upper 95% CI**	**Number of deaths**	**Rate per 100,000 population**	**Lower 95% CI**	**Upper 95% CI**
Men	5730	290.3	282.6	298.0	6483	331.4	323.9	338.9
Women	3595	150.1	145.2	155.0	3968	167	162.3	171.7
Total	9325	212.6	208.2	217.0	10,451	240.1	235.9	244.3

Note: CI, confidence interval.

Source: Own calculation based on the data from WHO mortality database.

Table 4. Number of deaths and standardised amenable death rates based on AMIEHS or EUROSTAT's list in Slovakia, 2014.

	AMIEHS's list				EUROSTAT's list			
Cause group	**Number of deaths**	**Rate per 100,000**	**Lower 95% CI**	**Upper 95% CI**	**Number of deaths**	**Rate per 100,000**	**Lower 95% CI**	**Upper 95% CI**
All amenable causes	9325	212.6	208.2	217.0	10,451	240.1	235.9	244.3
Infectious disease	1	0.02	0.0	0.06	159	3.5	3.0	4.0
Neoplasms	2020	44.6	42.6	46.6	2,324	52.2	50.2	54.2
Diabetes mellitus (type 2)	nc	nc	nc	nc	37	1.1	0.9	1.3
Ischaemic heart disease	4184	96.6	93.6	99.6	4184	96.6	93.6	99.6
Other circulatory disease	2650	61.3	58.9	63.7	2276	53.5	51.5	55.5
Respiratory diseases	nc	nc	nc	nc	585	13.4	12.4	14.4
Surgical conditions	275	6.3	5.6	7.0	465	10.5	9.6	11.4
Congenital and perinatal conditions	195	3.7	3.2	4.2	310	5.7	5.1	6.3
Epilepsy and status epilepticus	nc	nc	nc	nc	96	2.0	1.6	2.4
Misadventures to patients during surgical and medical care	nc	nc	nc	nc	15	0.3	0.1	0.5

Note: nc, non-classified.

Source: Own calculation based on the data from WHO mortality database.

Table 5. Standardised amenable mortality rates based on the AMIEHS and EUROSTAT's list (with 95% confidence intervals) by broad cause group in Slovakia, 2014.

additional causes of death included in the EUROSTAT's list accounted for 12.1%. A largest share in both lists is presented by ischaemic heart disease representing 44.9% under the AMIEHS's list and 40% in the EUROSTAT's list. However, standardised death rate of ischaemic heart disease has not changed when comparing the two lists. The other circulatory disease reported the statistically significant decrease of standardised death rates by 14.1% in the EUROSTAT's list contrary to the AMIEHS's list that was due to the exclusion of heart failure from the group. However, heart failure represented a substantial cause accounted for 14.1% in the group of other circulatory disease under the AMIEHS's list. In spite of the fact that infectious disease reflected the lowest numbers of deaths in the both lists, they recorded the largest statistically significant increase under the EUROSTAT's list because of the additional causes of death (tuberculosis, hepatitis C, selected invasive bacterial and protozoal infections) to the HIV contained in the AMIEHS's list. Moreover, in the HIV cause group, there was the extension of the age limit on the all age groups, whereas the age limit 0–74 years was included in the AMIEHS's list. In the neoplasms cause group, there was a statistically significant increase in the number of deaths by 15% mainly because of the addition of malignant neoplasms of skin and bladder cancer to the EUROSTAT's list and the shortness of the upper age limit of leukaemia. Finally, the standardised death rates for the surgical, congenital and perinatal conditions increased significantly under the EUROSTAT's list by 69.1 and 59%, respectively, mainly due to the inclusion of some surgical conditions (acute abdomen, appendicitis, intestinal obstruction, etc.) and the extension of the scope of congenital malformations to the overall 17 chapters of ICD-10.

5. Discussion about conceptual problems

While avoidable mortality seems to be an innovative indicator for measuring the effectiveness of medical services, it has number of limitations resulting from the data sets relevance, as well as the concept itself. It is very important to clearly distinguish between the meaning of the avoidable, amenable and preventable mortality. These terms are often mixed up what lead to the confusion in their interpretation. For example, interpreting the decrease in avoidable mortality only such as observing a positive impact of treatment can mask an effective introduction of public health interventions.

Since health care system characteristics as well as their levels of accessibility vary from country to country, there is an absence of international agreement on the uniform selection of causes of death and age limit in the cross-country comparison. Although the methodologies strictly do not distinguish causes of death or age limits for men and women separately, it would be useful to further develop the concept of avoidable mortality differentiating age limits for males and females to reflect the greater longevity of women. In our complementary analyses [29, 30], we found that amenable mortality is generally higher in men than in women, irrespective of the four concept used. The differences between men and women are much higher in countries with higher amenable mortality than in countries with lower amenable death rates. These facts are consistent with the findings of a research project AMIEHS. It declares that the disparity between male and female premature mortality is partially determined by the provision of health care.

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This concept does not take into account the fact that different countries do not have the same health care resources needed for effective treatment, such as available new required technologies, medical skills or sufficient number of professionals. Additionally, it is not monitored whether countries secure distribution and dissemination of the necessary resources. For this reason, avoidable mortality should be interpreted in the context of many other available characteristics of health care system performance in the country. Hence, avoidable mortality can be an effective indicator in the assessment of progress achieved by the country in a certain time period.

The lack of resources can lead to the increase of disease prevalence that is not adjusted in the amenable mortality indicator. For example, based on our previous study [31], Slovakia has gained the worst values of standardised mortality rate of ischaemic heart disease (above 500 deaths per 100,000) across the European countries in the long term. In this case, we should find out whether incidence or prevalence of ischaemic heart disease was not significantly increased in the examined time period, otherwise, we might interpret mistakenly a decrease of the quality of health care by an ineffective treatment of ischaemic heart disease or prevention programs in Slovakia. It is useful to assess the individual diagnosis in the given countries, as the countries with high levels of avoidable mortality tend to have a high level of mortality in individual cases.

Additionally, we see a disadvantage of variations in diagnostic practices and cause of death coding between countries, what also impacts both on international comparison and national level assessment of amenable mortality. We found out that by 2009, causes of death were coded at the third digit level (e.g. B17), while since 2010 at the fourth digit level (e.g. B171). These discrepancies may have led to the distortion of comparison of causes of death over time. The use of EUROSTAT's list before 2010 could overvalue the number of deaths, since the whole group of 'other acute viral hepatitis' (B17) would have been considered instead of 'hepatitis C' (B171).

One of the reasons for the benefits of composing the avoidable mortality concept at the national level, supported by previous studies of AMIEHS and Office for National Statistics, may be a time lag between the improved of health care services or introduction of a public health prevention program and a corresponding decrease of amenable mortality. Based on AMIEHS, a time lag was 7 years, while the Office for National Statistics in England suggests that selection of avoidable causes of death should be updated every 3 years.

We have to realise that variations in avoidable mortality are also influenced by socio-economic factors, which can mask the impact of health care system effectiveness. We consider as the main limitation of the concept of avoidable mortality the fact that many factors beyond the health system influence mortality and an indicator of avoidable mortality does not capture many of them. Therefore, cross-country comparison based only on this indicator can be biased. Other complementary indicators such as health services supply, health expenditures or gains in quality of life should be used in combination with avoidable mortality indicators to assess the effectiveness of the health care system.

Permanent evaluation of the concept based on the epidemiological studies, availability of health technologies and interventions supported by empirical evidence could help create an effective tool for measurement avoidable mortality mainly at the national level.

6. Conclusion

The aim of this study is to compare the impact of the four latest lists of causes of death on the age-standardised amenable death rates across the European Union countries in 2014. Our results showed that the rank order of countries does not change significantly, even though we applied Nolte and McKee, Tobias and Yeh, AMIEHS or EUROSTAT's concepts. In addition, we analysed whether age-standardised rates of amenable mortality based on AMIEHS or EUROSTAT's list are significantly different by sex and causes of death in Slovakia. We revealed that amenable mortality rates calculated by sex under the EUROSTAT's list were significantly higher than to the rates under the AMIEHS's list. This finding suggests that the structure of diseases together with the given age limits significantly influence the value of standardised amenable death rates, and hence, it is beneficial to develop the concept of amenable mortality at the national level in the light of actual availability of medical skills and effective treatments in the country.

Our results can serve as a valuable platform for revising the 'Strategic framework of health system in the Slovak Republic' aimed at increasing effectiveness of the health care system. Accurate quantification of the impacts of morbidity, comorbidities, socio-economic factors, lifestyle, health behaviours and others factors provide an extensive support in the interpretation of the development of avoidable mortality not only in international comparisons, but also in the development Slovak's own avoidable mortality methodology.

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