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QUANTIFICATION AND COMPARISON OF AVOIDABLE MORTALITY – CAUSAL RELATIONS AND MODIFICATION OF CONCEPTS

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Abstract. The fundamental criticism of the analyses of relations between the allocated sources into healthcare system and general indicators of health status (represented by mortality) form a concept of avoidable mortality. The concept is a result of a reaction of many specialists in this field. The efficient concept of avoidable mortality that consists of treatable and preventable mortality components should provide prominent information that is not directly absorbed in the metrics of general mortality rate traditionally used for measuring the healthcare systems' outputs. Permanent evaluation of the concept is based on confrontation of actual and relevant facts and supported by significant evidence from analytical outputs. This evaluation may help to form an efficient tool for measuring the amenable mortality with system connections as within health care system so in social policy, long-term health care policy, etc. The aim of this article is an analysis and evaluation of avoidable mortality development at conceptual and evaluative level and a specification of advantages and limitations that result from this concept. The analyses' outputs represent a valuable platform for revision of strategic framework of the Slovak healthcare as well as for formation of targeted policies that focus on increase of healthcare system efficiency.

Keywords: avoidable mortality, treatable mortality, preventable mortality, healthcare system efficiency, age–standardised death rates (ASDR), medical interventions.

JEL Classification: I10, I14, I15, I18.

Introduction

Dramatic changes have been evident in a character of reproductive behavior since 1990s. The whole society is significantly influenced by ageing population issues. Slovakia belongs to the youngest European countries and its uneven age structure and a rapid decrease in birth rate, various mortality rates, and standard of living will lead to its ageing process. In the Slovak regions, the demographic processes are not homogeneous. They are of

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different speed and intensity. This process deepens a differentiation from a demographic ageing point of view. The complex process, as well as the ageing process, will be determined by certain factors. Among them are an average life expectancy, economic conditions in a society by the level of health care (quality, range and availability), family environment, quality of the environment, lifestyle and education of an individual, etc. Demographic processes significantly influence structure and health system processes of a country (Marešová *et al.* 2015a; Mikušová Meričková, Nemec 2013). Generally, healthcare system has three fundamental aims: improvement of health condition, provision of services that are required by citizens, and implementation and development of fair financing system. Improvement of health condition has traditionally been measured by a mortality rate, life expectancy, amenable mortality, or so-called "life years lost". The choice of these metrics was predominantly determined by data availability as well as a possibility to measure and compare them in time horizons at national and international level. However, these measurements did not reflect disease load rate, which may be assigned to the health system (Marešová *et al.* 2015b; Mohelská *et al.* 2015). The main aim of each healthcare system should be an effective support, recovery and maintenance of inhabitants' health. It is important to examine many questions related to functioning of healthcare system to specify and evaluate them quantitatively (Mikušová Meričková, Halásková 2014). Among the questions is avoidable mortality that specifies s and provides a complex image of healthcare quality, but also forms many analytical trajectories related to morbidity, co-morbidity, efficiency of provided healthcare, as well as medical intervention rate. The outputs of these trajectories may provide valuable information for health and social policies makers and, consequently, may set an efficient policy for the improvement of the population's health.

1. Potential of demographic changes in mortality-based processes

In the European Union (EU), an average life expectancy, birth rate and migration influence a range and speed of inhabitants' ageing. Life expectancy of men should be increased from 76.7 years in 2010 to 84.6 years in 2060 and of women from 82.5 to 89.1 years. The birth rate should be increased from 1.59 births per one woman in 2010 to 1.71 births in 2060. It is supposed that total migration into the EU will represent 60 million of inhabitants in 2060. These data indicate a dramatic change of age profile in the EU that is projected in the following decades (European Commission 2012). The population will be much older in 2060 in spite of slight increase in number of inhabitants in 2060 (from 502 million in 2010 to 517 million in 2060). Almost 30% of the Europeans should be over 65 years and more, while lower number of people will be in a productive age (from 15 to 64 years). Number of persons in a productive age per one pensioner will decrease from 4 to 2 (caused by a projected decrease of persons in a productive age from 67% to 56%). The given demographic changes will have a significant influence on public finances in the EU. If we focus only on public expenses that are related to the age, such as pensions, health and long-term care, they should increase of 4.1% GDP in 2060 (in comparison to 2010), i.e. from 25% to 29% of GDP. Pension expenses are supposed to increase from 11.3% to 13%

of GDP, while there will exist many significant differences among countries that will be determined by structure and way of implementing the pension reforms. It requires support of effective measurements formation in a policy of each country (European Commission 2014; Gavurová, Hyránek 2013; Gavurová, Šoltés 2014; Ivlev *et al.* 2014; Minarik, Kraftova 2012). The changes in demographic development are reflected in population morbidity and mortality changes of the countries (Tsiachristas *et al.* 2013; WHO 2009; Woods 2009). Causalities between these components are subject to many research studies (Šimrová *et al.* 2014; Šoltés, Gavurová 2014a, 2014b, 2014c). Similarly, there are evident significant differences in a morbidity structure (Pampel 2001; Pagoto 2011; Pol, Thomas 2013). The most numerous diseases and causes of death have been transferred from group of infectious diseases to chronic diseases for the last three decades. In the scientific studies, mortality is differentiated from morbidity. Their explicit differentiation is not possible as in many cases a worsened health condition precedes death (Dlouhý, Barták 2013; Garrett *et al.* 2006; Gay *et al.* 2011). Many differences in mortality result from social assumptions and they are not biologically given. This may be found out by a deeper analysis of differences in mortality. On the other hand, the social differences in mortality may have a biological base, while they are developed via social mechanism and social environment (Dorman 1996; Moor *et al.* 2014; Spoerri *et al.* 2014). Oakes and Rossi (2003) submitted in their analyses specific causal ways in which a mechanism that causes different level of health and mortality is explained via social variables (Kajdiz, Bojnec 2014; Kearney, Levine 2014). Numerous scientific studies provide relevant evidence of socio-economic status influence on health and mortality that may help to understand deeper connections and to justify causal ways in the process of morbidity and mortality development (Manton *et al.* 2009; Marmot, Shipley 1996; Murray 2014). Mortality represents a reliable image of public health and it is also the most objective way of health measuring according to many authors (e.g. de Mello-Sampayo, de Sousa-Vale 2014; Holland 1997; Charlton *et al.* 1983; Jougla *et al.* 1998).

1.1. Avoidable mortality and its genesis

"Mortality" is a complex notion and it is confronted with a notion of avoidable mortality and amenable mortality. Amenable mortality and preventative mortality are subsets of avoidable mortality. Avoidable mortality was developed by a group of scientists from American Working Group on Preventable and Manageable from Harvard University (Rutstein *et al.* 1976). They defined it as "a number of deaths due to chosen groups of diseases that are considered either as treatable or preventative by means of healthcare services". This group of scientists created a notion "unnecessary premature deaths" by forming a list of diseases which should not cause immediate death in case of timely and effective healthcare. Medical care was defined in its broadest meaning as a prevention, treatment and care. The concept that was elaborated by this scientific group resulted from traditions of using the perinatal and maternal mortality rate as an indicator of healthcare provision. These rates were only used in the case of mothers and children. Consequently, the given professionals formed a list of death causes, which lead to premature mortalities, while it is possible to prevent them by means of preventive or medical measurements (Mejia-Lancheros *et al.*

2014; Milner *et al.* 2014). Similarly, this list of causes recorded mortality rates almost of the whole population. In the first list, the medical professionals incorporated approximately 80 different causes of death that are relevant to a general concept of avoidable mortality. Occurrence or increase of mortality number represented a warning signal in order to improve quality of prevention or healthcare provision (Korda, Butler 2004; Niti, Ng 2001; Westerling 2001).

The group of Harvard scientists was the first group that created notion amenable mortality. They differentiated the causes, which are specific for medical performances and procedures (e.g. tumors, diabetes, mellitus, etc.) and causes that react on actions outside healthcare (preventative diseases, such as lung cancer and hepatic cirrhosis). This concept drew attention of many specialists in their field, while there appeared various analyses that suggested deficiencies of original list of diseases, which belong to avoidable mortality category. Charlton *et al.* (1983) applied this concept of avoidable mortality in order to analyze the development changes of mortality in England and Wales during 1974–1978. They differentiated the following notions: "avoidable mortality" and "avoidable mortality in healthcare system interventions". It originated from Rutsteinoo's list and 14 chosen groups of diseases should have reflected different aspects of healthcare (including the primary one). These specialists considered the age level in the individual death causes between 5–64 years. Consequently, this amenable mortality concept was spread all over the Europe. Its development included many modifications, while a differentiation between "avoidable mortality" and "avoidable mortality in healthcare system interventions" was respected. The principal result of these research activities of Charlton *et al.* (1983) specialists and the European Commission was Atlas of avoidable mortality of the European Community in 1988 which was updated afterwards. Newey *et al.* (2004) modified the original list of diseases in this concept and their research ambition was a comparison of avoidable mortality in twenty European countries. The last revision of the International Classification of Diseases (ICD) inspired this group of scientists and they detailed 37 death causes or their groups, which were considered as avoidable according to them. They were divided into three categories:

- *Treatable diseases by medical interventions* or secondary healthcare: e.g. some types of tumors, high pressure diseases, appendicitis, etc.
- *Avoidable disease by preventative interventions* (so-called preventable diseases): e.g. lung tumors, avoidable measures limited by smoking, hepatic cirrhosis reduced by measures that limit alcohol consumption, car accidents, etc.
- *Ischemic heart disease* – it could be assigned into previous two categories, but it is not possible to explicitly determine a rate of healthcare and prevention contribution. Also large amount of deaths due to this disease could misrepresent the influence of healthcare or prevention on the other diseases.

Most of the scientific studies related to avoidable mortality analysis date back to 1980s and 1990s. The concept was especially developed by many European researchers, such as Mackenbach *et al.* (1990), Westerling (2001), Holland *et al.* (1997) during that period. In recent years, the specialists Nolte and McKee (2004, 2008) and Tobias and Yeh (2009) revised it. This led to actualization of diseases list according to the newest advances in the medical knowledge and technologies field. The revised list included only 34 death causes and the concept was applied in the European countries (EU – 15). The newest study of treatable mortality was led by world universities: Erasmus Medical University and London School of Hygiene and Tropical Medicine. The project is financed by the EU resources: "Avoidable Mortality in the European Union: towards better Indicators for the Effectiveness of Health Systems" AMIEHS (Plug *et al.* 2011). The principal aim of this project was to develop a generally recognized definition of avoidable mortality for Europe and to derive a file of avoidable metrics to measure an efficiency of health system, which could be commonly used. There participate seven European countries and the advisory committee is composed of international specialists in order to provide high quality of scientific and political relevance.

The recent definition of "avoidable mortality" according to the Office for National Statistics in UK (2013) explicitly differentiates the boundaries between these subgroups:

- amenable mortality: "It is a number of deaths, where death should not occur in case of providing a high quality healthcare on the basis of medical knowledge and available technologies at the time of death (depending on age level)".
- preventable mortality: "It is a number of deaths, where death should not occur in case of effective public medical campaigns that focus on prevention on the basis of medical knowledge and available technologies at the time of death (depending on age level)".

In defining this notion, it is necessary to take into consideration a fact that avoidable mortality is a part of premature death group which should not occur at that time.

The concepts of such specialists as Nolte and McKee (2008), Tobias and Yeh (2009) and the concept of AMIEHS (Plug *et al.* 2011) project had attracted us in our analyses from the point of their actual structure, development process and output significance. These concepts will be described in detail in order to show their structure heterogeneity and also discrepancies, which cause different outputs and thus make difficult an interpretation of their results.

1.2. Structure discrepancies in the concepts of avoidable mortality measurements

As the development of avoidable mortality concepts show, there was a reduction of number of death causes that formed a metric of avoidable mortality by further development of the American as well as European research teams since the first publication of a concept (Rutstein *et al.* 1976), which contained 80 death causes. The exact structure of concepts is given in the Table 1. We find out significant differences in the classification or non-classification of given death cause into the list, while there are evident conceptual changes in the diagnoses groups. Interestingly, surgical diagnoses that are linked with minimal morbidity and mortality due to improved surgical techniques (Poelman *et al.* 2013), proper selection of patients (Šoltés, Radoňak 2014) and innovative methods of traning (Buzink *et al.* 2012) – such as hernia or cholelithiasis were included in majority of methodologies. One of the possible explanations may be amenable mortality due to preventable failures of technology equipment due to malfunction or malpractice which is obviously alarming due to medicolegal reasons (Šoltés *et al.* 2011). On the other hand, diagnoses with unpredictable clinical course and relatively high mortality like pancreatitis remained neglected in the majority of methodologies.

These differences in methodological structures may result in the totally different evaluation of countries in amenable mortality.

The upper age limit was determined as 75 years in calculating the avoidable mortality. This limit is in accordance with an average life expectancy in the developed countries. This upper age limit is also the same in both sexes. The avoidable mortality and reliability of death cause determination is very disputable from this age level (Mackenbach *et al.* 1990).

Table 1. Structure of international concepts' comparison

Cause of death considered amenable to healthcare	Nolte and McKee (2008), ICD-10, (1. CONCEPT)	Tobias and Yeh (2009), ICD-10, (2. CONCEPT)	AMIEHS (Plug *et al.* 2011), ICD-10, (3. CONCEPT)
Infectious disease			
Tuberculosis	A15-A19, B90	A15-A19, B90	Non-classified
Selected invasive infections:			
Intestinal infectious diseases	A00-09 (age 0–14)	Non-classified	Non-classified
Whooping cough	A37 (age 0–14)	Non-classified	Non-classified
Measles	B05 (age 1–14)	Non-classified	Non-classified
Tetanus and Diphtheria	A35-36	Non-classified	Non-classified
Sepsis	A40-41	A40-41	Non-classified
Scarlet fever	Non-classified	A38	Non-classified
Meningococcal infection	Non-classified	A39	Non-classified
Acute poliomyelitis	A80	Non-classified	Non-classified
Influenza	J10-11	Non-classified	Non-classified
Pneumonia	J12-18	J13-15, J18	Non-classified
Erysipelas	Non-classified	A46	Non-classified
Legionnaires disease	Non-classified	A48.1	Non-classified
Malaria	Non-classified	B50-54	Non-classified
Meningitis	Non-classified	G00, G03	Non-classified
Cellulitis	Non-classified	L03	Non-classified
HIV	Non-classified	Non-classified	B20-24
Tumors			
Colorectal cancer	C18-21	C18-21	C18-21
Malignant neoplasm of skin	C44	C43-44	Non-classified
Breast cancer (females only)	C50	C50	C50
Cervical cancer	C53	C53	C53
Uterine cancer	C54-55 (age 0–44)	C54-55	Non-classified
Testis cancer	C62	Non-classified	C62
Bladder cancer	Non-classified	C67	Non-classified
Thyroid cancer	Non-classified	C73	Non-classified
Hodgkin's disease	C81	C81	C81

End of Table 1

Cause of death considered amenable to healthcare	Nolte and McKee (2008), ICD-10, (1. CONCEPT)	Tobias and Yeh (2009), ICD-10, (2. CONCEPT)	AMIEHS (Plug *et al.* 2011), ICD-10, (3. CONCEPT)
Leukaemia	C91-95 (age 0–44)	C91-95 (age 0–44)	C91
Benign tumours	Non-classified	D10-36	Non-classified
Diabetes (type 2)	E10-14 (age 0–49)	E10-14 (50% of deaths)	Non-classified
Ischemic heart disease	I20-25 (50% of deaths)	I20-25 (50% of deaths)	I20-25
Other circulatory disease			
Rheumatic & other valvular heart disease	I05-09	I01-09	I00-09
Hypertensive heart disease	I10-13, I15	I11	I10-13
Heart failure	Non-classified	Non-classified	I50-51
Cerebrovascular disease	I60-69	I60-69 (50% of deaths)	I60-69
Respiratory diseases (excl. pneumonia, influenza) (age 1–14)	J00-09, J20-99	Non-classified	Non-classified
Chronic obstructive pulmonary disease	Non-classified	J40-44 (age >45)	Non-classified
Asthma	Non-classified	J45-46 (age 0–44)	Non-classified
Surgical conditions			
Peptic ulcer disease	K25-27	K25-28	K25-26
Appendicitis	K35-38	K35-38	Non-classified
Hernia	K40-46	K40-46	Non-classified
Cholelithiasis, cholecystitis	K80-81	K80-83	Non-classified
Pancreatitis	Non-classified	K85-86	Non-classified
Postcholecystectomy syndrome	Non-classified	K91.5	Non-classified
Nephritis & nephrosis	N00-07, N17-19, N25-27	I12-I13, N00-09, N17-N19	N17-N19
Obstructive uropathy & prostatic hyperplasia	N40	N13, N20-N21, N35, N40, N99.1	Non-classified
Misadventures to patients during surgical & medical care	Y60-69, Y83-84	Non-classified	Non-classified
Maternal, congenital and perinatal conditions			
Maternal deaths	O00-99	Non-classified	Non-classified
Perinatal deaths, all causes (excl. stillbirths)	P00-96	H31.1, P00, P03-95	P00-96
Congenital malformations	Q20-28	Q00-99	Q20-24
Other conditions			
Thyroid disorders	E00-07	E00-07	Non-classified
Epilepsy	G40-41	G40-41	Non-classified

Source: processed via OECD Health Working Papers (Gay *et al.* 2011) and AMIEHS (Plug *et al.* 2011).

It is necessary to respect different age level proposed by the authors Newey *et al.* (2004) in some specific causes and groups of death causes. For instance, in whooping-cough, infectious intestinal disease, chicken-pox and juvenile pulmonary disease, death is considered until 15 years, in leukemia and uterus tumor, death is considered until 45 years, diabetes mellitus until 50 years. It is proper to confront amenable mortality with other metrics. In 2008, the specialists warned that correlation between the rates of amenable mortality and the life expectancy is high (>0.9), as amenable mortality is a subgroup of avoidable mortality. The amenable mortality rate may also differentiate in the countries with a similar life expectancy in birth, but it may also be different by applying various concepts. Significant substantial difference may be visible in evaluating the avoidable mortality in the countries in a context of "potential years of life lost" (PYLL). PYLL conveys all years of life lost between a certain age and a death, while the boundary age limit is 70 years (according to OECD Health Data database). PYLL accentuates the deaths in younger age and it includes all death causes, including car accidents, suicides, etc., while amenable mortality emphasized all deaths until 75 years. It means that in summarized evaluation, the countries may show similar rates of mortalities caused by healthcare according to Nolte and McKee (2008) concept, but simultaneously they may show different positions according to PYLL or even the opposite case – very similar PYLL rates, but significant differences in mortality on the basis of Nolte and McKee (2008) concept and Tobias and Yeh (2009) concept. The given facts form significant research platform in hypothesis formulation to research casual relations and differences in mortality rates in a context of aggregative health indicators.

The AMIEHS project (Plug *et al.* 2011) result is a development of the newest concept whose great particularity is a distinct change of a structure in the death causes' list. However, classification or exclusion of some death causes out of the list is a subject to many experts' discussions. As it was already mentioned, there participated seven European countries on this project and the given structure of the list is a result of accomplishments' consensus of their analyses. One of the first aims of this project was an identification of death causes, which may be considered as "amenable". Consequently, the experts summarized a systematic literature overview, while they considered the following criteria in choosing diagnoses into the concept:

- Mortality of death causes that decreased of more than 30% in England and Wales after 1970 (England and Wales, European countries with consistent data during 1970–2000, these countries also recorded all of the changes in coding the diagnoses the best) (Office for National Statistics 2013).
- Influence of significant medical innovations with an evident efficiency that was implemented after 1970 (this date is connected with a creation of avoidable mortality concept by its first author).

We considered the following steps in choosing the diagnoses. We had chosen out of all death causes classified according to the codes of the International Classification of Diseases (ICD) those diseases that had one or more mortalities in 2000. Subsequently, we chose only those which indicated 100 and more mortalities in 2000. Finally, we chose from that group only those that represented a decrease in mortalities during 1970–2000 of 30% and more.

It was necessary to explicitly prove that mortality of such a diagnosis decreased of 30% thanks to interventions during 1970–2000 (the rate of 30% had been given as significant) in order to arrange a diagnosis in the list. We had selected a group of 16 diagnoses which included available evidence of medical interventions' significance in healthcare system efficiency since 1970 (medicine, surgery, procedures, technologies, innovations, etc.) on the basis of the above mentioned facts. Evidence power of interventions' efficiency on mortality decrease of 30% and more was evaluated on the basis of four-point scale (Plug *et al.* 2011):

1. consensus announcement or expert testimonies,
2. observational studies evidence,
3. evidence of one or more randomly controlled studies,
4. evidence of systematic evaluations or meta-analysis.

Evidence of healthcare contribution to mortality decrease of 30% and more were evaluated on a three-point scale:

1. Published studies that describe mortality decrease at population level; there was discovered that healthcare interventions represent one of many explanations.
2. Published studies that describe mortality decrease at population level; there was discovered that healthcare interventions represent the most probable explanation.
3. Evidence of population registers (e.g. oncological register) of mortality decrease.

Evidence power was variable and only few interventions reached the highest level in evaluation (evidence of systematic literature overview or meta-analysis). Many interventions were supported by evidence from individual studies, or from observational studies. The result was a list of 16 death causes. These were justified by an adequate level of treatment evidence via literature overview (AMIEHS final report, p. 12–37, see Plug *et al.* (2011)). Three international concepts have their particularities, while a structure of death causes in the list of concepts significantly determines the final evaluations among countries as well as concepts. We focused on their detailed observation, specification of their advantages as well as limitations in the following subchapters.

1.3. Database and methods' application

Mortality development is evaluated by means of standardized death rates calculated via direct method with applied reference age structure of so-called European standard population (published by WHO). The analysis that analyzes influence of the individual groups of death causes on mortality change is subsequently realized by evaluation of temporary life expectancy since birth until 75 years and its change. This temporary life expectancy determines average years lived by a person until his 75 birthdays provided that the mortality rates given in mortality table will not change during his further life (Meszaros, Burcin 2008). The rates of amenable mortality are expressed by the age–standardized death rates (ASDR) per 100,000 population. We applied the method of direct standardization using the European Standard Population. The purpose of the standardization is to eliminate any effect from differences in the age structure across countries and over time. ASDR are computed by the following mathematic expression:

$$\mathrm{ASDR} = \frac{\sum_x m_x \cdot P_x^*}{\sum_x P_x^*}, \tag{1}$$

where: x – age/sex group 0–4, 5–9, ..., 70–74, mx – observed mortality rate (deaths per 100,000 population) in sex/age group, P_x^* – European Standard Population in sex/age group x.

Amenable mortality rate was calculated via WHO database on the basis of data that included number of dead people according to death causes, sex in the classification of five-year age categories. The database included data of 20 countries in the EU during 2002–2012. The remaining 8 European countries were not a part of this analysis, because the available data did not correspond to the requirements of avoidable mortality concept due to their inconsistency. Statistical office of the SR provided us the information of number of deaths in the given categories for 2013. We obtained data of a medium condition of inhabitants in the individual age groups and sex in each year from statistical database of the European Economic Commission of the UNO (United Nations Organization). Mortality rates of all diseases were standardized according to age by means of so-called European standard population as a consequence of possible international comparison. Standardized mortality rates according to sex were calculated for all considered death causes in the individual European countries during 2002–2012 and in Slovakia during 2002–2013. Data of the European standard population according to age groups were obtained from the Eurostat (2014). The WHO published information of the total expenses on healthcare system per one citizen that were given in the parities of purchasing price (PPP) per dollar. We conducted the analysis via Microsoft Access and Excel.

2. Analysis and results

The principal aim of this article was to evaluate a development of avoidable mortality in the European countries in 2012 by means of three present international concepts and to point to their heterogeneous structure, discrepancies and to propose some possibilities of their elimination. As a consequence of a realization of international comparison, our primary ambition was to apply these concepts in the European countries that have available database and to evaluate a development of avoidable mortality in Slovakia in a long-term horizon. Other limitations were connected to the concept, which will be explained in detail in the next parts besides these database limitations (8 countries had no data available).

2.1. Development of amenable mortality in the European countries in 2012

We conducted the calculations of amenable mortality in 2012 on the basis of the concept that was mentioned in subchapter 1.2 (we used the last available year in some countries due to data limitations) per 100,000 inhabitants in 20 European countries. The results are illustrated in Figure 1. As the Figure 1 shows, Slovakia belongs to one of five countries that reach the highest amenable mortality rate in 2012 in all three concepts. There is evident a

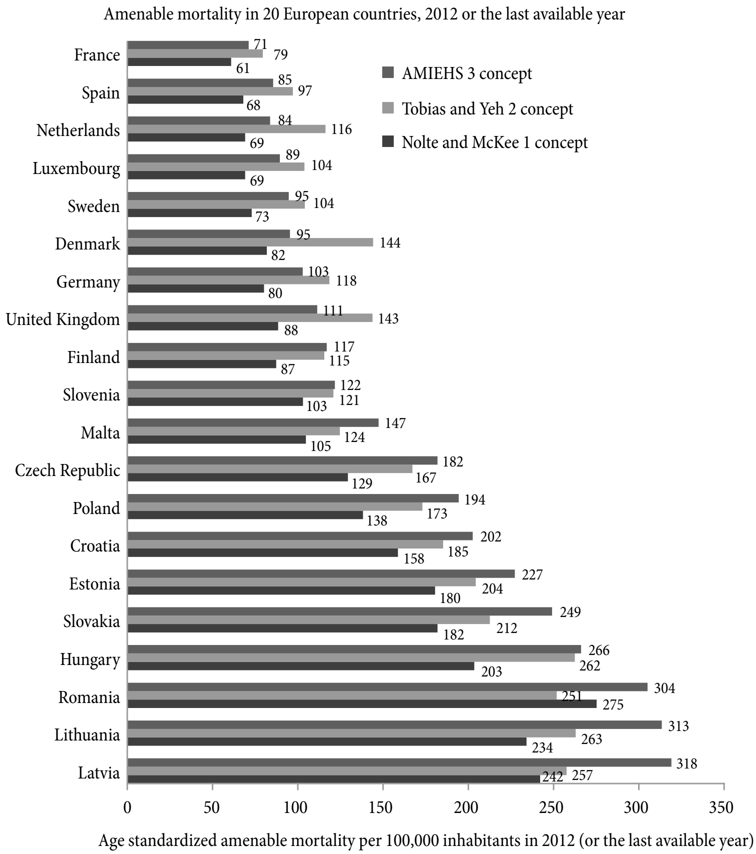

Fig. 1. Standardized amenable mortality in 2012 in the European countries
Source: own processing.

significant differentiation in the values of calculated age standardized amenable mortality in applying of various concepts, but also differences among countries within the individual concepts. Several factors influence these aspects. The problem component in the international mortality comparison may be heterogeneity of diagnostic practices that are related to a completion of confirmed deaths as well as practices connected to use of the ICD codes in the individual countries (Mathers *et al.* 2005). This fact is consequent as in analyzing the avoidable mortality so in all studies that require general data of mortality. Despite this fact, these data are sufficiently relevant in their usage in various epidemiologic studies especially in the European countries as Jougla *et al.* (1998) suggested in their study.

The choice of death causes which "are caused by healthcare" depends on time. Each technological advance increases the opportunities for better and more effective prevention of premature deaths via secondary prevention as well as subsequent treatment. As a consequence of this fact, the actualization of death causes' list in the metric of amenable mortality should react on efficiency of implemented medical interventions and this list must be regularly updated. In this aspect, consensus of significant specialists in their fields as well as representatives of interest groups is very important in defining the relevant and actual causes of death, while it should reflect on innovations in healthcare. Consequently, the long-term time horizon as well as heterogeneity in a structure of death causes of the individual concepts may cause significant differences as well as interpretation issues in the analyses. Age limit represents another significant component in the metrics of avoidable or amenable mortality in comparisons.

The concepts of such specialists as Nolte and McKee (2008) and Tobias and Yeh (2009) propose upper age limit of 75 years, while this age limit may varies in accordance with a significant increase of population life expectancy. The data quality of mortality may complementarily worse in connection with this higher age. It means that a presence of numerous co-morbidities of older citizens may worse the quality of provided data of a correct mortality cause and its potential avoidable process.

The sole measurement of co-morbidities' influence on a treatment success of individual diagnoses is methodologically very difficult and limited case reports of medical environment may serve this purpose. However, these are very difficult to implement in economic studies due to their heterogeneous and qualitative character.

Baltic countries reach the worst values of amenable mortality, while Latvia and Lithuania also belong to most rapidly developed countries of the Europe at present from economic point of view. Many European countries radically decreased the healthcare system budgets since the beginning of global financial crisis. It may be connected with a limited availability of healthcare, elimination of prevention activities, savings in medical institutions, insufficient interventions and low support of science and research. These disadvantages may be visible in increase of inhabitants' morbidity as well as in amenable mortality in a very short time and in a rise of pressure on financial sources in the healthcare system. Many diseases will become chronic due to insufficient prevention as well as non-effective treatment, numerous co-morbidities, or late diagnosis. Thus the treatment process becomes more difficult and it increases its financial difficulty. In the first places, according to the AMIEHS concept (Fig. 2) and from the point of view of amenable mortality causes' structure, there dominate: ischemic heart disease, cerebro-vascular diseases and colorectal cancer. Similarly, Nolte and McKee concept uses this list, while in Tobias and Yeh concept the chronic obstruction lung disease mortalities replaced cerebro-vascular diseases.

Mortalities of ischemic heart diseases reach in the AMIEHS concept double values in comparison to Nolte and McKee ad Tobias and Yeh concepts. The main reason is a construction of the concepts: in Nolte and McKee and Tobias and Yeh concepts, only 50% of dead were counted, while in the AMIEHS concept, all of the dead were counted. We find out the worst values in the analysis of death number of these diagnoses according to the AMIEHS concept in Lithuania and Latvia, while they are followed by Slovakia and Hungary with the same values (122/100,000 inhabitants). These negative findings require deeper analyses that focus on the development of these diseases in a long-term time horizon and depending on age structure they also require a logical mapping of medical interventions connected with a treatment of given diseases. Also, these analyses should be supported simultaneously with the evaluation of a development of diseases' number in order to confront the fact, whether death increase of these diseases is accompanied by increase, decrease, or stable value of diseases' number of this diagnosis.

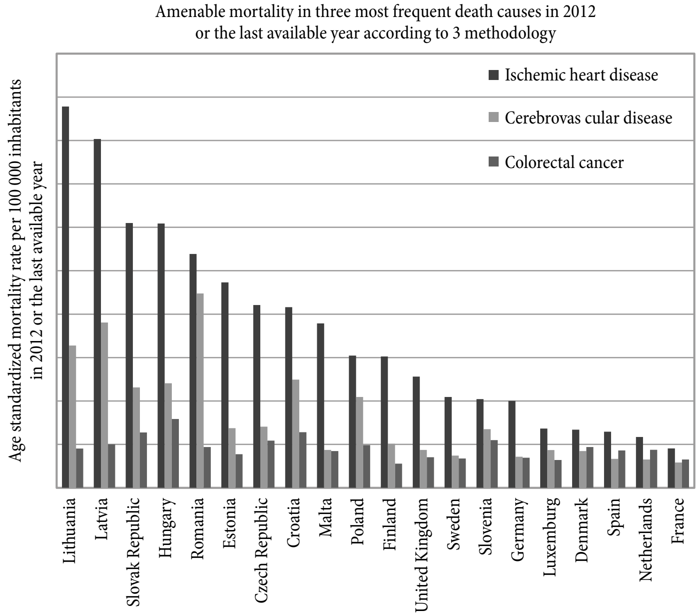

Fig. 2. Amenable mortality in three most frequent death causes according to AMIEHS concept
Source: own processing.

2.2. Amenable mortality in Slovakia

In the next analyses, we were interested in the development of amenable mortality in Slovakia during 2002–2013, while in all of three concepts, the age standardized amenable mortality decreased per 100,000 inhabitants (Fig. 3). We may not be satisfied with this condition in comparison to other countries neither with evaluation of this long-term time horizon in spite of the fact that amenable mortality decreased from 334 to 241 persons per 100,000 inhabitants in Slovakia during 2002–2013 according to the AMIEHS concept (Plug *et al.* 2011).

In Slovakia an evident decrease of amenable mortality during 2002–2013 is also obvious, from 261/100,000 to 177/100,000 (using methodology in Nolte and McKee (2008)). This condition is especially connected with a structure of Nolte and McKee concept as opposed to Tobias and Yeh concept, and the AMIEHS has a different structure of infectious diseases, while many of them do not contain of Tobias and Yeh concept and the AMIEHS concept had totally excluded them from their list of death causes (Table 1). Only 50% of deaths count in some diseases (diabetes, ischemic heart disease, circulatory system diseases in such concepts as Nolte and McKee and Tobias and Yeh). It would be appropriate to strictly focus on diagnoses that were changing in the concepts (or classified or eliminated), to evaluate their development in a long-term time horizon and also to quantify to what extent the changes are influenced by exclusion or inclusion of death cause into the list in the final values of amenable mortalities in the following analyses. The excluded death causes that are significant in the Slovak conditions (verified by outputs of scientific analyses) may misrepresent the interpretations of a real development of avoidable mortality.

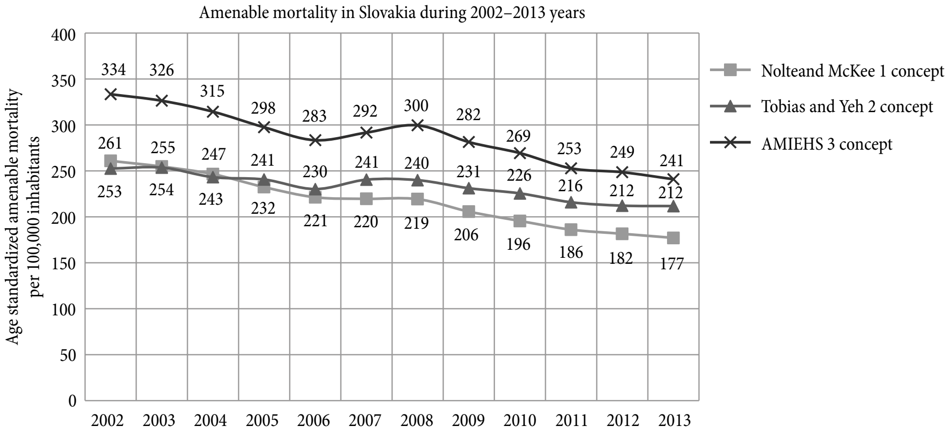

Fig. 3. Age standardized mortality per 100,000 inhabitants
Source: own processing.

Therefore, it is suitable to support the outputs of amenable mortality comparisons according to the international concepts by complementary analyses of the individual diagnoses and also mortalities in the Slovak conditions. These consequent facts are closely related to the medical system specifications of the European countries. Each country has its own health policy, medical system organization, system of public and private health insurance and also access to health and healthcare provision. Here belong allocation of resources into healthcare system as well as intervention form and costs, support of research and development. Consequently, we have decided to confront the values of amenable mortality rates with a capacity of healthcare system expenses per one citizen that are expressed in the parities of purchasing price (PPP), international $ (Table 2) and to obtain a different view on this analyzed issue.

The source table contains our calculations of standardized amenable mortality rate according to three concepts in the individual countries, as well as the capacity of healthcare system expenses in these countries. The illustration (Fig. 4) illustrates the values according to the AMIEHS due to content and range limitations of our article.

Figure 4 evaluates a relation between standardized amenable mortality rate in the European countries and health system expenses per one inhabitant expressed in PPP international $ in 2012. The highest determining index was represented by exponent regression of 84.69%, which means that even 84.69% of research values' dependency is expressed via exponent regression (the remaining 15.31% are accidental defects).

We may also expect a decrease of amenable mortality that is lower than 1 unit, which is caused by an increase of health system expenses per 1 unit. It means that the boundary decrease of amenable mortality always decreases with increasing financial costs. Romania spends the lowest amount of financial resources into health system per one citizen (872.9 international $) and simultaneously its ASDR (304/100,000) belongs to one of the highest among the EU countries. On the other hand, Luxembourg spends the highest amount

Table 2. Healthcare system expenses (per citizen) and amenable mortality in the European countries in 2012 or the last available year

Countries	Healthcare system expenses, per citizen (PPP int. $), 2012	Concepts		
		Nolte and McKee (2008)	Tobias and Yeh (2009)	AMIEHS (Plug *et al.* 2011)
Latvia	1,188.1	242	257	318
Lithuania	1,426.3	234	263	313
Romania	872.9	275	251	304
Hungary	1,729.3	203	262	266
Estonia	1,385.4	180	204	227
Slovak Republic	1,976.8	182	212	249
Croatia	1,409.8	158	185	202
Poland	1,489.3	138	173	194
Czech Republic	2,046.0	129	167	182
Malta	2,547.7	105	124	147
Slovenia	2,419.9	103	121	122
Finland	3,544.7	87	115	117
United Kingdom	3,494.9	88	143	111
Germany	4,617.0	80	118	103
Denmark	4,719.8	82	144	95
Sweden	4,157.8	73	104	95
Luxembourg	6,340.6	69	104	89
Netherlands	5,384.6	69	116	84
Spain	3,144.9	68	97	85
France	4,260.2	61	79	71

Source: own calculation.

of financial resources (6,340.6 international $) and its ASDR indicates one of the lowest values among the researched countries (89/100,000). Denmark, Sweden, Luxembourg, the Netherlands, Span and France reach the lowest amenable mortality rate. There also exist the minimum differences in the amenable mortality values among these countries and significant differences in the amount of the healthcare system expenses per one citizen (85/3,144.9 in Spain and 89/6,340.6 in Luxembourg). Countries in the left part and at almost the same horizontal level could represent more qualitative and more effective healthcare system, as they reach approximately the same level of amenable mortality rate in lower expenses on healthcare system per one citizen. However, it is necessary to apply an approach to other qualitative data of health systems in other countries in order to propose more detailed causal interpretations.

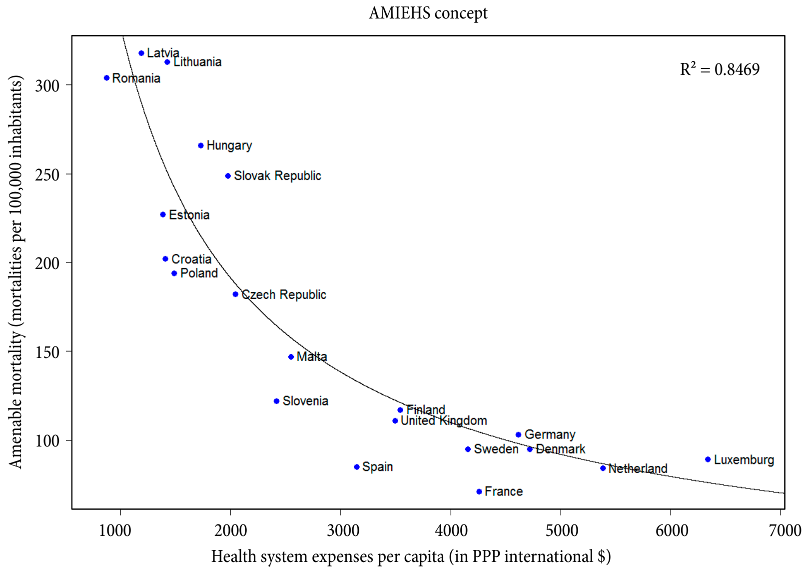

Fig. 4. Healthcare system expenses and amenable mortality in the European countries, 2012 or the last available year
Source: own processing.

3. Discussion

Avoidable mortality may be a relevant indicator of evaluation of healthcare system performance improvements. On the other hand, each concept has many limitations that result from relevance and comparison of available data, but also from a concept. In the international comparison, it is important to reflect the total change of diseases' number in a given year, while interpreting the avoidable mortality. For instance, higher mortality of a given diagnosis in a given year may signalize either parallel increase in the number of diseases of a given diagnosis or failure in preventions of a given disease, or even a combination of both possibilities. Other problems may result from a fact that avoidable mortality does not take into consideration the available sources on a provision of effective treatment in each country in the international comparison. The death causes are classified in the avoidable mortality list on the basis of available evidence of existence and efficiency of medical interventions in the preventions of premature deaths. However, it is not controlled, whether the required technical skills or medical technologies are available in comparing countries and whether a distribution of these medical interventions in a wider range is provided and available. If there exist large irregularities in available resources of healthcare, whether within EU or OECD, it will cause a different diffusion intensity and extent of new medical practices or technologies. Negative values of avoidable mortality in a given country may reflect on inaccessibility of particular medical technologies, or a low quality of healthcare, or a combination of both. Consequently, avoidable mortality should be interpreted in a context of efficient healthcare system in a given country and by many other available system characteristics. Thus, avoidable mortality may be an efficient indicator in a process of evaluating the progress of a certain country during certain period. One of its other disadvantages is a fact that the concept does not take into consideration improvements of life quality. Many interventions in the healthcare system do not focus on life extension, but rather on life quality improvement (e.g. cataract operation, replacement of lumbar joint, palliative care, etc.). Therefore, it is appropriate to combine the avoidable mortality indicator with other output indicators to make provision for life quality improvement and welfare. Avoidable mortality concept focuses on premature deaths, which could be prevented by effective interventions of healthcare. It means that they should not be used to evaluate efficiency of overall healthcare system. In the concept of avoidable mortality, there absent mental illnesses in all of the causes' lists. Also specialists did not classify premature mortality of suicides into the concepts as mortality avoidable by healthcare interventions. Similarly, there absents lungs cancer that may be reduced via interventions which limit smoking, etc. Therefore, it is necessary to use complementary and other indicators to evaluate efficiency of healthcare systems besides the services of healthcare. Despite the fact that all the given analyses are very useful in identifying weaknesses of healthcare system in the given countries, it is necessary to respect the fact that some variations may be explained by differences in coding of the individual countries. DRG system in Slovakia which is in a progress may increase transparency and relevancy of obtained data as well as it may be an efficient supporting tool in a development of the avoidable mortality concept in the Slovak conditions via standardized code process. The given analyses provide us with a significant analytical platform in the development of our own avoidable mortality concept in the Slovak conditions. We evaluate the development of individual mortality causes in a retrospective in the context of demographic parameters, bi-social and socio-cultural characteristics, healthcare provision and health interventions in cooperation with Ministry of Health of the SR, National Health Information Center**,** Association for the Protection of Patients' Rights Slovak Republic and Statistical Office of the SR. These aspects are necessary to analyze in the intentions of available healthcare web, adequate access to it, prevention measures as well as to confront it with available resources' capacity in healthcare system.

Conclusions

Measuring a range of healthcare system contribution on population health still remains a great challenge in the process of measuring health system efficiency all over the world. Despite the fact that there have been developed many indicators in order to evaluate a performance of healthcare system in the OECD countries, none of them represents a final and exact one, which would propose efficient healthcare systems without any limitations. The avoidable mortality concept represents a prominent way of measuring the healthcare system efficiency in the process of premature deaths prevention, which could be prevented by a correct medical intervention. This concept has a very high potential also for international comparison of healthcare system efficiency, but it has its limitations. High sensitivity of a chosen causes' list, which were labeled by experts as causes that "require a medical condition" represents the most evident limitation. Similarly, this indicator does not take into consideration neither life quality improvement nor amount of resources available in the individual countries to provide efficient healthcare. Despite these limitations, avoidable mortality is a very useful concept that provides valuable information of existing indicators' file that is necessary for measuring efficiency of medical systems. Despite these limitations, the avoidable mortality is a very useful concept that provides valuable information of existing indicators' file for measuring efficiency of health systems. The problem area is especially morbidity quantification and patient's co-morbidity influence on mortality in a way that it would be possible to analyze their influence and contribution to total mortality range. However, it is possible to set analytical trajectories of sex, age, co-morbidity, morbidity, lifestyle, health behavior and many other factors' influence on mortality processes and thus prepare a significant analytical platform. This platform would be an efficient and supportive tool in interpreting of avoidable mortality development as in the international comparison so in the development of its own concept in the Slovak conditions. This information would be valuable aim component in a strategic framework of the Slovak healthcare, as well as for its creators of health and social policies. As a consequence of global ageing of inhabitants, the forecasting of mortality and morbidity processes as well as the issue of avoidable mortality gain their own original significance at present.

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Disclosure statement

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