Zdrowie Publiczne i Zarządzanie 2016; 14 (3): 175–193
www.ejournals.eu/Zdrowie-Publiczne-i-Zarzadzanie, doi:10.4467/20842627OZ.16.021.5890

Approaches to Disease Burden Measurement: Disability-Adjusted Life Years (DALYs) Globally and in Poland, and National Income Lost Due to Disease in Poland, 1990–2015

Katarzyna Kissimova-Skarbek

Department of Health Economics and Social Security, Institute of Public Health, Department of Health Sciences, Jagiellonian University Medical College

Address for correspondence: Katarzyna Kissimova-Skarbek, Instytut Zdrowia Publicznego, Grzegórzecka 20, 31-531 Kraków, kskarbek@uj.edu.pl

Abstract

The purpose of this study was to identify the main health problems in Poland against global health problems using the latest Global Burden of Disease (GBD) study results. The burden of disease is assessed here in terms of: (i) time lost due to premature deaths and morbidity (expressed in Disability-Adjusted Life Years – DALYs measure) and (ii) national income lost due to disease in Poland. The study presents the estimates of total DALYs, Years of Life Lost (YLL) caused by deaths, Years Lived with Disabilities (YLD), both in total (due to all causes) and attributable to chronic non-communicable diseases (NCDs), in 2015 compared to year 1990. The economic value of time lost due to deaths and disability in Poland is measured using the method employed by the WHO Commission for Macroeconomics and Health, which makes the assumption that each DALY can be valued at between one and three annual GDPs per-capita for the country under study. In 2015 over 2.46 bln DALYs globally were lost due to all causes, of which 66.7% were due to NCDs and 18.2% were due to communicable diseases. Poland experienced over 11.3 mln DALYs in the year 2015, 81.9% of which were due to NCDs and 3.4% of which were due to communicable diseases. 68% of total DALYs globally and 41% in Poland were years of life lost due to deaths. 84% of the total years of life lost due to death in 2015 globally (69% in Poland) occurred under the age of 70 and are considered avoidable. Total income lost in Poland due to deaths in 2015 amounted to up to I$527 bln.

Key words: **burden of disease study, disability-adjusted life-years (DALY), years of life lost (YLL), avoidable YLL, years lived with disability (YLD), chronic non-communicable diseases, national income lost**

Słowa kluczowe: **badanie obciążenia chorobami, lata życia skorygowane niesprawnością (DALY), utracone lata życia (YLL), YLL do uniknięcia, lata życia z niesprawnością (YLD), przewlekłe choroby niezakaźne, utracony dochód narodowy**

Ministerstwo Nauki i Szkolnictwa Wyższego

Przygotowanie i edycja anglojęzycznych wersji publikacji finansowane w ramach umowy 914/P-DUN/2016 ze środków Ministra Nauki i Szkolnictwa Wyższego przeznaczonych na działalność upowszechniającą naukę.

Introduction

In conditions of limited resources, establishing investment priorities in the health care sector is essential. These investment priorities should reflect the most pressing health needs of a country and be focused on those diseases that constitute the greatest burden on society. The most important health problems are determined by assessing the burden posed by different diseases, injuries and risk factors on society.

Burden of disease analyses are predominantly applied in creation of evidence-based health policy [1]. They provide data that enable the comparison of different diseases, ordering them with respect to the costs they

impose on society as well as identifying areas where the health of the population can be potentially improved. In this way, they help develop preventative programmes geared towards solving the main problems which have been identified. Burden of disease studies provide a basis for allocating limited resources to those areas where the health and life of people is most at risk and where the greatest benefits for society can potentially be achieved. The results of disease burden analyses can also serve as a tool for benchmarking health care systems and help to understand the contribution of a health care system in preventing and treating particular diseases.

In the current study the existing methods of disease burden measurement were summarised and the main causes of health loss, both globally and in Poland, were identified using a complex measure of time lost and disability – DALY.

The research questions were: What causes the most deaths and years of life lost both globally and in Poland? What portion of the lost years (due to death) is avoidable? What causes the most disability and combined death and disability in Poland? What is the national income lost due to disease in Poland?

The secondary aim of this study was to illustrate the possible ways of using open access data sources available online, which can be easily applied to identify the main health problems in countries.

1. Methods and indicators for measuring a disease burden

A comprehensive analysis of disease burden requires making a correct epidemiological diagnosis (disease occurrence) and identifying the costs incurred in terms of both of treatment and social losses resulting from diseases as well as performing an analysis based on the method of calculating the direct and indirect costs of this treatment in addition to losses in economic growth. In order to identify the disease burden at national, regional or global levels, various approaches and units of measurement have been applied. The main indicators and approaches to measuring the disease burden can be divided into three groups which are presented in **Figure 1**. The first group – non-monetary units – includes: (i) natural units, consisting of mortality and morbidity indicators and (ii) time lost measures.

The simplest and most commonly used measures for assessing the health level of a population are mortality rate indicators. However, they do not take into account losses caused by factors that do not result in death. This is because they do not assess burdens in the form of impaired physical or mental capacity during the course of the disease or the time preceding death. Actually, these measures assume that a person who does not die remains "healthy" [3]. In such a way, losses resulting from the complications of disease, as well as any pain or disability caused by a particular disease, are overlooked. These also fail to take into account other consequences of diseases – the costs which they entail for people suffering from the disease as well as for the public payer and for society as a whole. Mortality rates do not usually show the social and economic dimension of death and disease in different periods of human life. In addition, it is believed that deaths at a younger age constitute a greater loss for society than deaths that occur over the age of 90.

Nevertheless, the indicator showing the number of deaths per 100,000 serves as a starting point for assessing the burden imposed on the health of a society by different diseases, risk factors and injuries in units of time lost.

1.1. Time lost measures without taking into account health-related quality of life – years of life lost caused by death

It was Dempsey [4] who first suggested that premature mortality should be measured in units of time lost [2, 5]. A number of variants of this method have been developed since 1947. These units measure the amount of time lost as a result of deaths caused by particular disease. The main idea is that death at an early age constitutes a greater burden than death at a later age. Depending on how we count a lost period of life, the following measures have been developed: Potential Years of Life Lost (PYLL), measuring the number of years between the age of death and an arbitrary chosen limit of life; Period Expected Years of Life Lost (PEYLL), counting the years lost equal to life expectancy at age of death (for males or females) in the country and Standard Expected Years of Life Lost (SEYLL), considering the period of life lost equal to the standard life expectancy at age of death (using a synthetic life table constructed from the lowest observed age-specific mortality rates for each age-group anywhere in the world). For more explanations and results on PEYLL and PYLL in Poland see [2] and Kozierkiewicz et al. in this issue [6].

1.2. Time lost measures taking into account health-related quality of life: DALY

In recent years, a number of studies have been targeted towards creating a synthetic (universal) unit for measuring the health of society that integrates measures of burdens associated with both mortality and disability and that makes it possible to compare the burden of different diseases as well as the effects achieved by various medical interventions.

DALY (*Disability-Adjusted Life Years)* is a measure developed by experts of the World Bank and World Health Organization within the Global Burden of Disease (GBD) study, the first results of which were reported in 1993 [7–9]. Since that time the burden of disease using DALY concept has been widely adopted by governments and international organizations in their attempts to identify the relative magnitude of different health problems. This information serves as crucial input in debates on the priorities of the health sector.

DALY is a combination of two measures: loss of life as a result of premature death (YLL – Years of Life Lost) and loss of years in health due to disability caused by disease or injury (YLD – Years Lived with Disabilities). DALYs = YLLs + YLDs.

As a unit for measuring the disease burden in a society as a whole, i.e. the sum of all burdens for particular

groups of people, DALY provides a basis for assessing not only the losses to society due to deaths, but also the losses resulting from disabilities caused by different diseases. To any death from a particular cause is attributed YLLs number equal to the highest observed life expectancy (standard life expectancy at age at death). The YLL calculation, accordingly, places more weight on the causes of deaths that occur in younger age groups. YLD are estimated based on incidence or prevalence number of disease cases and imply disability weights [3].

GBD methodology is constantly being improved and so far four phases have been distinguished in this process[1, 2]. For this reason it is important to remain cautious when using GBD results published in previous years since they are not comparable.

2. Burden of disease measured in monetary units

Three approaches can be listed [2, 16]:

- The value of lost output: economic growth approach;
- The value of statistical life (VSL) approach;
- The cost-of-illness (CoI) approach.

2.1. Lost economic growth: assessing the cumulative value of lost output

This is a prognostic measure of the impact of disease on an economy's gross domestic product (GDP) and economic growth that takes into account the impact of disease on reducing factors of production (labour and capital) in a country. This method was used by a team of experts led by Professor D. Bloom of the University of Harvard [16], assembled by the World Economic Forum to assess the economic burden of chronic non-communicable diseases globally in the years 2011–2030[3]. The impact of these diseases on the economy (on the level of GDP) was estimated by assessing how these diseases reduce labour resources, physical capital and other factors in different countries. This approach used the WHO--EPIC (WHO tool for Projecting the Economic Costs of Ill-Health) model prepared in 2006 [17], which provides a simulation of the macroeconomic consequences of chronic diseases (in 169 countries around the world) by looking at the effects of chronic diseases on economic growth. The EPIC model takes into account the negative impact of chronic diseases on the amount of labour and capital resources available[4]. The results are unequivocal: NCDs pose a substantial economic burden and this burden will rise. The macroeconomic EPIC model simulations suggest that five main chronic NCDs: cardiovascular disease, cancer, chronic respiratory diseases, diabetes, and mental illness, will cause a cumulative output loss of US$ 47 trillion globally over the next two decades [16].

2.2. The value of statistical life approach

The value of statistical life (VSL) approach reflects society's willingness to pay (WTP) a certain sum with the aim of reducing the risk of disability or death caused by a particular disease. By placing a value on (establishing a monetary value) loss of health, the VSL approach goes beyond simply measuring the impact of disease on GDP and economic growth. It reflects the preferences of a society. Various factors affecting the level of VSL are considered. The factors most commonly shaping VSL are age, the level of national income (or the average wage in a country, or the average wage in a specific branch associated with some degree of risk), the kind of risk involved (for example, death from cancer), and the moment when a risk may appear in the future. When the age factor is taken into account, the value of life of an individual suffering from a disease is adjusted in accordance with a fixed indicator, or a reduced value of life is considered together with age. Such a correction is called the "senior discount" [18]. Bloom et al. found that the value of life lost due to NCDs in 2010 is US$ 22.8 trillion and will double by 2030 to US$ 43.4 trillion [16]. For more details on valuing statistical life and the disease burden results achieved, including those for Poland using this approach, see [2, 16].

2.3. The cost-of-illness approach

This is the third method for measuring the disease burden on society in monetary units: the value of resources used or lost as a result of the disease is measured. This approach makes it possible to determine the potential savings that can be achieved as a result of preventative interventions.

Today's costs of illness have their roots in studies published in the 1950s and 1960s [19–22] when, as in present times, there was a debate over the most suitable approach to measuring improvement of population health. The best approach appeared to be using the results of earlier conducted studies. In 1966 Dorothy Rice published a monograph [22] in which she proposed a methodology for estimating the costs of a disease using information from existing data bases. This work became the *de facto* standard for future cost analyses of different diseases. In the following years, this approach was developed and applied on a wide scale by different agencies and governments to identify the costs of different diseases [23–29].

The cost-of-illness approach measures different kinds of costs, depending on the criteria used, to divide resources into those used or lost caused by disease. *Direct costs* are the costs of medical care and non-medical costs incurred because of disease, such as the costs of transport to the health provider or caregiving costs – either paid or informal uncompensated care provided in the patient's home. In turn, *indirect costs* (or also called *productivity lost*) are the value of production lost as a result of death or an individual's inability to work during the time he or she is suffering from a disease.

The third category of costs, encompassing the "psychological" costs of disease and the costs caused by pain, i.e. the impact of a disease on an individual's quality of life, are called *intangible costs*. This category is usually mentioned when determining the different elements of the disease costs. However, owing to the difficulties involved in measuring such costs (primarily because their content differs greatly from the other two cost categories), it is usu-

ally not considered when estimating the costs of diseases [30, 31]. For a more in-depth explanation of the cost-of-illness approach and the techniques used to value resources used and lost please consult [2, 26, 28, 29, 32, 33]. To our best knowledge there is no example of a cost-of-illness study summarising the costs of all diseases globally. The abovementioned study by Bloom et al. [16] attempted to measure the disease burden of chronic NCDs in the world. Due to the incomparability of the methods applied for each of the five main analysed NCDs the results were presented separately. The direct and indirect costs of illness for five distinct disease categories were [16]:

- Cardiovascular diseases: US$ 863 billion in 2010, rising to US$ 1.04 trillion in 2030;
- Cancer: US$ 290 billion in 2010, rising to US$ 458 billion in 2030;
- Diabetes: nearly US$ 500 billion in 2010, rising to at least US$ 745 billion in 2030;
- COPD: US$ 2.1 trillion in 2010 rising to US$ 4.8 trillion in 2030;
- Mental illness: US$ 2.5 trillion in 2010 rising to US$ 6.0 trillion by 2030.

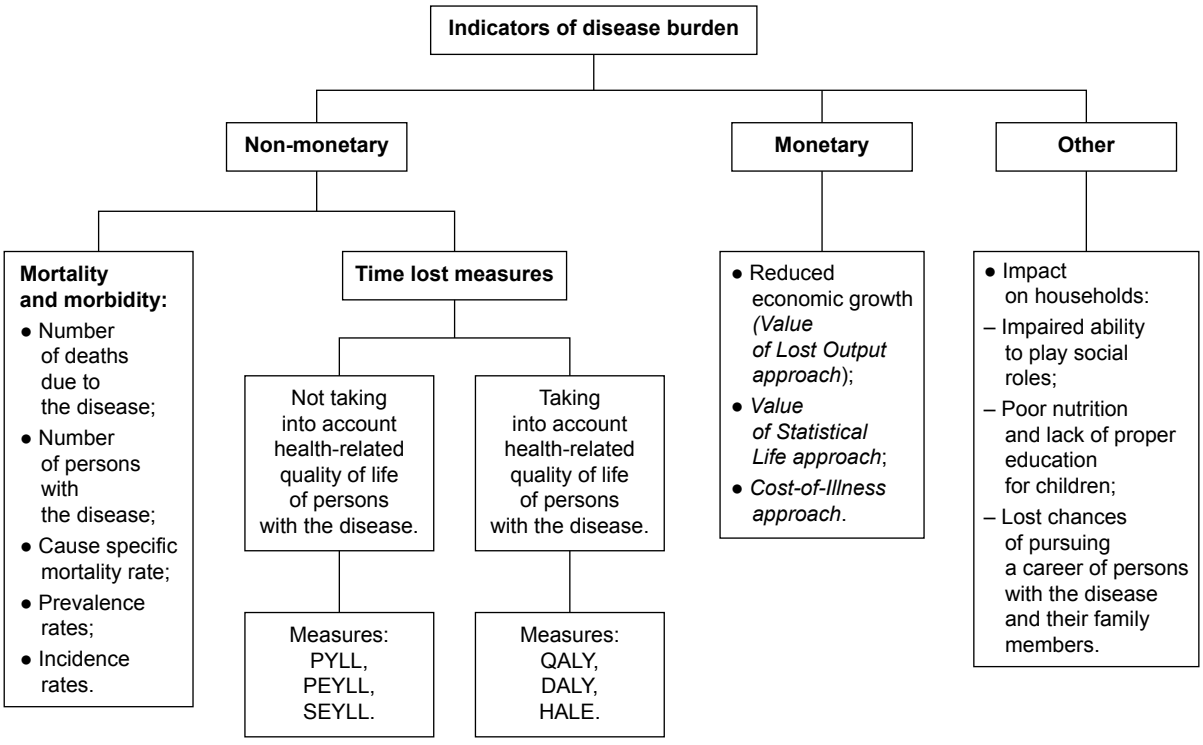
3. Considering individual and intergenerational spillovers of disease

Disease burden analyses may also focus on illnesses consequences other than those summarised in the first two groups described above (monetary and non-monetary units). These are called individual and intergenerational disease spillovers and may include: the impaired ability of ill persons to play social roles successfully, poor nutrition and lack of proper education for children, lost career opportunities both for persons with the disease and for their family members (**Figure 1**).

A disease causes direct loss of well-being to an individual. In their report, focusing on health investments in developing countries, the WHO Commission on Macroeconomics and Health [34] emphasised that there is a reduction in the "utility" of the individual as a result of poor health (even if there is no change in the level of goods and services consumed or in the life span of the individual) due to the likely significance of the long-term consequences of early disease episodes. Early disease may obstruct physical and cognitive development, which, in turn, may reduce an adult's economic productivity. Reduced cognitive capacity may lead to leaving school early, a lack of educational achievement, and reduced earnings in adulthood.

The intergenerational spillover of disease also occurs [34]. When one individual in a family is affected by disease, it may have important adverse effects on other family members, especially children. An adult's illness may result in the poor health, or even death, of a previously healthy child because of a drop off in care giving and family income. A parent's illness or death may, for example, force a child to leave school prematurely in order to help support the family. The adult's illness will also reduce the transfer of knowledge from parent to child.

Figure 1. *Indicators and approaches to measuring disease burden*



Source: Author's own elaboration based on Kissimova-Skarbek K., Koszty obciążenia chorobami, in: Golinowska S. (ed.), Od ekonomii do ekonomiki zdrowia. Podręcznik ekonomiki zdrowia, PWN, Warszawa 2015: 354–391 [2].

Identification and recognition of individual and intergenerational spillover of disease should be, but rarely are, considered in *cost-of-illness* studies (particularly in estimating indirect costs of the disease). It is believed that *CoI* literature often understates, for example, the costs of nonfatal chronic conditions at all stages of the life cycle [34] by not considering the above mentioned spillovers. These may be substantial and should be taken in-to consideration when assessing indirect costs within the CoI studies.

4. The occurrence of diseases

Civilizational progress and medical advances have affected the balance (in terms of frequency) between the three main groups of diseases: (i) communicable, maternal, neonatal and nutritional, (ii) non-communicable diseases (NCDs) and (iii) injuries. At the present time, chronic non-communicable diseases, resulting both in death and permanent disability, impose the biggest burden on society.

Characteristics of chronic diseases

According to WHO experts [35], the main chronic diseases are: heart disease and cerebral strokes (cardiovascular diseases), neoplasms, asthma, obstructive pulmonary disease (chronic diseases of the respiratory system) as well as diabetes mellitus[5]. Neuropsychiatric diseases are also nowadays regarded as one of the most common non-communicable diseases.

Cardiovascular disease includes diseases affecting the heart and blood vessels as well as the conditions resulting from poor blood flow caused by vascular disease. More than 82% of global deaths as a result of cardiovascular disease are due to ischaemic heart disease, cerebral strokes (both haemorrhagic and ischaemic), hypertension and congestive heart failure. Over the course of the last decade cardiovascular disease has become the most important cause of death around the world (it accounts for almost 30% of all deaths as well as over 45% of deaths from chronic non-communicable diseases. In 2010, cardiovascular diseases caused 15.6 million deaths around the world.

Cancer consists in the rapid and excessive growth and division of abnormal cells in the body. These cells outlive normal cells and have the ability to make metastases and spread to other parts of the body as well as other organs. There are more than 100 different types of cancer as well as different risk factors contributing to the growth of cancers in different parts of the body. Cancers are the second biggest cause of death in the world, accounting for 16% of all deaths globally and 22% of global deaths due to NCDs. In 2015, 8.76 million people died of cancer globally. This translates into an increase of 54% compared to 1990.

Diabetes mellitus: Diabetes type 2 accounts for 90–95% of all cases of diabetes mellitus. In 2015, over 435 million people globally had diabetes [13], which represents a 30.6% increase compared to 2005. This number is expected to rise to over 642 million by 2040 if no major preventative measures are taken [36]. A considerable number (around 50%) of cases of diabetes type 2 remain undiagnosed. Delayed diagnosis of diabetes mellitus as well as ineffective treatment of this condition may cause late complications of the disease, in particular vascular complications, which result in premature invalidity and increased mortality in this group of people. They include microvascular complications, such as nephropathy and retinopathy as well as macrovascular complications, e.g., heart attacks, heart failure, strokes and peripheral artery disease, e.g., diabetic foot. International Diabetes Federation estimates that about 5 million deaths in 2015 were due to diabetes [36], and it accounts for 9% of all deaths and 13% of deaths caused by NCDs globally.

Chronic respiratory diseases together account for 3.8 million deaths worldwide, 7% of all deaths globally and 10% of deaths due to chronic non-communicable diseases [37]. They are the fourth main cause of deaths globally. The most common diseases in this group are asthma, chronic obstructive pulmonary disease (COPD), respiratory allergies, occupational lung diseases, and pulmonary hypertension. COPD refers to a group of progressive pulmonary diseases which cause breathing difficulties, including chronic bronchitis and emphysema.

COPD contributes to 3.8 million deaths each year [37] and accounts for 3–8% of all deaths in countries with a high national income and 4–9% of all deaths in countries with low and average national incomes [16]. Morbidity and mortality rates from COPD are expected to increase in the future. A causal relation exists between this disease and four main sources of exposure: tobacco smoking, smoke inside premises, environmental pollution and professional exposure to the effects of certain microparticles (e.g., asbestos). Despite the fact that the development of COPD can be checked be preventing exposure to the main risk factors, it cannot be cured fully according to the present state of medical knowledge.

Mental illness is a term referring to a group of medical conditions which affect the thinking, feeling and moods of an individual, his or her ability to relate to others and his or her ability to function in daily life. They are sometimes also referred to as mental disorders, mental health or neuro-psychiatric diseases. These disorders affect the lives of hundreds of people around the world. In 2015 over 311 million people in the world were suffering from major depressive disorders and almost 64 million were dependent on alcohol [13]. Close to 900,000 people suffering from mental illness commit suicide every year [16].

Methods

The techniques for measuring the disease burden and health of a population illustrated with examples have been described in detail elsewhere [2, 5].

The present study focuses on two approaches to assessing disease burden: (i) a GBD study that includes a DALY measure and (ii) the WHO Commission on Macroeconomics and Health, which values each unit of DALY at one or three times GDP per capita in the coun-

try in the year being evaluated. As mentioned earlier, the DALY is calculated by adding Years of Life Lost (YLL) due to deaths to Years Lived with Disability (YLD).

In accordance with the methodology adopted in the latest Global Burden of Disease (GBD) study [12], the global and Polish DALYs presented here are not age weighted, not discounted, and contain a higher (compared to GBD-2010 study version) equal standard life expectancy at age of death. The normative life table of 91.9 years at birth [12] has been used to calculate YLLs in order to avoid disparities both between countries and between males and females. Estimating YLDs involves three main steps [38]: (i) establishing the prevalence and incidence of causes and sequelae (health states caused by a disease, for example, the blindness that can be caused by diabetes) related to disability, (ii) classifying these disabilities according to their degree of severity, and (iii) combining these two results into one comprehensive measure of nonfatal health loss. Several data sources and techniques have been used in the present GBD 2015 study, such as collecting data from government reports, data from population-based disease registries, antenatal clinic data, hospital discharge data, and other sources as well as modelling[6] to generate estimates of the prevalence and incidence of disability-causing sequelae. To classify disability complications of diseases according to their degree of severity, surveys were conducted to establish disability weights, among other things. These weights are coefficients of severity on a scale of 0 to 1 attributed to each disability. These are used to estimate the period of life reduced due to disability [13].

The top ten health problems globally and in Poland in 2010 have been listed elsewhere [2, 39]. Presented in this paper, on the other hand, is the burden of diseases for 2015 compared with 1990 based on the results of the recently published GBD study [12, 13, 37]. This paper identifies the main causes of disease burden in different ways:

- the top ten causes in the world and in Poland based on deaths per 100,000 in 2015 and the percentage change compared to 1990;
- the ten main causes of DALYs, YLD and YLL in Poland in 2015 and the percentage change between 1990 and 2015;
- the number of YLLs due to all causes in Poland over a 25 year period (1990–2015), and the percentage of avoidable YLLs (occurring below the age of 70);
- DALYs by age group and sex due to NCDs in Poland;
- the value of income lost due to all causes of death and unnecessary income lost (and in consequence – a downturn in economic development) due to premature deaths;
- the value of income lost due to DALYs caused by NCDs in Poland.

The study also presents the distribution of DALYs in the working age population both globally and in Poland among three main groups of diseases – communicable diseases, maternal, neonatal and nutritional diseases, noncommunicable diseases, and injuries (external causes of mortality and morbidity), which indirectly demonstrates the impact of diseases on the economy. By way of comparison, we adopted the 15–59 age group (the most commonly used in publications) as the working age for both Poland and the world[7]. Our analyses for Poland by gender also concerned different working age periods, according to the working age ranges for males and females advised by the Central Statistical Office of Poland.

To estimate the amount of income lost in Poland, we used the method utilised by the WHO Commission on Macroeconomics and Health so as to give a direct estimate of DALYs due to disease. It recommends valuing DALYs at between one and three times GDP per capita (referred to as CMH1 and CMH3, respectively) [34]. Constructing the CMH1 and CMH3 estimates required multiplying the annual number of DALYs by the relevant multiple (1 or 3) of income per capita in Poland for the year in question. GDP per capita was presented in current International Dollars (I$). Future time lost due to deaths (YLL) and in consequence – income lost due to all causes in Poland in 2015 was discounted at a 3% discount rate.

To determine the real change in income lost over time and to ensure international comparisons, levels of income lost in previous years have been converted to 2015 prices using GDP deflators for Poland in respective years [40]. Next, values in 2015 national currency units (NCU) were converted to 2015 I$ by applying purchasing power parity (PPP) conversion factors for GDP (NCU per I$) [41].

Results

1. Ranking of diseases by their burden, measured with death rate

The average ranks of diseases and injuries globally, measured by the deaths per 100,000 rate in 2015 and the percentage change compared to the year 1990 are shown in **Table I**. We can observe the direction of the change in the top ten causes. In 2015 five of the ten main global causes of deaths were chronic non-communicable diseases. Three of the NCD group causes have increased their position in the ranking. Neoplasms moved from the third rank in 1990 to the second rank in 2015. The global burden of diabetes mellitus also increased – shifted from the eighth place in 1990 to the fifth place in 2015. The burden of neurological disorders increased from rank eleven to rank seven (with an almost 47% increase within a 25 year period).

Chronic NCDs were responsible for 90% of all deaths in Poland in 2015. 46% were due to cardiovascular diseases, which still represent the main cause of death in Poland. The top ten causes of death in Poland in 2015 ranked by number of deaths per 100,000 are presented in **Table II**. Even though the death rate due to ischemic heart disease in 2015 has decreased compared to 1990 by 24.9%, it is still a main cause of death in Poland, causing 270.56 deaths per 100,000. Alzheimer disease and other dementias had the highest percentage increase in the last 25 years in Poland (73.4%).

Table I. *Top 10 global problems in 2015, ranked by number of deaths per 100,000 population and percent change, 1990–2015, both sexes, all age groups*

1990 ranking		2015 ranking		Change
1	Cardiovascular diseases	1	Cardiovascular diseases (243.13)	2.41%
2	Diarrhoea/LRI/other	2	Neoplasms (118.91)	11.91%
3	Neoplasms	3	Diarrhoea/LRI/other (67.29)	–55.37%
4	Chronic respiratory diseases	4	Chronic respiratory diseases (51.49)	–22.4%
5	Neonatal disorders	5	Diabetes, urogenital, blood, and endocrine diseases (46.25)	44.14%
6	Unintentional injuries	6	HIV/AIDS and tuberculosis (31.27)	–7.47%
7	HIV/AIDS and tuberculosis	7	Neurological disorders (30.65)	46.84%
8	Diabetes, urogenital, blood, and endocrine diseases	8	Neonatal disorders (29.35)	–55.73%
9	Transport injuries	9	Unintentional injuries (24.95)	–35.14%
10	Neglected tropical disease and malaria	10	Transport injuries (19.9)	–12.71%
11	Neurological disorders	14	Neglected tropical disease and malaria (11.44)	–45.28%

I. Communicable, maternal, neonatal, and nutritional diseases
II. Non-communicable diseases
IIII. Injuries

The ratio of number of deaths per 100,000 by cause in 2015 is provided in parentheses. LRI = lower respiratory infections.

Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 08.10.2016 [37].

As in the global ranking, the top cause of mortality in Poland in 2015 was the cardiovascular disease group. Here (where a more detailed classification of diseases is used) ischemic heart disease together with cerebrovascular disease are the first two out of the top ten causes of mortality. This cause has not moved from the first rank since 1990 in either Poland or in the world. However, compared to the global burden, the ratio in Poland of 270.56 deaths due to ischemic heart disease per 100,000 members of the population in 2015 (vs. 120.97 deaths per 100,000 globally [37]) is over two times higher than average global rate. The global death rate due to cardiovascular diseases in 2015 was 243.13 deaths per 100,000 vs. 460.84 per 100,000 deaths in Poland in the same year [37].

On the other hand, unlike the global ranking where lower respiratory infections (from the communicable diseases group) have decreased their rank from third to fourth place, in Poland lower respiratory infections have increased their rank from 9th place in 1990 up to 7th place in 2015. However, the rate of number of deaths per 100,000 population in Poland in 2015 was lower compared to the global burden of LRI (30.48 vs. 37.13 [37]).

2. Burden of disease measured with DALY

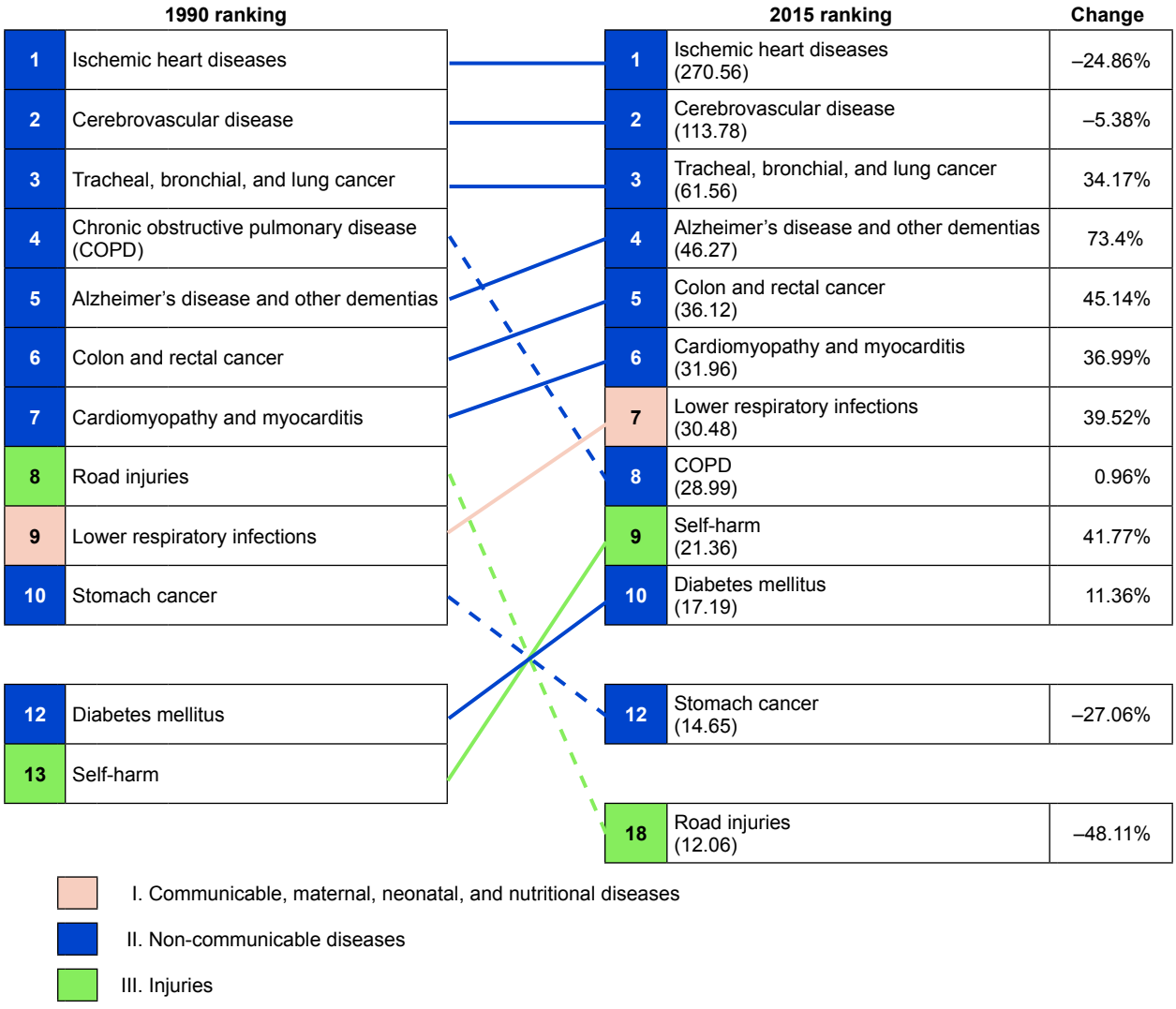
2.1. The global and national burden of disease in the years 1990–2015

In 2015 over 2.46 bln DALYs globally were lost due to all causes, of which 67.9% were years of life lost due to deaths [37]. 84% of the total years of life lost due to deaths (and 57.2% of all DALYs in year 2015) appeared under the age of 70 and are considered avoidable.

The largest share of the global burden (60%) is attributable to NCDs. In 2015 over 1.47 bln DALYs globally were due to NCDs. (**Chart 1(a)**). During the entire period of 1990–2015, the share of YLL was much higher than YLDs. Deaths caused a higher number of YLLs in males compared to females (**Chart 1(b)**). In females a minor decline in YLLs was observed in 2010 compared to 2005. The highest increase in DALYs due to NCDs in the 1990–2015 period was observed in disability (YLDs) caused by disease. Both sex groups have presented an increase in YLDs.

Poland experienced over 11.3 mln DALYs in 2015, 86.7% of which were due to NCDs, followed by injuries (external causes of deaths and morbidity), responsible for 9.3% of DALYs, and communicable diseases,

Table II. *The top ten health problems in Poland, 2015, ranked by number of deaths per 100,000 population, both sexes, all age groups, and percent change, 1990–2015*



The ratio of number of deaths per 100,000 by cause in year 2015 is provided in parentheses.

Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 08.10.2016 [37].

maternal and nutritional disorders, accounting for 4.0% of all-cause DALYs [37]. The NCDs showed a 4.7% decrease in the number of DALYs compared to 1990. Injuries – with a decline of 30.2% and the group of communicable, maternal, neonatal, and nutritional diseases showed the highest decline of DALYs – 56.25%, compared to the 1990 number of DALYs. **Chart 1(c)** shows the number of YLL and YLD in Poland in the period of 1990–2015 and **Chart 1(d)** – divides these values among both sex groups. Similar to the global trend for both sex groups considered together, in Poland an increase in YLDs due to NCDs has been observed during the last 25 years (**Chart 1(a)** and **(c)**). In YLL due to deaths, Poland showed better achievement in averting YLLs compared to the entire world. This is further confirmed when analysing the number of YLLs by sex (**Chart 1(b)** and **(d)**). When observing DALYs over 25 years, the number of DALYs in Poland has slightly decreased (or stayed stable) as opposed to the global tendency where the number of DALYs has increased (**Chart 1(a), (b), (c), (d)**).

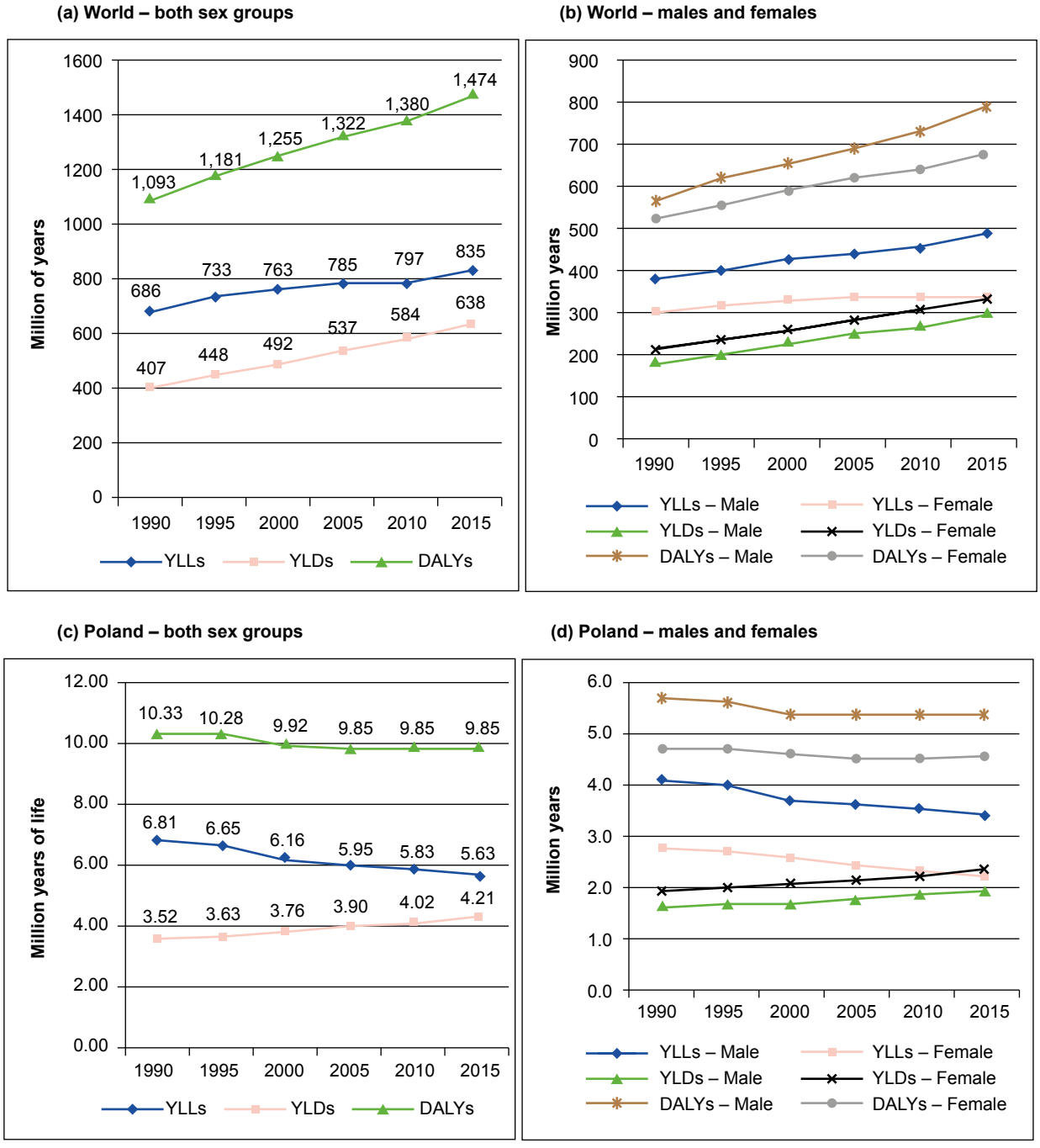
2.2. The global and national burden of NCDs by age group

When the YLLs and YLDs due to NCDs in 2015 are presented by age groups the first observation is that in Poland the years of life lost due to both death and disability, appeared mainly over the age of 50 with few in the below 20 age group. In the entire world – the burden of NCDs (especially due to deaths) is substantial in the below age 20 age groups (**Chart 2**).

2.3. Ranking of diseases based on DALY in Poland in 2015

The leading causes of disability in Poland are presented in **Table III**. At the top of the list are lower back and neck pain, sense organ diseases, depressive disorders and diabetes.

Chart 1. *Global and national in Poland burden of non-communicable diseases expressed in YLLs, YLDs and DALYs, years 1990–2015*

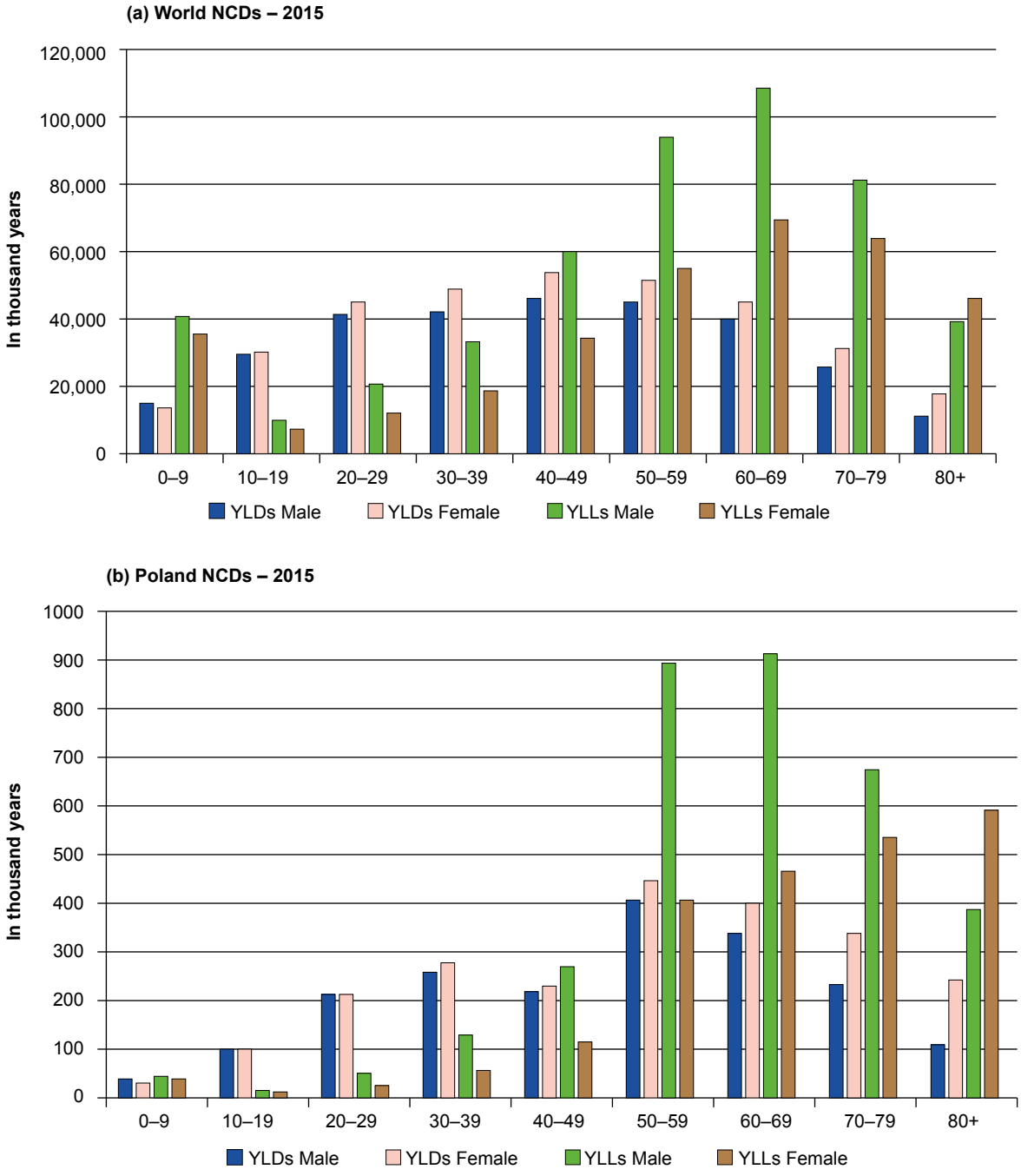


Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 08.10.2016 [37].

As can be seen in **Table III,** all the top ten causes of disability in Poland in 2015 were due to NCDs. Lower back and neck pain in the first rank (the same as 25 years ago) caused the most disability in Poland (803,456 years lived with disability) representing a 17.2% increase compared to 1990. The second rank was held by sense organ diseases, which showed an over 30% increase since 1990 and led to 513,612 YLD in the Polish population in 2015. Depressive disorders in the third rank caused 330,423 YLDs and demonstrated an increase by 15.5% since 1990. The largest increase of burden in the last 25 year period has been observed in diabetes (77%) which caused 223,139 YLDs and moved from 6th to 4th place. Osteoarthritis showed a 48.5% increase, causing 118,030 YLDs. Falls demonstrated an over 22% decrease and iron deficiency anaemia from the first group (communicable diseases) – almost a 26% decline in the last 25 year period.

Table IV shows the leading causes of years of life lost due to deaths in Poland in 2015. Seven of the ten causes were non-communicable diseases with ischemic

Chart 2. *Burden of NCDs globally and in Poland, by sex and age groups in 2015*



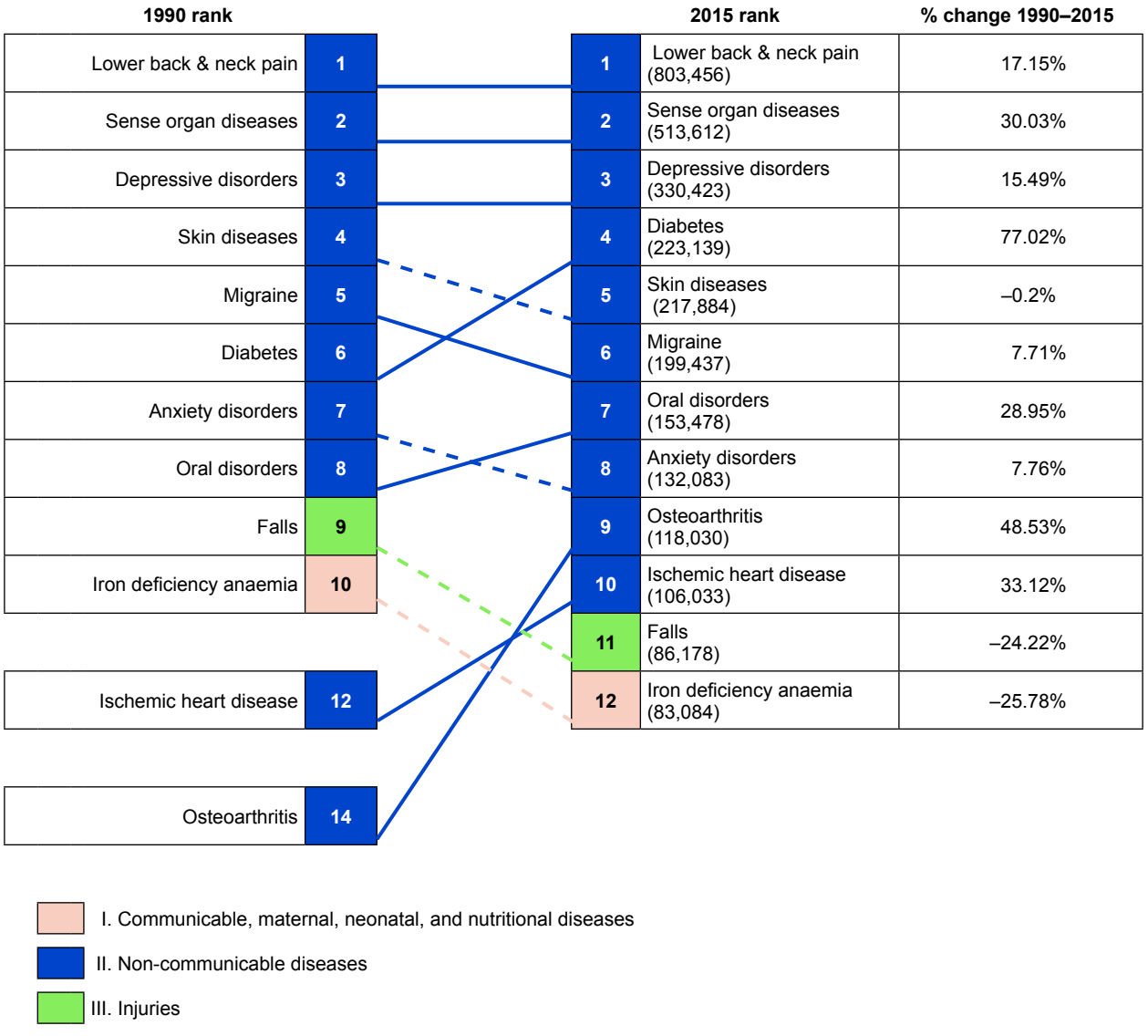
Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 08.10.2016 [37].

heart disease in the top position. Even with five of these seven NCD causes having shown a decline in YLL numbers, these are still the leading causes of premature death in Poland. Three of the causes showed a substantial increase in time lost during the last 25 years: lung cancer (by 19.2%), self-harm (by almost 29%), colorectal cancer (by 26.4%) and the highest, almost a 50% increase demonstrated by Alzheimer's disease.

Applying the DALY measure, the main diseases causing the most death and disability combined in Poland are presented in **Chart 3**.

Eight out of the ten leading causes of death and disability combined in Poland 2015 were NCDs (**Chart 3**). The top cause of disability adjusted life years in Poland in 2015 was ischemic heart disease, which showed a 38% decrease compared to 1990. However, it still remains the number one cause of years of life lost due to death and disability in Poland (accounting for over 1.45 mln DALYs in 2015). The second leading cause of burden to the Polish population was lower back and neck pain, accounting for 803,456 DALYs and presenting a 17% increase in the 25 year period. The biggest improve-

Table III. *Leading causes of disability (YLDs) in Poland in 2015 and percent change, 1990–2015*



The number of YLDs by cause in 2015 is provided in parentheses.

Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 22.10.2016 [37].

ment Poland achieved was in preventing consequences of road injuries (–46% compared to1990). Unfortunately, road injuries still remain among the ten leading causes of death and disability (ranking 9th). The DALYs due to colorectal cancer in Poland in 2015 were 252,875 and presented an almost 30% increase in the last 25 years.

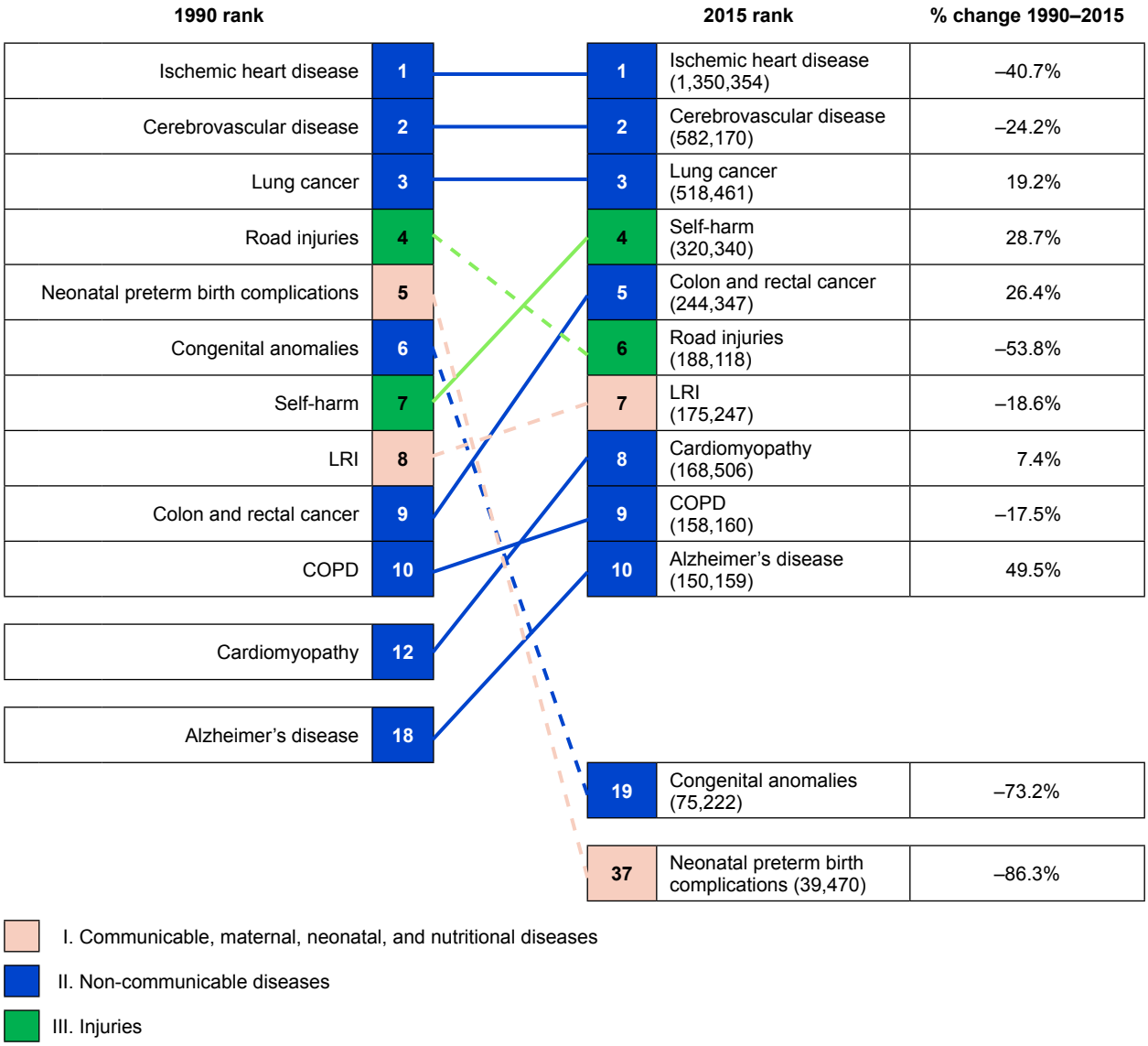
2.4. Burden of diseases on the working age population

In 2015 45.7% of all disability adjusted life years globally were from the working-age (in 15–59 years of life) population (an aggregate distribution of working-age DALYs can be seen at **Chart 4(a)**). In Poland – almost 47% of DALYs due to all causes were in the working age population. Over 66.7% of global DALYs in the working age population were due to NCDs, 18.2% due to communicable diseases and 15.1% due to injuries (**Chart 4(a)**).

Although the share of non-communicable diseases in the overall burden of disease varied in countries with different income levels, it was prevailing everywhere. In *High-Income Countries* as in Poland about 82% of DALYs in the working age population are due to chronic non-communicable diseases.

Chart 4(b) presents the share of working age DALYs attributable to the three main groups of diseases in Poland. To assure the comparability of results, the identical age group of 15–59 years was considered as the working age group for analyses performed for both Poland and the world. This is the age interval most commonly used in publications.

Table IV. *Leading causes of premature deaths (YLL) in Poland, 2015 and percent change, 1990–2015*



LRI = lower respiratory infections; COPD = Chronic Obstructive Respiratory Disease; The number of YLLs by cause in 2015 is presented in parentheses.

Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 22.10.2016 [37].

Chart 5 presents the distribution of working-age DALYs results for Poland for men and women adopting the working age range for women of 18–59 and for men of 18–64. In the group of women 26.4% of all cause DALYs were in the working age (18–59) group, in males it was 64.6% (in the 18–64 age group), which leads to substantial productivity losses for the economy. In women the share of working-age DALYs due to NCDs is much higher than in men. This is mainly due to the larger share of injuries for men (specifically road traffic accidents), which in males was 17.37% compared to 6.5% in the female group.

The impact of NCDs on the working age population in Poland in 2015 is substantial. 89.6% of working age DALYs in females were due to NCDs, in males – 80.33%. Females had a higher number of working age DALYs due to communicable, maternal, neonatal and nutritional diseases than males (3.9% vs. 2.3%).

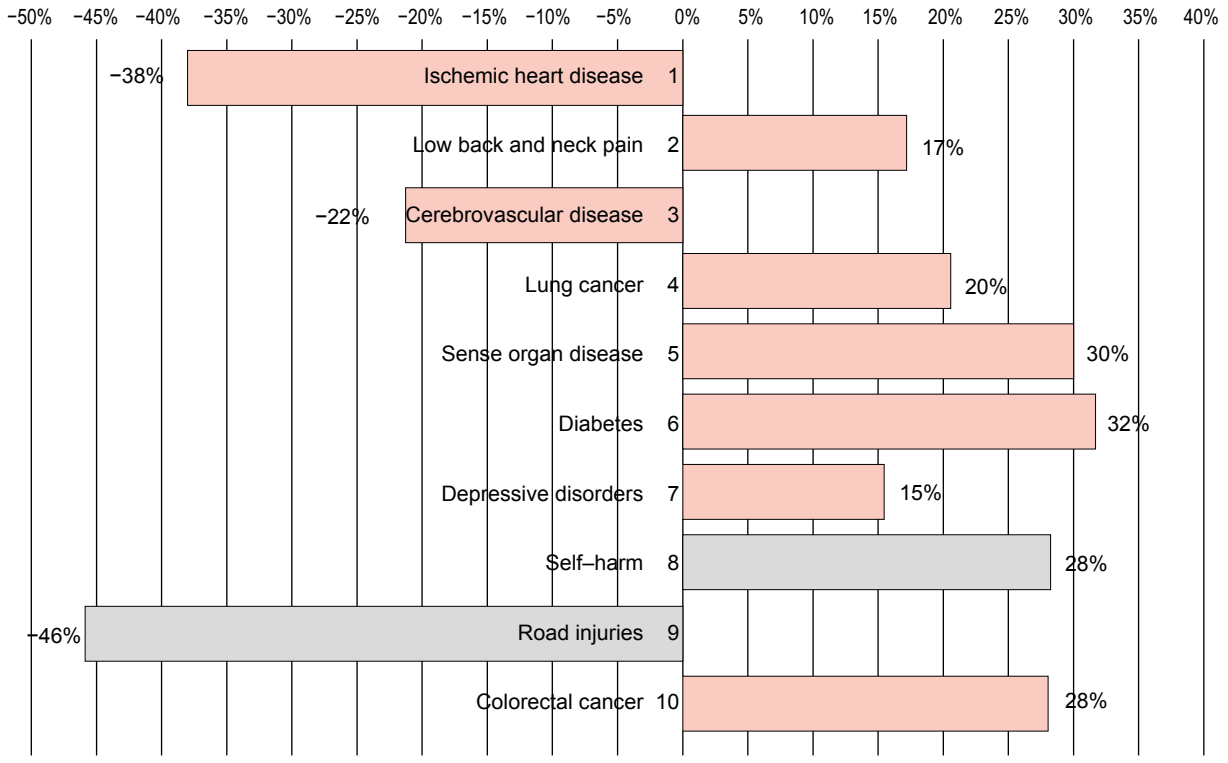
3. Income lost due to ill health in Poland

The income lost due to diseases is calculated based on number of DALYs presented earlier.

3.1. Income lost due to all causes deaths in Poland

The results of applying the WHO Commission on Macroeconomics and Health (CMH1 and CMH3) approach in measuring the income lost due to diseases are presented in **Chart 6**.

Chart 3. *Leading causes of DALYs in Poland, 2015 and percent change, 1990–2015*



Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 22.10.2016 [37].

The total income lost due to all causes in Poland in 2015 was I$176 bln according to CMH1 and I$527 estimated with the CMH3 approach (Chart 6). After discounting with a 3% discount rate the income lost due to all causes YLL in Poland 2015 accounted for I$108 bln when CMH1 was used and I$324 bln estimated with the CMH3 method. Almost 69% of lost income occurred due to deaths below the age of 70 and is assumed to have been avoidable.

3.2. Income lost due to NCDs in Poland 2015

Estimated income lost due to non-communicable diseases in Poland 2015 due to NCDs is presented in **Table V**.

The total economic burden of NCDs in Poland 2015 estimated with the CMH1 and CMH3 approaches accounted for between I$259 bln and over I$776.7 bln (Table V). 57% of the lost income was due to deaths. Among them, 61% were below the age of 70, which are considered avoidable and the economic loss could have been avoided.

Conclusion

The disease burden globally and in Poland was assessed here with non-monetary units: the death rate and a synthetic indicator considering both duration of time lost due to deaths and reduced quality of life during disease – the DALY measure with YLLs and YLDs in its construct. The DALY also formed the basis for estimating the income lost due to disease in Poland.

Below are the key findings in the study.

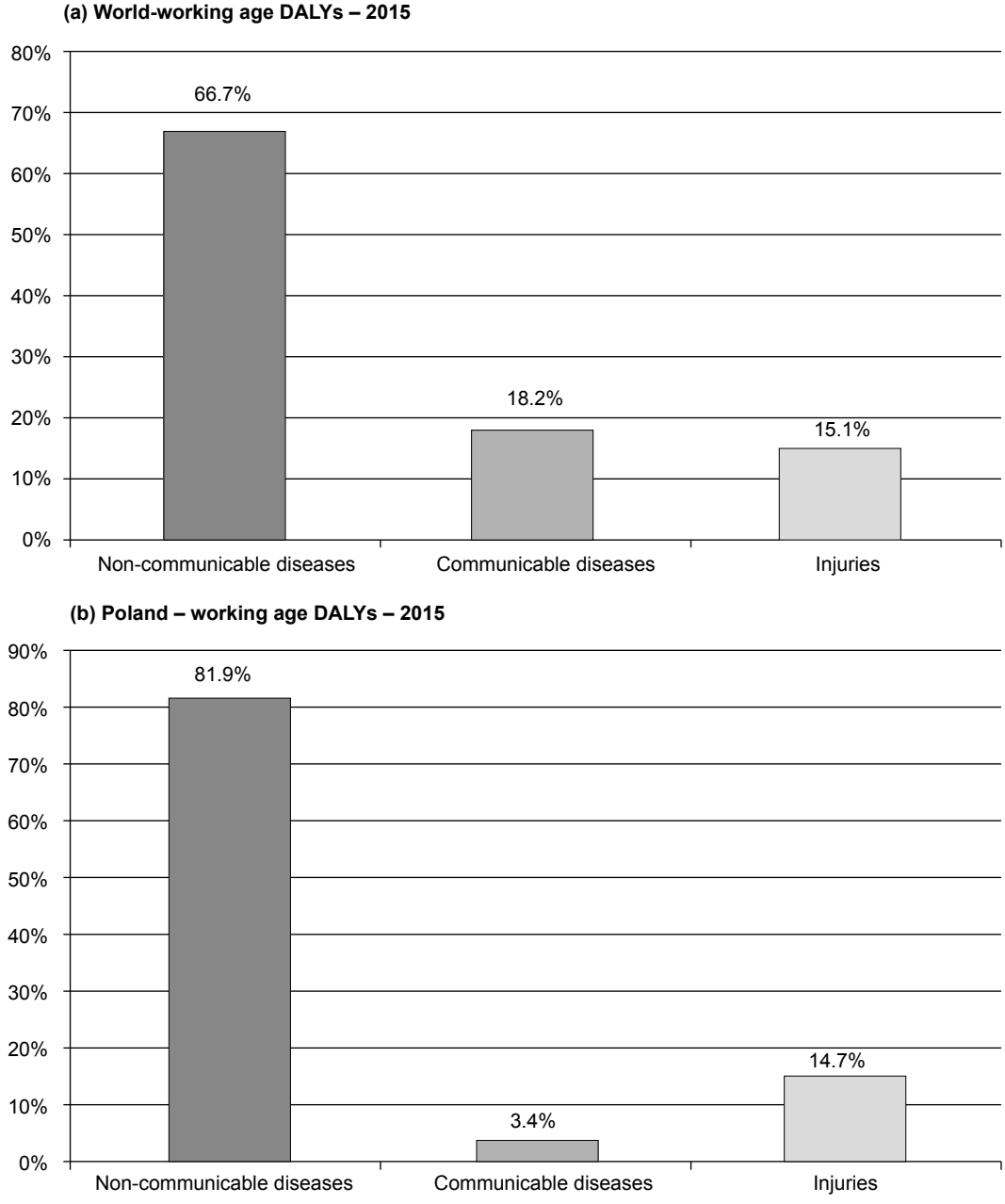
Main causes of deaths both globally and in Poland

In 2015 the leading causes of deaths globally were non-communicable diseases: cardiovascular diseases, neoplasms, chronic respiratory disorders, diabetes and neurological disorders. Most of them increased or held the same high rank during the last 25 years.

In Poland eight out of the ten top causes were also from the NCD group. Most of them moved upward in the ranking during the last 25 years like: diabetes, Alzheimer's disease and other dementias, cardiomyopathy and colorectal cancer. Others have held their position in the first three ranks: ischemic heart disease, cerebrovascular disease and lung cancer. Even having achieved a decrease in the mortality rate of almost 25% compared to 1990, ischemic heart disease is still at the top of the list. Some of substantial changes in disease burden due to deaths elicited in the study (the percent increase of death rates in diseases like Alzheimer's disease and other dementia, or diabetes mellitus) may be due to an improved diagnosis of the cases or as a result of improved recognition by researchers[8].

In 2015, 54% of all deaths globally and about 43% of deaths due to NCDs were premature and avoidable (oc-

Chart 4. *Distribution of working age DALYs due to three main groups of diseases globally and in Poland, 2015*



Source: Author's own elaboration based on Oxford Health Alliance working group, Economic consequences of chronic diseases and the economic rationale for public and private intervention, Draft for circulation to participants of OHA 2005 conference, 21 October 2005 [35] and data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 08.10.2016 [37].

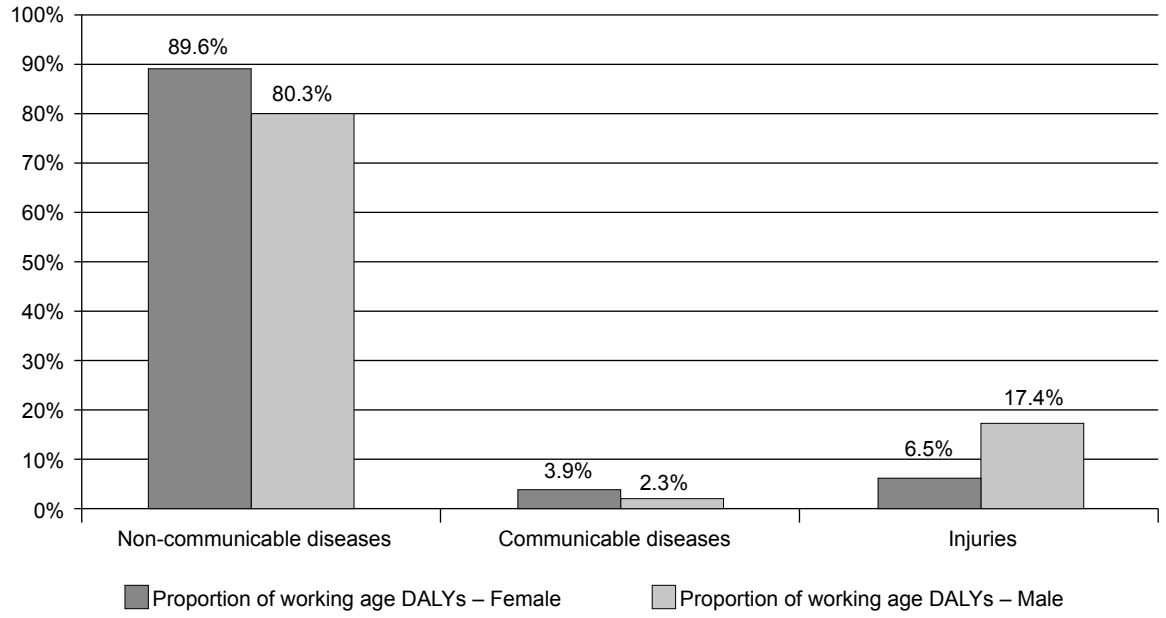
curring before the age of 70). Compared to the previous analyses done by the author [2] there has been a clear shift in the age of death in the direction of the older ages.

The world has achieved an improvement in combating deaths in the last 25 years. The all cause death rate in 2015 was 756.92 deaths per 100,000 which, compared to 1990, has decreased by 16.24%. In Poland the all cause death rate in 2015 was 994.13 deaths per 100,000 which, compared to 1990, has decreased by 3.02%.

The burden of non-communicable diseases is growing due to the aging population and unhealthy life styles. Due to its mass character, this has become a huge burden to societies. At present, over 71% of all deaths (accounting for over 39.8 mln) globally are due to NCDs [37]. In Poland 90% of all deaths in 2015 (accounting for over 348.7 thousands) are due to NCDs. 32% of these deaths occur below the age of 70 and are considered to be avoidable.

The burden of communicable diseases, maternal, neonatal and nutritional diseases declined from 1990 to 2015 – both globally and in Poland, with the bulk of that achievement being driven by reductions in the burden of child and maternal mortality. In Poland the community

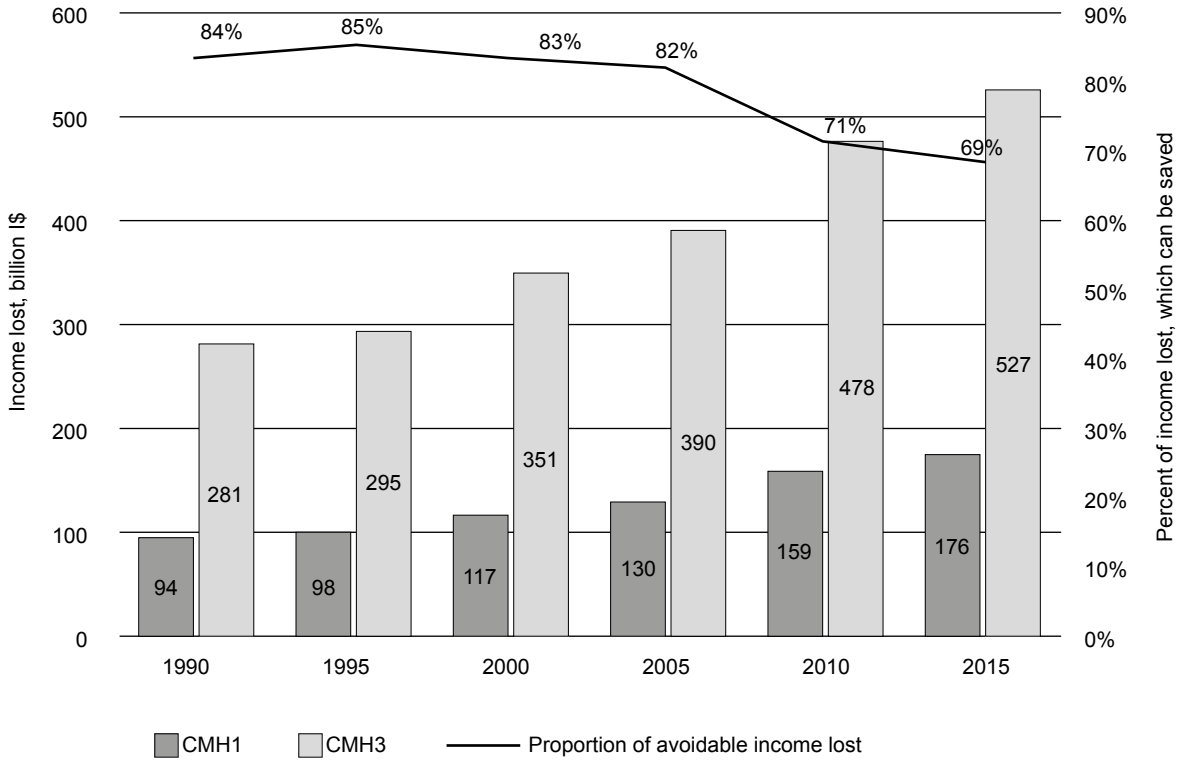
Chart 5. *Distribution of working age* DALYs among the main groups of diseases in Poland in 2015, by sex*



* Working age according to GUS Poland

Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 08.10.2016 [37].

Chart 6. *Income lost due to years of life lost caused by deaths in Poland, all causes, both sex groups (in bln I$, 2015 prices) – CMH1 and CMH3 methods*



Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 08.10.2016 [37], World Bank, World Development Indicators, GDP per capita PPP (current international $) [43], World Bank, World Development Indicators, GDP deflators [40] and World Bank, World Development Indicators, PPP conversion factor, GDP (Local Currency Unit per international $), International Comparison Program database [41].

Table V. *Income lost due to NCDs in Poland in 2015 estimated with the CMH1 and CMH3 (bln current I$)*

Measure	Income lost due to NCDs Males 2015 (CMH1)[1]	Income lost due to NCDs Females 2015 (CMH1)	Income lost due to NCDs Both sex groups 2015 (CMH1)	(%)	Income lost due to NCDs Males 2015 CMH3[2]	Income lost due to NCDs Females 2015 CMH3	Income lost due to NCDs Both sex groups 2015 CMH3
YLD	50.2	59.9	110.1	43%	150.6	179.7	330.3
YLL	89.5	59.3	148.8	57%	268.5	177.9	446.4
DALY	139.7	119.2	258.9	100%	419.1	357.6	776.7

[1] CMH1 when 1 × GDP per capita is applied.
[2] CMH3 when 3 × GDP per capita is used.

Source: Author's own elaboration based on data from Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME); accessed: 08.10.2016 [37], World Bank, World Development Indicators, GDP per capita PPP (current international $) [43], World Bank, World Development Indicators, GDP deflators [40] and World Bank, World Development Indicators, PPP conversion factor, GDP (Local Currency Unit per international $), International Comparison Program database [41].

focus on child survival appears to be reaping rewards as the neonatal preterm birth complications cause in 2015 dropped to the 37th from the 5th rank in 1990 in the top leading causes of premature deaths (accounting for an over 86% decline in YLLs).

Main causes of premature deaths – years of life lost in Poland

Over 6.7 mln years of life were lost in Poland in 2015 due to all causes. 57.4% of these were due to the top ten causes (seven of which were NCDs). Compared to 1990, Poland has achieved a decrease in the number of YLL by 24%. Ischemic heart disease caused 1.35 mln YLLs and held, as in 1990, the first rank of the diseases causing the most premature deaths.

Main causes of disability and combined death and disability in Poland

All of the top ten causes of disability in Poland 2015 were non-communicable diseases. These are: lower back and neck pain, sense organ diseases, depressive disorders, diabetes, skin diseases, migraines, oral disorders, anxiety disorders, osteoarthritis and ischemic heart disease. All above listed causes, except skin diseases, demonstrated a substantial increase of YLDs compared to 1990. The highest increase was observed in diabetes mellitus (over 77%), followed by osteoarthritis (almost 49%), ischemic heart disease (over 33%), sense organ disorders (30%) and oral disorders (29%).

The leading causes of DALYs in Poland in 2015 were ischemic heart disease, lower back and neck pain, cerebrovascular disease, lung cancer, sense organ disease, diabetes, depressive disorders, self-harm, road injuries and colorectal cancer. Eight of these are from the NCD group. Seven of these causes showed an increase in the last 25 years. In three of them a decrease of DALYs was observed: in ischemic heart disease (–38%), in cerebrovascular disease (–22%) and in road injuries (–46%).

National income lost due to disease in Poland

The total income lost in Poland in 2015 due to years of life lost as a consequence of all cause deaths was between I$176 bln, estimated with the VSL-CMH1 method, and I$527 bln, estimated with VSL-CMH3 method. 69% of this dramatic effect could have been saved.

Chronic non-communicable diseases have been established as a clear threat not only to human health but also to global development. NCDs reduce the national income, the supply of labour and productivity, cause early retirement, high turnover in the work place and large production losses due to a reduction in productivity[9]. Chronic non-communicable diseases affect the economy by virtue of the fact that a significant portion of the lost life years fall on the working-age.

National income lost due to NCDs in Poland

The distribution of working age DALYs establishes the prevailing burden of NCDs in Poland as well as in the world. 82% of working age (15–59 years of life) DALYs in Poland in 2015, and 67% globally, were due to NCDs. NCDs in Polish women cause a larger share of working age (18–59 years) DALYs than in men (aged 18–64): almost 90% vs. 80%.

The total income lost due to NCDs in Poland (due to death and disability, both sex groups) was between I$259 bln and I$777 bln. The national income that could have been saved if the premature deaths had been avoided accounts for between I$91 bln to I$273bln.

The approximations of income lost in Poland presented here are probably underestimations because GDP growth has not been considered.

A course of action

The world is in the middle of an epidemiological transition [38]. As countries increase their levels of development, their communicable disease burden is declining

and non-communicable disease burden is raising. The disease burden change is mainly through an increase in burden due to disability.

Poland has achieved an impressive decline in the number of DALYs due to causes like ischemic heart disease, cerebrovascular diseases, road injuries and neonatal preterm birth complications. However there is still a lot of work to do in combating NCDs.

Overall, the extent of the burden of non-communicable diseases is rising. The burden of some non-communicable diseases has declined, but generally not quickly enough to overtake the rate of population growth. As populations grow and increase in average age, however, the total burden of disability is rising quickly [38]. While development drives many positive changes in health outcomes, certain diseases (such as ischemic heart disease and diabetes) tend to worsen with development and need preventive actions.

The DALY measure, the principal metric of the GBD study, helps decision-makers compare the impact of different diseases and injuries not just in terms of early death but also in terms of disability and suffering. Now researchers are focusing on transferring the analyses of burden of diseases to local, regional and county levels. The aim is to increase the impact of burden of disease analyses on improving decentralized health policy making.

Notes

[1] 1) GDB results released in 1993–1995: six classes of disability were used to estimate the average disability weights for both treated and un-treated forms of a disease [3, 10]; 2) results published in 1996–2009, in which disability weights based on 7 classes of disability were used. Both of the stages described above took into consideration social preferences – age weighting (differentiated values depending on the age of a person – reflecting changes in the way the value of an individual's life during the life cycle is assessed); 3) Work in years 2010–2013, during which the new GBD-2010 methodology was introduced and results released in 2012 [11]. This was the first significant revision in the approach to calculating DALY in that it: (i) eliminates age weights in the YLD and YLL calculation models; (ii) uses a morbidity approach to calculate YLD; (iii) introduces a new standard life expectancy at each age that is equal for women and men in order to avoid gender inequalities when assessing disease burden and health programmes (in previous studies males had a lower life expectancy at birth than females); 4) The recently published GBD-2015 assessment of disease burden [12, 13], as the authors have declared, provides new and more robust evidence on the health of populations worldwide through the inclusion of an expanded group of countries and data sources. The new data set – the entire time series from 1990 to 2015 – has been updated on the basis of newly identified data sources released or collected since GBD 2013 [12, 13]. As a consequence, the 2015 results may differ from the previous findings for particular years.

[2] Examples of assessing the disease burden in Poland (using the old methodology – the first three stages of the GBD study described above) have been given elsewhere [2, 14, 15].

[3] The results were presented in September 2011 at a United Nations High Level Summit devoted to problems associated with chronic non-communicable diseases.

[4] The EPIC model is the standard model of economic growth. It reflects gross domestic product depending on capital and labour inputs, a relationship that is also mediated by technology and productivity. The basic assumption is that if it were not for chronic non-communicable diseases there would be more resources of labour and physical capital available, and thus GDP would be higher. Chronic non-communicable diseases are introduced into the model with the assumption that they have a destructive impact on both physical capital and labour capital. Physical capital is reduced as a result of diminished savings (and, in turn, lower investment) due to the increased consumption of medical services for individuals with chronic diseases. Labour resources are depleted as a result of mortality caused by chronic diseases. This model does not take into account domestic growth in human capital or technological progress due to expenditure on research and development. It likewise does not reflect any changes in the savings rate in society as a result of mortality caused by chronic diseases (a fixed savings rate is assumed). The model only considers mortality caused by chronic diseases, while overlooking any losses in capital and labour caused by morbidity [16].

[5] Non-communicable diseases are identified by WHO as "Group II Diseases", a category that aggregates (based on ICD-10 code) the following of conditions/causes of death and disability: malignant neoplasms, other neoplasms, diabetes mellitus, endocrine disorders, neuropsychiatric conditions, sense organ diseases, cardiovascular diseases, respiratory diseases (e.g. chronic obstructive pulmonary disease – COPD, asthma, other), digestive diseases, genitourinary diseases, skin diseases, musculoskeletal diseases (e.g., rheumatoid arthritis), congenital anomalies (e.g., cleft palate, down syndrome), and oral conditions (e.g., dental caries). These are separate from "Group I Diseases" (communicable, maternal, perinatal and nutritional conditions) and "Group III Diseases" (unintentional and intentional injuries).

[6] With a tool called DisMod-MR 2.1 (Disease Modeling--Metaregression).

[7] Working age refers to that age range within which people are usually employed in some form of work. Depending on the classification used, working age covers the following groups: women aged between 15 or 18 and 59 and men aged between 15 or 18 and 59 or 64. According to the methodology employed by the Central Statistical Office of Poland, the following groups are of working age: men between 18 and 64 and women between 18 and 59.

[8] This issue was raised during the Meeting: "Development is Not Destiny", the launch of the annual Global Burden of Diseases, Injuries, and Risk Factors Study on Friday, Oct. 7 in Washington D.C; the event was co-sponsored by the World Bank Group, The Lancet, and the Institute for Health Metrics and Evaluation (IHME) at the University of Washington.

[9] Considering these facts, the UN held on 19–20 September 2011 in New York City the First High Level UN Summit on chronic NCDs. World leaders have agreed to meet to focus on global action that will reverse the NCD epidemic.

References

1. Murray C.J.L., Lopez A.D., *Evidence-based health policy – lessons from the Global Burden of Disease Study*, "Science" 1996, 274 (5288): 740–743.
2. Kissimova-Skarbek K., *Koszty obciążenia chorobami*, in: Golinowska S. (ed.), *Od ekonomii do ekonomiki zdrowia. Podręcznik ekonomiki zdrowia*, PWN, Warszawa 2015: 354–391.
3. Murray C.J.L., Lopez A.D., *The global burden of disease: A comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990 and projected to 2020*. Global Burden of Disease and Injury Series, Volume I, Harvard University Press, Cambridge 1996.
4. Dempsey M., *Decline in tuberculosis – the death rate fails to tell the entire story*, "American Review of Tuberculosis" 1947, 56: 157–164.
5. Kocot E., *Wskaźniki ekonomiczne, społeczne i zdrowotne*, in: Golinowska S. (ed.), *Od ekonomii do ekonomiki zdrowia. Podręcznik ekonomiki zdrowia*, PWN, Warszawa 2015: 145–170.
6. Kozierkiewicz A., Megas B., Natkaniec M., Topór-Mądry R., Kissimova-Skarbek K., Śliwczyński A., Gajda K., *Years of life lost due to deaths in Poland measured with Potential Years of Life Lost (PYLL) and Period Expected Years of Life Lost (PEYLL) indicators in years 2000–2014,* "Zeszyty Naukowe Ochrony Zdrowia. Zdrowie Publiczne i Zarządzanie" 2016; 14 (3): 165–174.
7. World Bank, *World Development Report 1993. Investing in Health*, Oxford University Press, New York 1993.
8. Murray C.J.L., Lopez A.D., Jamison D.T., *The Global Burden of Disease in 1990: Summary Results, Sensitivity Analysis, and Future Directions*, "Bulletin of the World Health Organization" 1994; 72 (3): 495–509.
9. Murray C.J.L., Lopez A.D., *Global comparative assessments in the health sector*, World Health Organization, Geneva 1994.
10. Murray C.J.L., Lopez A.D., *Global Health Statistics. A Compendium of Incidence, Prevalence, and Mortality Estimates for Over 200 Conditions*. Global Burden of Disease and Injury Series, Volume II. Harvard University Press, Cambridge 1996.
11. *The Global Burden of Disease Study 2010*, "Lancet" 2012; 380 (9859): 2053–2260.
12. GBD 2015 Mortality and Causes of Death Collaborators, *Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015*, "Lancet" 2016; 388: 1459–544.
13. GBD 2015 Disease and Injury Incidence and Prevalence Collaborators, *Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015,* "Lancet" 2016; 388: 1545–602.
14. Kissimova-Skarbek K., Pach D., Płaczkiewicz E., Szurkowska M., Szybiński Z., *Ocena ekonomicznego obciążenia cukrzycą społeczeństwa Polski*, „Polskie Archiwum Medycyny Wewnętrznej" 2001, Tom 106, Nr 3 (9), Urban & Partner Wydawnictwo Medyczne, Wrocław 2001: 867–875.
15. Kissimova-Skarbek K., *Ekonomika cukrzycy – wybrane zagadnienia metodologiczne*, „Zeszyty Naukowe Ochrony Zdrowia. Zdrowie Publiczne i Zarzadzanie" 2007; V (1–2): 46–64.
16. Bloom D.E., Cafiero E.T., Jané-Llopis E., Abrahams-Gessel S., Bloom L.R., Fathima S., Feigl A.B., Gaziano T., Mowafi M., Pandya A., Prettner K., Rosenberg L., Seligman B., Stein A., Weinstein C., *The Global Economic Burden of Non-communicable Diseases*, World Economic Forum, Geneva 2011.
17. Abegunde, D., Stanciole, A., *An estimation of the economic impact of chronic noncommunicable diseases in selected countries*, WHO Working Paper, World Health Organization Department of Chronic Diseases and Health Promotion, Geneva 2006.
18. Aldy E.J., Viscusi W.K., *Age Differences in the Value of Statistical Life: Revealed Preference Evidence*, RFF Discussion Paper 07-05, April 2007, http://www.rff.org/rff/Documents/RFF-DP-07-05.pdf; accessed: 7.05.2015.
19. Fein R., *Economics of Public Health*, Basic Books, New York 1958.
20. Mushkin S.J., Collins F., *Economic costs of disease and injury*, "Public Health Reports" 1959; 74: 795–809.
21. Weisbord B.A., *Economics of Public Health,* University of Pennsylvania Press, Philadelphia 1961.
22. Rice D.P., *Estimating the Cost of Illness*, "Health Economics Series" 1966; 6, US Government Printing Office, Washington DC.
23. World Health Organisation, *The World Health Report 2002 – Reducing risks*, *promoting healthy life*, World Health Organization, Geneva 2002.
24. Rice P.D., Hodgson T.A., Kopstein A.N., *The economic costs of illness: A replication and update*, "Health Care Financ. Rev." 1985 Fall; 7 (1): 61–80.
25. Rice D.P., *Cost-of-illness studies: fact or fiction?* "The Lancet" 1994; 344: 1519–1521.
26. Drummond M., McGuire A. (eds), *Economic evaluation in health care. Merging theory with practice*, Oxford University Press, New York 2001: 68–93.
27. Koopmanschap M.A., Rutten F.F.H., van Ineveld B.M., van Roijen L., *The friction cost method of measuring the indirect costs of disease*, "Journal of Health Economics" 1995; 14: 171–189.
28. Koopmanschap M.A., Rutten F.F., *A practical guide for calculating indirect costs of disease*, "Pharmacoeconomics" 1996; 10 (5): 460–466.
29. Krol M., Brouwer W., *How to Estimate Productivity Costs in Economic Evaluations*, "PharmacoEconomics" 2014; 32 (4): 335–344.
30. Jönsson B., *The economic impact of diabetes*, "Diabetes Care" 1998, 21 (Suppl. 3): C7–C10.
31. Cooper B.S., Rice D.P., *The economic cost of illness revised*, "Soc. Sec. Bull." 1976; 39: 21–36.
32. Gold M.R., Siegel J.E., Russell L.B., Weinstein M.C., *Cost-effectiveness in health and medicine*, Oxford University Press, New York 1996.
33. Hermanowski T., *Szacowanie kosztów społecznych choroby i wpływu stanu zdrowia na aktywność zawodową i wydajność pracy*, Wolters Kluwer Polska, Warszawa 2013.

34. World Health Organization, *Macroeconomics and health: Investing in health for economic development*. Report of the Commission on Macroeconomics and Health, Geneva 2001.
35. World Health Organization, *Preventing chronic disease: a vital investment*. A WHO Report, Geneva 2005, http://apps.who.int/iris/bitstream/10665/43314/1/9241563001_eng.pdf; accessed: 27.04.2011.
36. International Diabetes Federation, *IDF Diabetes Atlas seventh edition*, Brussels 2015, www.diabetesatlas.org; accessed: 11.10.2016.
37. Global Burden of Disease Study 2015. (GBD 2015) Results. Seattle United States: Institute for Health Metrics and Evaluation (IHME) 2016, https://http://vizhub.healthdata.org/gbd-compare/; accessed: 22.10.2016.
38. Institute for Health Metrics and Evaluation (IHME), *Rethinking Development and Health*: Findings from the Global Burden of Disease Study. IHME, Seattle, WA 2016.
39. Institute for Health Metrics and Evaluation, *Global Burden of Disease Study 2010. GBD Compare. Results by cause*, Seattle, United States 2015.
40. World Bank, *World Development Indicators, GDP deflators*, http://data.worldbank.org/indicator/NY.GDP.DEFL.ZS; accessed: 8.10.2016.
41. World Bank, *World Development Indicators, PPP conversion factor, GDP (Local Currency Unit per international $)*, International Comparison Program database, http://data.worldbank.org/indicator/PA.NUS.PPP; accessed: 8.10.2016.
42. Oxford Health Alliance working group, *Economic consequences of chronic diseases and the economic rationale for public and private intervention,* Draft for circulation to participants of OHA 2005 conference, 21 October 2005.
43. World Bank, *World Development Indicators, GDP per capita PPP (current international $)*, http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD; accessed: 8.10.2016.