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METHODOLOGY FOR CALCULATING ADVERSE HEALTH EFFECTS IN LATVIA

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Abstract. Calculating the value of life and adverse health effect is necessary for developing public policy in providing compensation to families of victims of fatal accidents; it is also needed to create reasonable safety measures for the public, and enable the functioning of life insurance and healthcare systems. No methods for assessing the value of life of a person have so far been developed in Latvia. The study was carried out to determine how much an average person's life costs in the event of an accident associated with the early death of a person, as well as the possible inpatient medical care for the victim in Latvia and see the general adverse health effect calculation methods. The methods for estimating the value of life of an average person are very different, that is why authors make a comparison of the estimated value of life and the cost of medical treatment.

Keywords: average value of life, methods of calculation, assessment, accidents, emergencies, financial loss.

JEL Classification: C1, O15, I0.

1. Introduction

In performing the research, the aim was to determine the value of average human life from death at work, as well as to determine medical costs from various types of injury factors in Latvia. While achieving the aims, common algorithms were created and determined to reasonably calculate the cost of treating a moderate person from an injury, using country-specific information on gross domestic product as well as hospital costs.

In order to meet the aim, the tasks were put forward to determine the average human life value in Latvia, by briefly examining the main methods for determining the value of human life, as well as by using the specific method to calculate the average value of average human life. After calculating the average human life value, collect and review information on average treatment terms of different types of traumatism in a hospital. The review of these tasks resulted in a new approach based on an average statistical assessment of human injury, which depends on the costs of hospital treatment, based on the average duration of treatment from the effects of various exposure injuries.

The research used a number of scientific methods, mainly induction and deduction. Deduction was used to extract individual data from a common medical assessment system, such as dividing traumatism to individual parts, marking out burns, intoxication, bone fractures. Basically, the average human loss to the national economy to be paid by the patient or insurer was assessed in the hospital treatment process, which was based on the technogenic accident. The induction method was used to collect information from different sources of information on the treatment of different types of trauma in their intermediate terms. The method of analogy was used to compare two methods of evaluating human life, as well as a method of formalisation, to reflect results obtained and to compare them with one another.

As a part of the research, a total average statistical algorithm for measuring the value of human life was created, as follows: 1. choose a method for determining the value of life; 2. Determine the average human life duration at the time of death and determine its average value; 3. apply aggregated average treatment times and determine the average treatment costs at the hospital. Innovation – the proposed algorithm can be used for the assessment of the consequences of an emergency in stationary hazard areas where the age of each person is unknown, but there are known sanitary and irreparable losses among the affected people that can be determined by a risk assessment in the area and surrounding the site, for example in the event of a specific type of accident. Research restrictions: the research did not cover information on price development for medical treatment form a specific inju-

ry, but takes into account certain known costs of hospital treatment according to official data available.

2. Literature review

Assessment of the value of human life is also a topical theme in 21st century. When everything seems to have been calculated, there are a number of methods that give different results in measuring the value of human life. It is believed that the first money estimates for assessing an able-bodied person were started by U. Petie, who valued the capitalisation of the reserves of human capital as an annuity at an interest rate. A. Smith explained the differentiation of qualified and non-qualified workers with differences in time, work and money costs, which the first ones had to acquire the necessary knowledge, skills and craftsmanship (Krakovskaja, 2018). In 2014 Russian scientists examined several methods of evaluating the value of life in the world, two main approaches to measuring the value of human life were analysed (Karabchuk et al., 2014; Nifantova & Shipicyna, 2012). Assessment of the value of human life is necessary to enable state institutions, insurers to identify potential losses from human injury or death, as well as this is an important point in comparing the price of human life in one country to another. Human life value shows what amount of money the country is willing to invest in raising security to neutralize hazards and reduce risk (Trunov et al., 2006).

There exist a number of separate methods for assessing damage from various injuries, such as: evaluation of economic losses from death and injury of fire as a element of indicators of effectiveness of the activities of state fire supervision (Vojtenok & Saj, 2017), where the authors carry out a research on the assessment of damage from fires, as well as a number of mathematical formulas for assessing losses, as well as for forecasting, the research takes into account a particular human injury or death-time age without giving an algorithm, to the average human value. In general, burn injuries have been identified as one of the most important medical and social problems associated with their prevalence and high rates, and are associated with high time intervals for treatment (Brusselaers et al., 2010). A survey of the results of human deaths related to burns showed that the World Health Organisation in 2002 conducted a study entitled "Global Burden of Disease in 2002: data sources, methods and results", which found that fatal outcomes related to burns per 1000 people in the United States ranged from 3.9 to 4.5, in Europe varied from 2.8 to 35.4, but in Asia's North-East – 184 (Global Burden of Disease). All around the world, burn injuries are in 4th place after the most common injuries (Unizhaeva & Martynchik, 2013). The costs of treating burns were viewed by V. Patil and others, noting that modern intensive care management of burn is resource intensive with important ramifications for funding of regional burn services (Patil et al., 2010), which makes the treatment of burns very important in the economy sector because of the costs involved.

3. Main approaches to defining the value of human life

The socioeconomic losses associated with the effects of anthropogenic environment factors on the human body can be estimated using various assessment methods, of which one of the most popular globally is the "human capital theory", which includes 4 key approaches, see Figure 1.

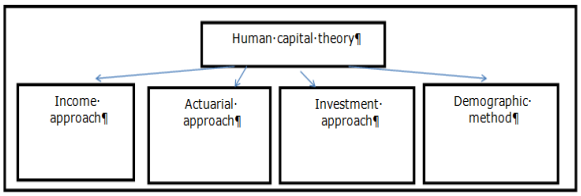

Figure 1. Approaches to value of life assessment

Income approach: value of life is estimated based on their income. It is based on the average value of statistical life, and the estimation is made to assess the investment necessary to ensure survival throughout the lifecycle of a person, comprising the person's expenses to support their life and public costs at different stages of life of the person (Shultz, 1968). This approach involves the use of GDP per capita. In its pure form, this approach is used in Denmark and Germany, and in conjunction with other approaches, in the USA, Australia, Austria and Belgium (Karabchuk et al., 2015).

The actuarial approach assesses the value of life by using GDP and average per-capita income, and accounting the probability of a fatal outcome in its mathematical formulas.

The investment approach estimates the average value of life as a total of investments necessary to reproduce a person in terms of the public cost of education, healthcare, training etc.

The demographic method determines the value of life based on the balance of financial value produced and consumed at a specific age of a person, it assesses the economic capacity of the age group, its ability to accumulate resources and prepare a financial foundation for future generations.

Socioeconomic studies commonly include the term "value of statistical life", or VSL (Best Practice Regulation Guidance…, 2014). It is frequently used to estimate the benefit of reducing the risk of death (Viscusi, 2003).

4. Assessment of financial loss

In view of the above, we use objective economic indicators in order to assess the financial loss of early death for households and the society in general. As part of this approach, we assess the value of life as a total loss in the GDP produced caused by an emergency in a high-risk facility resulting in a fatal outcome for an average statistical person; we use the formula (1) below for the assessment.

$$VSV = \sum_{i=k}^{n} PIKP, \quad (1)$$

where: *VSV* is the average value of statistical life; *PIKP* is the expected GDP value per capita in the i (year) prices (not accounting for inflation); k is the first year after the early death of the person; n is the year of expected death of the person, given the average life expectancy for that person (on average, or gender-based), whereby n–k is the number of years lost as a result of the fatal outcome (Zubec et al., 2016).

Formula (1) makes it possible to determine the loss for the public, if we know the age of the person at the time of their death. It is also possible to estimate the average value of life of a person: the average loss for the public caused by the death of a statistically average person. Where k is the year after the current year, and n is calculated using the formula (2):

$$N = k + \alpha - \beta, \quad (2)$$

where: α is the average life expectancy of the person, as of the current year; β is the average age of people in the country, as of the current year.

The data necessary to estimate the average value of a person using the formula (1) are provided in Table 1. In order to estimate the expected GDP value in Latvia after 2018, we assumed that GDP will grow 2.5% per year, because according to the CSB data obtained from Eurostat for 2014–2018, GDP growth in Latvia fluctuated between 1.8 and 2.5%, with an overall trend for the GDP to grow (Reālais IKP pieauguma temps…). Furthermore, the 2018 GDP data for Latvia show that the per-capita GDP for working individuals is EUR 14,704 (Data base of Central Statistic Office), the average age is 42.4 years, and the life expectancy is 74.6 years.

Table 1. Average estimated GDP in Latvia, in 2018 prices

Year	Estimated GDP value, EUR	2.5%	Year	Estimated GDP value, EUR	2.5%
2018	14704	367.6	2036	22932.28	573.31
2019	15071.6	376.79	2037	23505.59	587.64
2020	15448.39	386.21	2038	24093.23	602.33
2021	15834.60	395.87	2039	24695.56	617.39
2022	16230.47	405.76	2040	25312.95	632.39
2023	16636.23	415.21	2041	25945.34	648.63
2024	17051.44	426.29	2042	26593.97	664.85
2025	17477.73	436.94	2043	27258.82	681.47
2026	17914.67	447.87	2044	27940.29	698.51
2027	18362.54	459.06	2045	28638.80	715.97
2028	18821.60	470.54	2046	29354.77	733.87
2029	19292.14	482.30	2047	30088.64	752.22
2030	19774.44	494.36	2048	30840.86	771.17
2031	20268.80	506.72	2049	31612.03	790.30
2032	20775.52	519.39	2050	32402.33	810.06
2033	21294.91	532.37	2051	33212.39	830.31
2034	21827.28	545.68	2052	34042.7	851.07
2035	22372.96	559.32			
			Total, 2020–2052	777854.3	2.5%= const

We use the formula (2) to estimate the mean statistical value of life in Latvia as of 2020, according to 2018 statistical indicators, n = 2020+74.6–42.4 = 2052, meaning that the assessment must extend up to 2052, with a detailed estimation provided in Table 1, which shows that the mean statistical value of life is EUR 777,854.3.

As part of the study, we consider a method to assess the losses based on the number of man-days necessary to rehabilitate the victim, enabling them to continue working. International Labour Organisation Social Security (Minimum Standards) Convention No. 102 (1952) (Dosrochnye pensii za rabotu vo vrednyh uslovijah truda…, 2017) provides for compensation for people losing capacity to work, income or life, which may be caused by illness, accident, injury at work, occupational disease, death of income earner, age etc. According to the recommendations of the International Labour Organisation, a fatal outcome results in the mean loss of 6000–7500 man-hours for society, whereas the financial losses of physical injuries can be calculated using the tables in Annex 3 and 4. In order to calculate this value, one must divide the daily gross national income, which includes income that belongs to the residents of that country (including income from the economic activity of its residents

abroad) (Ar ko atšķiras iekšzemes kopprodukts…, 2011), and divide it by the number of people working in the industry in question, without accounting for the workers' life insurance expenses. The gross national income is an indicator used to calculate the contribution of EU member states in the main budget of the European Union. According to the Workforce Survey conducted by the Central Statistical Bureau (CSB), 909.4 thousand people (i.e. 64.5% of 15–74 year-olds) were employed in 2018 in Latvia (Nodarbinātība 2018 gadā). The gross national income calculated using the data provided in Annex 3 is EUR 32,044 per working person, according to 2018 data.

In certain cases, one can use the amount of insurance proceeds in the event of death. The amount of losses calculated using the above data and based on the 2018 total income is specified in Table 2. It has been found that the amount of losses calculated using the previous method and this method differ, because in this method, the gross income is calculated for all residents aged 15–74, while the previous method provides the average value of life of one resident. This approach is largely used to calculate losses resulting from mechanical injuries caused by overpressure, while the fatal outcome and permanent disability calculations may be used for assessing other injuries, such as heat radiation injuries and poisonings.

Table 2. Loss from permanent incapacity to work

No.	Cause of loss of capacity to work	Degree, %	Loss, in man-days	Loss, in EUR
1.	Fatal outcome (death)	100	7500	240330
2.	Permanent disability	100	8750	280385
	Partial loss			
3.	Loss of entire arm	35	2600	83314
4.	Loss of forearm	30	2250	72099
5.	Loss of hand	25	1860	59601.84
6.	Loss of leg	20	1500	48066
7.	Loss of eye	15	1125	36049.50

Information about economic losses associated with people retiring due to disability, in order to calculate the amount of investment necessary to reduce the losses by planning preventive measures in high-risk facilities. The main problem of this method is that the assessment does not make it possible to predict what specific injuries a person will sustain in the event of an accident.

In assessing the socioeconomic losses, we chiefly determine the direct costs of inpatient care for the victims. Indirect costs include a reduction in capacity to work, costs of reconstructive surgery, emotional trauma, disability (WHO and the International Society…, 2004). Our calculations are largely based on minor and medium injuries, because they constitute most injuries overall, although in individual cases, e.g. burns, we also consider severe injuries. According to the information about assessing bodily injuries provided in Table 3 of the Latvian Law on the Procedures for the Coming into Force and Application of The Criminal Law, two key injury groups are defined: Severe injuries (including life-threatening injuries), and minor and medium injuries (Likums Par Krimināllikuma spēkā stāšanās un piemērošanas kārtību, 1998). The classification of minor and medium injuries is provided in Table 3.

Table 3. Description of injuries based on the type of burn

Degree of injury	Type number	Description of injury
Medium injuries	1.	Isolated fractures to outer calvarial table, fractures to the eye periorbital area of ethmoid bone and isolated fractures to the lateral epicondyle of the occipital bone without life-threatening symptoms
	2.	Fractures to the breastbone, one or several ribs without damage to internal organs
	3.	Partial or non-compound fractures of individual tubular bones
	4.	Fractures of facial bones, except for non-compound fractures of the nasal bone
	5.	Fractures to the body or cornu of the hyoid bone without asphyxiation features
	6.	Fractures of the larynx cartilage without life-threatening symptoms
	7.	Isolated damage to large joints and ligaments or cartilage of such joints: hip, knee, shoulder sprains, and also sprains of other joints if there is damage to the joint capsule or severance of ligaments
	8.	Trauma of the cerebrum and the cover thereof which causes cognitive loss (9 to 12 points according to the Glasgow Coma Scale) and does not cause dangerous cerebral displacement and compression
	9.	Prolonged disruption of health, exceeding 21 days
	10.	Permanent physical disorder, 10–30%
	11.	Mental disorder or mental trauma with long-term effects on the social adaptation of the person

End of Table 3

Degree of injury	Type number	Description of injury
Minor injuries	1.	Injuries that have caused a short-term health disorder, lasting 7 to 21 days, or permanent health disorder of under 10%, as certified by a forensic medical expert.

The type of injury caused by heat radiation is burns, which can be external, as the heat directly affects the body, or internal, if occurring as a result of inhaling hot air. Modern developments in burn care have greatly decreased mortality caused by burn. However, the treatment of massively burned patients remains a global challenge due to the lack of autologous skin and the great risk of complications (Cheng et al., 2019). Economic assessment of trauma caused by burns is significant for this study, because it considers the costs of treating burns. Severe burns typically result in death, disease, as well as economic and social costs covered by the burn victims themselves, their families, healthcare facilities and society as a whole. In March 2008, the WHO described non-fatal burn injuries as a leading cause of morbidity, including prolonged hospitalization, disfigurement and disability (Amal, 2019). Burn injuries are noted by WHO to be one of the leading causes of preventable injuries (The World Health Organisation, 2018). Treatment of burns is one of the most expensive fields of healthcare: it involves prolonged hospital stay, because severe burns usually require multiple surgeries as well as expensive equipment making treatment very costly (Sahin et al., 2011). The expenses associated with burn trauma are higher than those caused by other health-related problems, such as stroke and AIDS (Lopez Bastida et al., 2003). Patil calculated the mean cost of treatment of burns per day, and gained the following results, expressed in US dollars: UK – 1512, France – 934, Germany – 726 and Hungary – 280.12 (Patil et al., 2010). In Latvia, the cost of one day of standard inpatient hospital stay is EUR 103, while treatment in intensive care units, intensive toxicology and sepsis care wards, and stroke wards costs EUR 401 per day (Maksa par ārstēšanos…, 2019). In accordance with the Latvian Law on the Procedures for the Coming into Force and Application of The Criminal Law, degree IIa burns covering more than 20 percent of the body surface, degree IIb and III burns covering at least 10 percent of the body surface, burns in the respiratory tract with major oedema and stenosis of the glottis that have caused life-threatening breathing disruptions are classified as life-threatening injuries.

Table 4. Fatal outcomes for patients with different body surface area burns (Zhilinskij et al., 2014)

Indicator	Body surface area of the burns, %				Patients overall
	0–19	20–39	40–59	60–100	
Total number of patients	2519	175	71	35	2800
Number of deceased patients	42	27	34	27	130
Fatal outcomes	1.67	15.43	47.89	78.26	4.36

I. Sahin et al. conducted a study at the Centre for Burns of the Gulhane Military Medical Academy in Ankara, Turkey, in order to calculate the average cost of treating burn patients in 2005–2008. Based on the research criteria, forty-three patients with large-area burns were selected, and it was found that the average stay in hospital for them was 73±33 days, whereas the average surface area of the burns was 36±7%. Total mean cost was USD 15,250 (Sahin et al., 2011). It can be concluded that treating burn patients is one of the most expensive areas of healthcare, as it involves prolonged stay in hospital, frequent need for multiple surgeries, and expensive modern equipment. In addition to the degree of the burns, it is also important to determine the surface area of the body affected, which also a factor in the frequency of fatal outcomes; Žilinskis et al. conducted a study to determine the proportion of people who did not recover, depending on the body surface area affected; the results of the study are presented in Table 4. The combined effects on people that typically occur during accidents at high-risk facilities usually have a strong negative influence on the prognosis of burn injuries (Brusselaers et al., 2010).

In determining the degree of severity, which depends on the effect of the injury on health, (Il'inskaja & Isaev, 2008). propose linking the duration of the disorder with the degree of severity using the breakdown shown in Table 5, with the first two indicators matching the criteria defined in the Law on the Procedures for the Coming into Force and Application of the *Criminal Law*.

Table 5. Breakdown in the duration of the disorder and the degree of severity

No.	Health impact duration (days)	Severity of health impact
1.	7–21	minor
2.	21>	medium
3.	120>	severe

As part of the study, we use I. Sahin's research data in assessing the economic consequences of heat radiation, assuming an average hospital stay of 73 days, and 36% body surface area of the burns. It has been found that treating burns costs EUR 401 per day in Latvia, which involves intensive care of the patient, as well as the medical side effects in particularly severe cases (e.g. infections), resulting in EUR 29273 per patient for 73 days of treatment, which matches the global burn treatment criteria overall. 1–2.3% of all people with burn injuries caused by heat radiation become disabled, while 40% of patients with medium and severe burns need additional surgery after discharge from hospital (Унижаева).

The consequences of toxic effects on the body are assessed for the medium and severe degrees of poisoning involving 2–3 weeks (Medicinskie aspekty likvidacii avarij…, 2008) of inpatient care, depending on the chemical composition of the substance released into the atmosphere. In order to estimate the consequences for patients with medium and severe poisoning, we assume an average hospital stay of 2 weeks/14 days, with one day of inpatient care costing EUR 103. The total cost of inpatient care for 14 days is thus EUR 1442.

Table 6. Cost of inpatient treatment of injuries

No.	Type of injury	Impact factor	Days of inpatient treatment required	Daily cost	Total direct costs, EUR
1.	Burns	Heat radiation	43	401	29273
2.	Poisoning	Toxic substances	14	103	1442
3.	Bone fractures	Excess pressure	79	103	8137

The types of trauma associated with excess pressure include bone fractures, with the average treatment taking 137.5+/–2.85 days on sick leave for all bone fractures, with 79+/–2.45 days in inpatient care, and 64.41+/–2.08 days in outpatient care (Sroki vosstanovitel'nogo lechenija…, 1991). The total cost of inpatient care for 79 days is thus EUR 8137. The costs of inpatient treatment of medium injuries, the number of days spent in inpatient facilities due to various degrees of injuries caused by heat radiation, toxicity and excess pressure are provided in Table 6.

It has been found that inpatient care is the most expensive for people who suffered heat radiation injuries, with the mean cost amounting to EUR 29,273, while injuries caused by excess pressure take the longest to treat.

5. Conclusions

The study has shown that the cost of medical treatment differs from country to country, and that different methods produce estimated values of statistical life in Latvia that vary significantly.

The study achieved the aim of determining the average human life value from death at work, as well as determining medical costs from various types of injury factors in Latvia. In order to achieve the aim, common algorithms were established and determined, based on country-specific information on gross domestic product, as well as hospital costs, on how to reasonably calculate the cost of treatment of a moderate person from an injury.

The method of calculating the average value of the life of the statistical person has been developed. After calculating the average human life value, information on average treatment terms in a hospital of various types of traumatism was collected and examined. The assessment of these tasks resulted in the development of a new approach as a result of human injury to assess losses to the community, depending on the costs of treatment in the hospital, using the average duration of treatment.

Innovation – the proposed algorithm can be used in the assessment of the consequences of an emergency in stationary hazard areas where the age of each person has not been known, but there are known sanitary and irreparable losses among the affected people, which can be determined by a risk assessment in the site and surrounding area of the site, for example in the event of a specific type of accident – explosion, fire, toxic leak.

Further tasks: This analysis was carried out for a specific country; however, in order to understand the value of statistical life in a whole region, it would be necessary to calculate and compare data in every country using the same methods.

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