

## STATISTICAL ANALYSIS REGARDING THE MORTALITY AND MORBIDITY OF DIABETES IN ROMANIA - FORENSIC PERSPECTIVE

Nona Gîrlescu<sup>1,6</sup>, Eosefina Gina Botnariu<sup>2,\*</sup>, Elena Claudia Coculescu<sup>7,\*</sup>, Andrei Daniel Timofte<sup>3</sup>,  
Adrian Ioan Ciureanu<sup>4</sup>, Diana Bulgaru Iliescu<sup>5,6</sup>

*“Grigore T. Popa” University of Medicine and Pharmacy, Faculty of Medicine, <sup>1</sup>Department of Anatomy,*

*<sup>2</sup>Department of Diabetes, Nutrition and Metabolic Disease, <sup>3</sup>Department of Morphofunctional Science1,*

*<sup>4</sup>Department of Medical Informatics, Biostatistics, Computer Science, Mathematics and Modelling Simulation,*

*<sup>5</sup>Department of Forensic Science, <sup>6</sup>Institute of Legal Medicine, Iasi, <sup>7</sup>“Carol Davila” University of Medicine and Pharmacy, Faculty of Dental Medicine, Department of Dental Medicine III, Bucharest, Romania*

**Abstract:** Diabetes mellitus (DM) is a metabolic disorder being considered a real health problem. In low and middle income countries, diabetes is often inadequately treated and undiagnosed due to lack of awareness of the symptoms and limited access to healthcare services. Thus far, no analysis of deaths among diabetics has been performed from a forensic perspective. This research analyzed a total of 4.438 cases of autopsy files, by accessing the archive of the Institute of Legal Medicine in Iasi, Romania, over a period of 5 years, identifying 235 cases with DM, of which 7 cases of type 1 DM (3%), 192 cases of type 2 DM (81.7%) and 36 cases of unspecified DM (15.3%). The study includes a complete view with macroscopic, histopathological and toxicological analysis, but also investigation data and medical information. This study offers the first forensic perspective of people known to have DM who died in North-Eastern Romania. The diagnosis of DM was identified in most cases in the content of the autopsy files and never in the death certificate. The number of identified diabetics represents the minimum number in forensic cases for the period and area investigated. Acute diabetic complications were not found in this study as medical cause of death. This research brings into discussion a pathology that in forensic medicine in Romania is disputed and often underestimated, proving once again the importance of studying the carbohydrate metabolic imbalance by applying postmortem biochemistry in every forensic service.

**Keywords:** diabetes mellitus, autopsy, mortality, cause of death.

### INTRODUCTION

Diabetes Mellitus (DM) is a chronic, not transmissible metabolic disease that develops when the pancreatic tissue does not produce or can no longer use insulin properly. This metabolic disorder is considered a real health problem, the latest data published by the International Diabetes Federation (IDF) shows that 463 million adults are diagnosed with diabetes worldwide, and this number could increase to 578 million by 2030, if control measures are not applied. In low and middle income countries, diabetes is often inadequately treated and undiagnosed due to lack of awareness of the symptoms and limited access to healthcare services.

According to age profile of diabetes by IDF, 72% of people living with diabetes in 2019 are of working age (i.e., between 20 and 64 years old) [1]. Hence the impact that DM has on society, by affecting the economy and human productivity.

At European level, in 2017 there were 693,351 deaths due to diabetes, the top countries being occupied by Russia, Germany, Turkey, Spain and Italy [2]. According to data published by the World Health Organization (WHO), during 2017 in Romania there were 2527 deaths caused by diabetes, representing 1.07% of the total number of deaths [3], the mortality rate being increased compared to the previous year. In 2016 there were 2430 deaths, respectively 1% of the

\*Correspondence to: Eosefina Gina Botnariu, “Grigore T. Popa” University of Medicine and Pharmacy, Department of Diabetes, Nutrition and Metabolic Disease, 16 Universitatii Str, Iasi, Romania, E-mail: ginabotnariu66@gmail.com. Elena Claudia Coculescu, “Carol Davila” University of Medicine and Pharmacy, Faculty of Dental Medicine, 17-23 Calea Plevnei, Bucharest, Romania, E-mail: elenacoculescu@yahoo.com

total number of deaths [4].

In the period 2008-2017, an ascending trend of the prevalence and incidence of DM was observed among the Romanian population [5]. According to the PREDATORR study, the North-East region (12.38%) of Romania is on the third place in the top of the prevalence of diabetes, after the regions of South-Muntenia (13.39%) and Bucharest-Ilfov (12.79%) [6].

For the Romanian population, there are several studies that have analyzed the mortality and cause of death among diabetics through death certificates [7, 8]. Thus far, no analysis of deaths among diabetics has been performed from a forensic perspective.

## MATERIALS AND METHODS

This research analyzed a total of 235 cases of necropsy with diabetes, by accessing the archive of the Institute of Legal Medicine in Iasi (IOLM Iasi), Romania. The access to the archive was according to the rules of ethics after obtaining the agreement of the IOLM Iasi management. The identification of cases within the institute was performed over a period of 5 years, from January 2014 to January 2018. This analysis included/admitted only those deaths considered forensic cases, which fulfilled the forensic criteria necessary and mandatory for performing the forensic autopsy. These criteria included sudden, violent and unknown deaths. The cases with diabetes were identified by analyzing the necropsy files, more precisely by studying the medical and medico-legal documents available for each file: investigation data, observation sheets/hospitalizations, forensic report-necropsy with macroscopic, histopathological and toxicological examination. The cases were divided into 3 categories: type 1 DM, type 2 DM and unspecified diabetes. By observing the steps regarding the conclusions of autopsy report, the type of death was subdivided into: pathological (nonviolent), violent (traumatic) and competing. The medical cause of death was classified into the following categories: cardiovascular, respiratory, digestive, cerebrovascular, sepsis, genital, violent/traumatic and competing. Cases of violent deaths were left as such, considering that the thanatogenerative mechanism was independent of the diagnosis of diabetes, having exclusively external causes. Cases of competing deaths were left as such also, because it was considered that both the violent and pathological causes of death contributed equally in the thanatogenerative mechanism.

## RESULTS

During the 5-year period, by analyzing 4.438 cases of autopsy files, 235 cases with DM were identified, of which 7 cases of type 1 DM (3%), 192 cases of type 2 DM (81.7%) and 36 cases of unspecified DM (15.3%). Regarding the sex of the participants, 156 (66.4%) are male and 79 (33.6%) are female. The age of the participants is between 19 and 94 years ( $M = 64.76$ ,  $SD = 11.99$ ). The most common type of death is pathological death (59.6%;  $n = 140$ ), followed by violent death (37.9%;  $n = 89$ ) and competing/concurrent death (2.6%;  $n = 6$ ). The most common category of medical cause of death is violent/traumatic (38.7%;  $n = 91$ ), followed by cardiovascular (34.5%;  $n = 81$ ), respiratory (10.6%;  $n = 25$ ), digestive (6.8%;  $n = 16$ ), cerebrovascular (4.7%;  $n = 11$ ), sepsis (2.1%;  $n = 5$ ), competing (1.7%;  $n = 4$ ) and genital (0.9%;  $n = 2$ ).

The frequency of death in men is higher than in women for the following categories of death: violent, cardiovascular, respiratory, sepsis and competing. There are no differences between the frequencies of death in men and women for the digestive, cerebrovascular and genital categories (similar frequencies).

For cases under 30 years of age, the most common categories of death are digestive and respiratory. For cases of 30s the most common categories of death are digestive and violent. For 40s cases, the most common category of death is cardiovascular. For the 50s, 60s and 70s cases the most common category of death is violent. For 80s cases, the most common categories of death are cardiovascular and violent. For the 90s the most common categories of death are cardiovascular and respiratory.

Regarding the frequency of DM per year, in 2016 were identified the highest number of DM in forensic cases (5.1% of the total), followed by 2014 (3.9% of the total).

### *DM type 1*

A number of only 7 cases of type 1 DM were identified. Regarding the sex of the participants, there was only 1 female (14.3%) and the rest 6 were male (85.7%). The age is between 45 and 63 years ( $M = 55.28$ ,  $SD = 7.43$ ), no death under the age of 45 was recorded. Regarding the classification, the medical causes of death are: violent/traumatic (42.9%;  $n = 3$ ), cardiovascular (28.6%;  $n = 2$ ) and respiratory (28.6%;  $n = 2$ ). There are no differences between the frequencies of these death categories (the frequencies are similar) for type I DM.

The types of death are: pathological (57.1%;  $n$

= 4) and violent (42.9%; n = 3). The types and medical causes of death among type 1 diabetics are shown in Tables 1 and 2.

**DM type 2**

A number of 192 cases of type 2 DM were identified. Regarding the sex of the participants, 122 (63.5%) are male and 70 (36.5%) are female. The age is between 38 and 94 years (M = 66.80, SD = 10.67). The medical causes of death are: violent (36.5%; n = 70), cardiovascular (35.9%; n = 69), respiratory (9.9%; n = 19), digestive (7.3%; n = 14), cerebrovascular (4.7%; n = 9), sepsis (2.6%; n = 5), competing (2.1%; n = 4) and genitals (1%; n = 2). The categories of violent and cardiovascular death are the most common for type 2 DM.

Types of death are: pathological (60.9%; n = 117), violent (36.5%; n = 70) and competing (2.6%; n = 5)(Table 4).

The number of deaths in men is higher than in women for the categories Violent, Cardiovascular, Respiratory, Sepsis and Competing, and for the categories Digestive, Cerebral and Genital the frequencies are similar.

**Diabetes unspecified**

A number of 36 cases of unspecified DM were identified. Regarding the sex of the participants, 28 (77.8%) are male and 8 (22.2%) female. The age is between 19 and 93 years (M = 55.72, SD = 14.35). The medical causes of death are: violent (50%; n = 18), cardiovascular (27.8%; n = 10), respiratory (11.1%; n = 4), cerebral (5.6%; n = 2) and digestive (5.6%; n = 2). The most common cause of death is violent (Table 5).

The types of death are: pathological (52.8%; n = 19), violent (44.4%; n = 16) and competing (2.8%;

n = 1) (Table 6). The number of deaths in men is higher than in women for the Violent, Cardiovascular and Respiratory categories, and for the Cerebral and Digestive categories the frequencies are similar.

Regarding decades of age and classification of causes of death, the data show the following frequencies:

- under 30s: Digestive (50%; n = 1) and Respiratory (50%; n = 1);
- 30s: Violent (100%; n = 1);
- 40s: Cardiovascular (45.5%; n = 5), Violent (45.5%; n = 5) and Respiratory (9.1%; n = 1);
- 50s: Violent (60%; n = 3) and Respiratory (40%; n = 2);
- 60s: Violent (57.1%; n = 8), Cardiovascular (21.4%; n = 3), Cerebral (14.3%; n = 2) and Digestive (7.1%; n = 1).

**DISCUSSION**

This study offers the first forensic perspective of people known to have DM who died in North-Eastern Romania. Moreover, the study includes a complete view with macroscopic, histopathological and toxicological analysis, but also investigation data and medical information. This gross analysis is due to the provision of the entire autopsy file for each case and not just the death certificate. The main disadvantage of the study was represented by the time consuming method applied, which involved the analysis of every single case extracted from the archive, by actually browsing through 4.438 files.

Pathological death was the main type of death in all 3 categories of DM analyzed: type I (57.1%), type II (60.9%) and unspecified (52.8%). In the top of pathological deaths was cardiovascular. A possible argument regarding this preponderance could be

**Table 1.** Summary of causes of deaths occurring in individuals with a history of type 1 diabetes

	Number of cases (%)	Mean Age at Death (range)	Males: Females
Violent/traumatic	3 (42.9%)	M = 57.66 SD = 6.65 (50-62)	2:1
Peritonitis fasciitis	1 (14.3%)		
Poisoning	1 (14.3%)		
CBT	1 (14.3%)		
Cardiovascular	2 (28.6%)	M = 55.50 SD = 10.60 (48-63)	2:0
MF	2 (28.6%)		
Respiratory	2 (28.6%)	M = 51.50 SD = 9.19 (45-58)	2:0
BP	2 (28.6%)		

CBT = Craniocerebral trauma; MF = Myocardial fibrosis; BP = Bronchopneumonia

**Table 2.** Summary of type of deaths occurring in individuals with a history of type 1 diabetes

	Number of cases (%)	Mean Age at Death (range)	Males: Females
Pathological	4 (57.1%)	M = 53.50 SD = 8.42 (45-63)	4:0
Violent	3 (42.9%)	M = 57.66 SD = 6.65 (50-62)	2:1

**Table 3.** Summary of causes of deaths occurring in individuals with a history of type 2 DM

	Number of cases (%)	Mean Age at Death (range)	Males: Females
Violent	70 (36.5%)	$M = 67.90$ $SD = 9.54$ (41-89)	44:26
CBT	40 (20.8%)		
Burns	7 (3.6%)		
SCI	6 (3.1%)		
Asphyxies	6 (3.1%)		
Poisoning	9 (4.5%)		
RTA	1 (0.5%)		
Hypothermia	1 (0.5%)		
Cardiovascular	69 (35.9%)	$M = 67.04$ $SD = 10.41$ (44-86)	45:24
MF	37 (19.3%)		
ATS	18 (9.3%)		
AMI	8 (4.2%)		
Dilated Cardiomyopathy	2 (1%)		
Abdominal Aortic Aneurysm Ruptures	1 (0.5%)		
Haemopericardium	1 (0.5%)		
Heart Failure	1 (0.5%)		
PTE	1 (0.5%)		
Respiratory	19 (9.9%)	$M = 71.15$ $SD = 12.01$ (49-94)	12:7
Bronchopneumonia	16 (8.3%)		
BP Cancer	3 (1.5%)		
Digestive	14 (7.3%)	$M = 59.21$ $SD = 11.93$ (38-78)	7:7
Pancreatitis	5 (2.6%)		
Decompensated Liver Cirrhosis	3 (1.6%)		
Esophageal Cancer	1 (0.5%)		
Pancreatic Cancer	1 (0.5%)		
Rectal Cancer	1 (0.5%)		
Upper Digestive Hemorrhage	1 (0.5%)		
Perforated Duodenal Ulcer	2 (1%)		
Cerebral	9 (4.7%)	$M = 64.11$ $SD = 12.32$ (47-83)	4:5
Hemorrhagic Stroke	7 (3.6%)		
Ischemic Stroke	1 (0.5%)		
Leptomeningitis	1 (0.5%)		
Sepsis	5 (2.6%)	$M = 59.80$ $SD = 3.27$ (57-65)	5:0
Competing	4 (2.1%)	$M = 67.75$ $SD = 15.32$ (48-83)	4:0
RTA, Comorbidities	1 (0.5%)		
Fasceitis MOF	1 (0.5%)		
ME, CBT	1 (0.5%)		
CBT Ischemic CVA	1 (0.5%)		
Genital	2 (1%)	$M = 59.50$ $SD = 2.12$ (58-61)	1:1
Prostate Cancer	1 (0.5%)		
Cancer Uterin	1 (0.5%)		

CBT = Craniocerebral Trauma; BP Cancer = Bronchopulmonary Cancer; SCI = Spinal Cord Injury; PE = Acute Pulmonary Edema; RTA = Road Traffic Accident; MOF = Multiple Organ Failure; AMI = Acute Myocardial Infarction; MF = Myocardial Fibrosis; ATS = Atherosclerosis; PTE = Pulmonary Thromboembolism.

**Table 4.** Summary of type of deaths occurring in individuals with a history of type 2 diabetes

	Number of cases (%)	Mean Age at Death (range)	Males: Females
Pathological	117 (60.9%)	$M = 66.18$ $SD = 11.19$ (38-94)	73:44
Violent	70 (36.5%)	$M = 67.85$ $SD = 9.58$ (41-89)	45:25
Competing	5 (2.6%)	$M = 66.40$ $SD = 13.61$ (48-83)	4:1

represented by the risk factors present in diabetics, which make cardiovascular diseases the main cause of morbidity and mortality in this pathology, a statement supported and demonstrated in the literature [5-8]. It is known that people with diabetes are at high risk

of developing acute thanatogenerative complications, especially insulin-treated cases.

As expected, due to the forensic nature, the main cause of death was unnatural (violent) in all 3 categories of DM analyzed: type I (42.9%), type II

**Table 5.** Summary of causes of deaths occurring in individuals with a history of Diabetes unspecified

	Number of cases (%)	Mean Age at Death (range)	Males: Females
Violent	18 (50%)	$M = 56.88$ $SD = 10.30$ (38-75)	15:3
CBT	8 (22.2%)		
SCI	2 (5.6%)		
Burns	2 (5.6%)		
Asphyxies	2 (5.6%)		
RTA	1 (2.8%)		
Poisoning	2 (5.6%)		
Hypothermia	1 (2.8%)		
Cardiovascular	10 (27.8%)	$M = 58.20$ $SD = 16.84$ (41-93)	8:2
MF	5 (13.9%)		
ATS	3 (8.4%)		
APE	1 (2.8%)		
Acute Coronary Syndrome	1 (2.8%)		
Respiratory	4 (11.1%)	$M = 46.00$ $SD = 15.70$ (23-57)	3:1
Bronchopneumonia	3 (8.4%)		
Lung abscess	1 (2.8%)		
Cerebral	2 (5.6%)	$M = 65.00$ $SD = 2.82$ (63-67)	1:1
Stroke	1 (2.8%)		
Cerebral coma	1 (2.8%)		
Digestive	2 (5.6%)	$M = 43.00$ $SD = 33.94$ (19-67)	1:1
Hepatic abscess	1 (2.8%)		
Pancreatitis	1 (2.8%)		

**Table 6.** Summary of type of deaths occurring in individuals with a history of Diabetes unspecified

	Number of cases (%)	Mean Age at Death (range)	Males: Females
Pathological	19 (52.8%)	$M = 55.15$ $SD = 17.46$ (19-93)	14:5
Violent	16 (44.4%)	$M = 56.81$ $SD = 10.51$ (38-75)	14:2
Competing	1 (2.8%)	$M = 49.00$ (49)	0:1

(36.5%) and unspecified (50%), being followed by the cardiovascular and respiratory cause. This discrepancy between the results, respectively between the main type of death - pathological death and the main cause of death - violent, is explained by the division of case with pathological death on different systems (nervous, cardiovascular, respiratory, digestive, genital).

No cases were reported due to acute diabetic complications, namely diabetic ketoacidosis (DKA) and non-ketotic hyperglycemic hyperosmolar state (HHS). These complications are diagnosed postmortem only by thanatochemical determinations and it is known that not all forensic services benefit from these tests. Therefore it is outlined this obvious underestimation of these causes of death, a problem recognized and debated internationally, both by lack of constant biochemical determinations and general standardization of the thanatochemical values necessary for these diagnoses. Although these 2 deadly complications are not very common, it is necessary to mention that the lack of these causes in the analyzed deaths is due to the absence of the necessary thanatochemical analyzes.

There are few published studies regarding the

mortality of diabetics in the Romanian population. A recent study [6], analyzed 5.053 deaths, from a total number of 49.328 diabetic adults, from Bucharest, Romania, aged between 20 and 64 years, for a period of 11 years (from 2001 to 2011). The authors analyzed the deaths through the death certificate, considering only the primary cause of death. The primary cause is defined as the morbid condition that caused the death, while the secondary cause is defined as another major morbid condition that contributed to the death. Mortality data was examined by accessing the National Institute of Statistics, by reference to the general population. This study highlighted the male sex as the majority compared to the female, in terms of mortality rate, like our research did. Contrariwise, the mortality rate ratio against the general population was higher in women than men. Another recent study [7], analyzed 168.854 cases of death in Romania in the period 1998-2015, accessing the data of the National Institute of Statistics and analyzing the primary and secondary causes of death stipulated in the death certificates. It is mentioned that DM was found mainly as secondary cause of death in death certificates, so the analysis of

this pathology as the primary cause of death could not be analyzed. Most of the deaths occurred at the hospital and at home, emphasizing that very few cases of those analyzed had secondary confirmation, by performing the autopsy. The authors concluded that the mortality rate among diabetics increases with age and that males have a higher mortality rate than females for most age groups during the analyzed period. None of the studies subdivided the cases with DM analyzed in type I and II.

Both studies discuss the accuracy of the data taken from the death certificate. There may be many variables in performing this act, able to lead to incorrect results, or at least with the existence of errors that must be identified and taken into account. The quality of information regarding DM, retrospectively collected from death certificates, has been many times disputed, with studies showing that this disease is mentioned for only 30-40% of diabetics cases in death certificates [8-11]. Moreover, a recent study from 2017 demonstrates the internationally impact of mortality analysis through various methods of completing death certificates [12]. In addition, it is pointed out that a very low percentage (less than 1%) of diabetic deaths were also confirmed by autopsy, a problem debated internationally, stating that death certificate is not a reliable method of analysis [13]. As the authors of the mentioned studies say, these studies follow the same problem of mortality among diabetics, but from different angles. There are analyzes based on different perspectives: the general population, the diabetic population and forensic cases, as in the present study, complementing each other.

Although there were differences in magnitude, the increased mortality rate among diabetics compared to the general population has been demonstrated and studied in various publications [14-16], clearly representing an issue to be debated and analyzed by each country. A retrospective analysis of forensic cases regarding the mortality rate among diabetics provides an amplified picture about causes of death, such as violent ones, where DM is often not specified in the death certificate. In Romania, there are no reports on the mortality rate in diabetics from a forensic perspective.

Compared to international studies [17, 18], the present research did not report deaths whose main cause is acute diabetic complications, a possible explanation being the low number of cases studied and the lack of thanatochemical data on carbohydrate metabolism. In addition to this research, a social perspective can also be discussed, with reference to the living standard of each case analyzed. Romania is one of the Eastern European countries where access to medical services is

not uniform and accessible to all. Thus, either due to poor education or financial problems, there are people who choose not to be in the records of a doctor and/ or refuse to go to a hospital even when they have severe symptoms, with high lethal risk. From here derives the numerous sudden deaths at home, with lack of medical information and investigation data.

The analysis in this research constantly faced deaths at home, whose medical history was absent either due to minimal investigative data, or by incomplete and deficient medical data. Therefore, if the diagnosis of diabetes is not identified in the background, this does not mean that it doesn't exist. Hence, it can be easily stated that the present study represents a minimum threshold in terms of number of diabetics whose death have been forensically investigated. Moreover, it is known that undiagnosed diabetes can cause and/or start with acute complications causing death [17,18]. In Romania, there are no reports regarding the mortality rate in diabetics from a forensic perspective.

**In conclusion**, this study offers the first forensic perspective of people known to have DM who died in North-Eastern Romania. The diagnosis of DM was identified in most cases in the content of the autopsy files and never in the death certificate. The number of identified diabetics represents the minimum number in forensic cases for the period and area investigated. Acute diabetic complications were not found in this study as medical cause of death. This research brings into discussion a pathology that in forensic medicine in Romania is disputed and often underestimated, proving once again the importance of studying the carbohydrate metabolic imbalance by applying post-mortem biochemistry in every forensic service.

#### **Conflict of interest**

The authors declare that they have no conflict of interest.

#### **References**

1. International Diabetes Federation. IDF Diabetes Atlas, 9th edition, 2019, <https://www.diabetesatlas.org/en/introduction/> (accessed on 28 July 2020).
2. OECD/European Union. Diabetes prevalence, in Health at a Glance: Europe 2018: State of Health in the EU Cycle. OECD Publishing, Paris/European Union, Brussels, 2018.
3. Mota M, Popa SG, Mota E, Mitrea A, Catrinioiu D, Cheta DM, Guja C, Hancu N, Ionescu-Tirgoviste C, Lichiardopol R, Mihai BM, Popa AR, Zetu C, Bala CG, Roman G, Serafinceanu C, Serban V, Timar R, Veresiu IA, Vlad AR. Prevalence of diabetes mellitus and prediabetes in the adult Romanian population: PREDATORR study. *J Diabetes*. 2016;8(3):336-344.

4. World Health Rankings, <https://www.worldlifeexpectancy.com/romania-diabetes-mellitus> (accessed on 05 August 2020).
5. World Health Organization. Diabetes Country profiles, 2016, [https://www.who.int/diabetes/country-profiles/rou\\_en.pdf?ua=1](https://www.who.int/diabetes/country-profiles/rou_en.pdf?ua=1) (accessed on 12 August 2020).
6. Ioacara S, Guja C, Ionescu-Tirgoviste C, Martin S, Tiu C, Fica S. Rates and causes of death among adult diabetes patients in Romania. *Endocr Res.* 2019;44(3):81-86.
7. Ioacara S, Sava E, Georgescu O, Sirbu A, Fica S. Recent diabetes-related mortality trends in Romania. *Acta Diabetol.* 2018;55(8):821-826.
8. Bild DE, Stevenson JM. Frequency of recording of diabetes on U.S. death certificates: analysis of the 1986 National Mortality Followback Survey. *J Clin Epidemiol.* 1992; 45(3):275-281.
9. Will JC, Vinicor F, Stevenson J. Recording of diabetes on death certificates. Has it improved? *J Clin Epidemiol* 2001;54(3):239-244.
10. Coculescu BI, Manole G, Coculescu EC, Ionescu E, Popoviciu O, Stocheci CM. Autophagy as a neuronal survival mechanism in ischemic stroke, *Rom J Leg Med.* 2018; 26(4):333-339.
11. McEwen LN, Kim C, Haan M, Ghosh D, Lantz PM, Mangione CM, Safford MM, Marrero D, Thompson TJ, Herman WH; TRIAD Study Group. Diabetes reporting as a cause of death: results from the Translating Research Into Action for Diabetes (TRIAD) study. *Diabetes Care.* 2006;29(2):247-253.
12. Zucker I, Shohat T. Variations in death certification practices distort international comparisons of mortality from diabetes. *Eur J Public Health* 2017;27(2):247-250.
13. Ravakhah K. Death certificates are not reliable: revivification of the autopsy. *South Med J.* 2006;99(7):728-733.
14. Tancredi M, Rosengren A, Svensson AM, Kosiborod M, Pivodic A, Gudbjörnsdóttir S, Wedel H, Clements M, Dahlqvist S, Lind M. Excess mortality among persons with type 2 diabetes. *N Engl J Med.* 2015;373(18):1720-1732.
15. Rao Kondapally Seshasai S, Kaptoge S, Thompson A, Di Angelantonio E, Gao P, Sarwar N, Whincup PH, Mukamal KJ, Gillum RF, Holme I, Njølstad I, Fletcher A, Nilsson P, Lewington S, Collins R, Gudnason V, Thompson SG, Sattar N, Selvin E, Hu FB, Danesh J; Emerging Risk Factors Collaboration. Diabetes mellitus, fasting glucose, and risk of cause-specific death. *N Engl J Med.* 2011;364(9):829-841.
16. Baena-Díez JM, Peñafiel J, Subirana I, Ramos R, Elosua R, Marín-Ibañez A, Guembe MJ, Rigo F, Tormo-Díaz MJ, Moreno-Iribas C, Cabré JJ, Segura A, García-Lareo M, Gómez de la Cámara A, Lapetra J, Quesada M, Marrugat J, Medrano MJ, Berjón J, Frontera G, Gavrila D, Barricarte A, Basora J, García JM, Pavone NC, Lora-Pablos D, Mayoral E, Franch J, Mata M, Castell C, Frances A, Grau M; FRESCO Investigators. Risk of cause-specific death in individuals with diabetes: a competing risks analysis. *Diabetes Care.* 2016;39(11):1987-1995.
17. Li L, Li CL, Tian H, Wei LX. Analysis of mortality causes for 165 type 2 diabetics: an autopsy study. *Zhonghua Yi Xue Za Zhi.* 2011;91(18):1265-1267.
18. Tu E, Twigg SM, Duflou J, Semsarian C. Causes of death in young Australians with type 1 diabetes: a review of coronial postmortem examinations. *Med J Aust.* 2008;188(12):699-702.