HOCHSCHULE FÜR ANGEWANDTE WISSENSCHAFTEN HAMBURG
Hamburg University of Applied Sciences
Faculty of Life Sciences
Ulmenliet 20
21033 Hamburg

Master Thesis

Analysing Gender, Body Mass Index (BMI), Self-Reported Risk Factors as predictors of Type 2 Diabetes – A Case Study

Submitted by:
Jeongwon Richter
[redacted]
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Examination Committee:
1st Examiner: Prof. Dr. Johanna Buchcik
2nd Examiner: Dr. Adekunle Adedeji

Abstract

Background**:** Diabetes is a serious global health problem. In humanitarian crises, the delays in diagnosis and appropriate treatment of diabetes can exacerbate the condition. This study aims to fill an important gap in our understanding of diabetes risk factors in the unique context of the current situation in Ukraine. We sought to investigate the impact of gender, body mass index (BMI), and self-reported risk factors, including alcohol consumption, smoking, sedentary behaviour, overweight and unhealthy eating habits on the development of type 2 diabetes (T2D) among Ukrainians.

Methods: This cross-sectional study utilised secondary data from individuals who visited medical mobile teams (MMTs) in four Ukrainian regions (Lviv, Rivne, Dnipro, and Poltava) between 6th of April and 8th of August 2023. The analysis involved 12,092 datasets. Multiple logistic regression was employed to explore various risk factors associated with T2D.

Results: Our analysis revealed several significant predictors of T2D, including Gender, BMI, Unhealthy Diet, Overweight, and Sedentary Lifestyle. Overweight individuals were 3.016 times more likely to have T2D, while each unit increase in BMI raised the likelihood by 1.046-fold. An unhealthy diet increased the risk by 1.286 times. Women had 1.157 times higher T2D prevalence than men. Sedentary individuals were 16.1% less likely to have T2D.

Conclusions: This study established the association between T2D and several risk factors in the context of the humanitarian crisis in Ukraine. Notably, this study is significant in that self-perceived overweight status was found to be the most important risk factor associated with T2D prevalence. These findings provide important guidance for organisations seeking to support T2D diagnosis and management efforts in Ukraine and emphasise the need to recognise self-perceived overweight status as an important consideration.

Keywords*:* Ukraine*,* Type 2 Diabetes, T2D, Gender, BMI, Self-Reported Risk Factors, Smoking, Alcohol, Unhealthy Diet, Sedentary Behaviour, Overweight

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1 Background

Diabetes represents a significant global health challenge. According to International Diabetes Federation (IDF) Atlas 2021, an estimated 537 million people are living with diabetes in 2021, rising to 783 million by 2045 (Magliano & Boyko, 2021). This chronic disease is categorised into two main types: Type 1 diabetes (T1D), the early-onset autoimmune type and Type 2 Diabetes (T2D) the late-onset non-autoimmune type (ADAPPC, 2021). Despite substantial advances in the understanding and management of diabetes, it remains a major global public health challenge of the 21st century. The burden of diabetes extends beyond its immediate metabolic effects, contributing to complications such as cardiovascular disease ('myocardial infarction'), nerve damage ('stroke'), eye disease ('retinopathy') and blindness, kidney damage ('kidney failure') and lower limb amputation (Cole & Florez, 2020). Therefore, diabetes affects both life expectancy and the burden of healthcare costs. There were 6.7 million deaths from diabetes-related causes among people aged 20 to 79 years in 2021, but also results in significant healthcare expenditures, accounting for an estimated $966 billion of global healthcare spending in 2021, an increase of 316% over the past 15 years (Magliano & Boyko, 2021).

Diabetes is caused by either absolute or relative insulin deficiencies associated with β-cell dysfunction, insulin resistance or both (American Diabetes Association, 2014). T1D results from low insulin levels that do not adequately control blood glucose levels. Whereas T2D is caused by insulin resistance, where the body does not properly use the insulin it produces, resulting in high blood sugar levels (Magliano & Boyko, 2021). The diagnostic criteria for diabetes are fasting plasma glucose of ≥126 mg/dl (or ≥7.0 mmol/l), 2-hour plasma glucose after 75 g oral glucose tolerance test (OGTT) of ≥200 mg/dl (or ≥11. 1mmol/l), a random plasma glucose of ≥200mg/dl (or ≥11.1mmol/l), and an HbA 1c of ≥6.5% (or ≥48mmol/mol) are indicative of diabetes (ADAPPC, 2021).

Previous studies have identified that factors such as gender, body mass index (BMI) and overweight, and lifestyle factors including unhealthy diet, physical inactivity, smoking, and drinking alcohol have a significant impact on the prevalence and management of T2D. Gender differences are notable, with men are more likely to be diagnosed at younger ages and have lower percentage of body fat, while women tend to have a higher rate of obesity (Kautzky-Willer et al., 2023). Furthermore, BMI and being overweight are significant risk factors of developing T2D in many studies. For instance, research in western Ukraine involving 400 participants identified a positive correlation between BMI and 10-year-risk of developing T2D (Lushchak et al., 2023). Similarly, a large-scale study in China with 53,288 participants identified that individuals who were overweight or obese had higher odds of T2D than those with normal BMI (Xia et al., 2021). This association was supported by another study in China analysed 69,388 subjects and concluded that waist circumference and BMI are strong predictors of T2D among males and females, respectively (Bai et al., 2022). In addition, a comprehensive seven-year follow-up-study (2009-2015) conducted in Korea which included a cohort of over four million individuals identified higher BMI as significant risk factor for T2D, particularly among women (Hyun et al., 2021).

Lifestyle factors also play a crucial role in the management and prevention of T2D. Eating healthy is one of the important risk factors to prevent and control the T2D. Unhealthy diets including red and processed meats, sugar-sweetened beverages, and eggs have been associated to increased disease risk, while increased intake of whole grains, vegetables, fruits, and dairy products can significantly lower this risk (Neuenschwander et al., 2019; Schwingshackl et al., 2017). Physical activity (PA) is another crucial risk factors of T2D. According to American College of Sports Medicine and the American Diabetes Association, at least 2.5 hours of moderate to vigorous exercise per week should be part of lifestyle changes to prevent the development of T2D in high-risk adults (Colberg, Sigal, et al., 2010). Previous studies have consistently showed that PA is associated with T2D reduction and control. The Whitehall II study including 9987 participants found that those who engaged in moderate to vigorous physical activity during 1985-1988 had a lower risk of developing T2D during a mean follow-up of 27.1 years (Yerramalla et al., 2020). Smoking has been consistently associated with an increased risk of developing T2D. A large scale cohort study in Korea with 1,236,443 participants over 7 years found that compared with never smokers, current male smokers who smoked 20 cigarettes/day had increased risk for incident diabetes, and death from diabetes (Jee et al., 2010). On the other hand, the relationship between alcohol consumption and T2D risk is more complex. The results of systematic reviews and meta-analyses showed that drinking about 22 g of alcohol per day was the most protective against the relative risk (RR) of T2D in men (RR 0.87). However, this protective effect was reduced when alcohol intake exceeded about 60g/day (RR 1.01). Similarly, in women, the greatest protective effect was seen when alcohol intake was around 24g/day (RR 0.60), but this protective effect decreased when alcohol intake approached 50g/day (RR 1.02) (Valiyunas et al., 2009). In a similar vein, another study of a cohort of 22,778 twin pairs in Finland found that moderate drinking may lower the risk of T2D, while both binge drinking and heavy drinking may increase the risk of T2D in women (Carlsson et al., 2003).

The level of social capital in Ukraine is generally low and it is unevenly distributed among the population (Karhina et al., 2019). The ongoing war has only made this situation worse.The impact of military conflict has made life difficult for Ukrainians, with those who remain in conflict zones face shortages of hospitals, pharmacies with supplies running out, being attacked or even shutting down (The Lancet Diabetes & Endocrinology, 2022). In addition, military conflicts have forced the reallocation of resources to support war victims, overloading the healthcare system and making it difficult to predict the availability of care when it is needed (Alessi & Yankiv, 2022). In addition, the humanitarian crisis may lead to an increase in smoking, insufficient physical activity, improper dietary intake, increased alcohol consumption (Lawless et al., 2015; Ng et al., 2020; Vanderbruggen et al., 2020).

In case of Ukraine, the average BMI of the population was 26.8 kg/m^2, with a high prevalence of overweight and obesity, which increases with age and is more prevalent among women. One-third (33.9 %) of the population aged 18-69 years are smokers, with particularly high prevalence among men (50.3%) and increasing rates among women (16.7%). Alcohol consumption is common and often excessive, with a significant proportion of the population reporting occasional heavy drinking. A higher proportion of men than women reported symptoms of alcohol dependence (WHO Regional Office for Europe, 2020). However, according to the study conducted during the COVID-19 pandemic, self-reported alcohol and tobacco consumption did not change from before the pandemic (Kilian et al., 2022). Dietary habits were poor, with two thirds of population not consuming recommended levels of fruit and vegetables, and excessive salt intake was widespread. On the other hand, physical activity levels were high, with only 10 % failing to meet the WHO's recommended levels (WHO Regional Office for Europe, 2020).

The prevalence of T2D accounted for more than 80% of all diabetes cases (Ong et al., 2023). Symptoms of T2D often develop gradually and may remain unnoticed for years. When symptoms do appear, individuals may experience increased thirst, frequent urination, unintentional weight loss, fatigue and blurred vision (World Health Organisation, 2023). In 2021, nearly half of the adults with diabetes are not aware of their diabetes status and 87.5% of people with undiagnosed diabetes live in low- and middle-income countries(LMICs) (Magliano & Boyko, 2021). The management of T2D includes both non-drug and drug strategies. In terms of non-drug management, people with diabetes are encouraged to maintain a balanced, healthy diet, manage their weight by reducing calorie intake if necessary, and engage in at least 150 minutes of moderate to vigorous aerobic exercise each week, appropriate to their physical ability(World Health Organisation, 2020).

In Ukraine, diabetes screening is conducted through a clinical visit with an endocrinologist, or family physician, as well as outreach campaigns. Individuals who received positive result from glucose test are advised to undergo confirmatory testing including oral glucose tolerance test and/or fasting glucose test, by an endocrinologist (Stuart et al., 2020). The average fasting blood glucose level across the population was 5.1 mmol/L, equal for both genders it tends to rise from 4.7 mmol/L in 18–29-year-olds to 5.7 mmol/L in 60–69-year-olds (WHO Regional Office for Europe, 2020). Individuals in Ukraine faces challenges with diabetes screening and diagnosis. Over a quarter (27.4%) of Ukrainians have never had their blood glucose checked by a healthcare professional (WHO Regional Office for Europe, 2020). This result was due to the cost of diagnosis, lack of awareness of risk, and low health seeking and disease prevention behaviours (World Bank, 2019).

The ongoing war in Ukraine stands as one of the world's deadliest conflicts (ACLED Conflict Index, 2024). Humanitarian crises have a huge impact on health both in the short- and long-term, especially among vulnerable populations in LMICs, who are more often affected by humanitarian crises but are less prepared (Kohrt et al., 2019). Weak health systems in affected countries are already faced with surging healthcare needs and limited resources, reducing their ability to provide quality healthcare during crises (Aebischer Perone et al., 2017). The significant barriers to accessing health services for chronic conditions Ukrainians are the cost of medicines (17%) and treatment (18%), and lack of access to services (21%) (WHO Regional Office for Europe, 2023). The impact of conflict on mortality extends beyond the immediate violence. Such as in Syria, reveal that most deaths since 2017 have been due to non-violent causes of non-communicable diseases(NCDs), exacerbated by Syria's weakened and fragmented health system and the small number of health workers left after prolonged conflict (Alrashid Alhiraki et al., 2022). Research on diabetes care in conflict zones like Ukraine is limited, underscoring the need for focused studies on managing chronic diseases amidst crises (Kehlenbrink et al., 2019).

This study aims to investigate the impact of gender, body mass index (BMI) and self-reported risk factors, including alcohol consumption, smoking, sedentary lifestyle, overweight and unhealthy diet, on the incidence of T2D among Ukrainians accessing medical services from mobile medical teams (MMTs) during the humanitarian crisis. By focusing on these associations, this research endeavors to fill a critical gap in our understanding of diabetes risk factors within the unique context of Ukraine's current situation.

To achieve this, the following objectives are considered:

1. To determine the prevalence rate of T2D among Ukrainian population who visited mobile medical teams.
2. To identify the differences in distribution of T2D risk factors between diabetics and non-diabetics.
3. To analyse the predictive effects of identified risk factors on incidence of T2D.

2 Methods

2.1 Study Design and Data Source

This study utilised cross-sectional secondary data sourced from four regions of Ukraine: Lviv, Rivne, Dnipro, and Poltava. The data used in the study was collected from 6th of April till 8th of August,2023. The project was funded by the Swiss Development and Cooperation (SDC). The primary data collection procedures were planned and designed by the project's team at GFA Consulting Group, which ensured compliance with ethical guidelines and obtained informed consent from the participating patients. Data acquisition for this study employed by using ArcGIS survey 123digital tool. In total,18,589 data points were collected in this study.

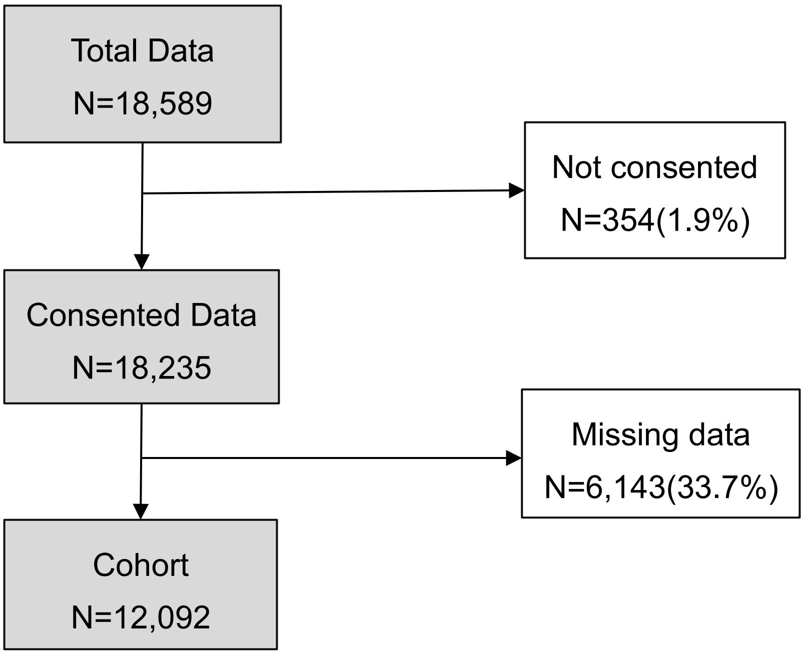
2.2 Medical Mobile Team (MMT)

Act4Health, led by GFA Consulting Group in collaboration with the Ministry of Health of Ukraine, is one of SDC's investments to combat NCDs in Ukraine. In response to the humanitarian crisis in Ukraine, the Act4Health project has deployed nine Mobile Medical Teams (MMTs) to four regions of Ukraine to improve access to health care during a humanitarian crisis. The MMTs are strategically located in each region: three in Rivne, two in Poltava, two in Lviv, and two in Dnipro. The MMTs are staffed by multi-disciplinary teams of health professionals, including medical doctors (MDs), nurses, psychologists, and drivers. The van is equipped with a comprehensive NCD kit containing a range of essential medical equipment and supplies. To ensure effective medical outreach, regional coordinators are responsible for organising the MMTs' schedule and determining the locations to be visited. Regional coordinators use a variety of communication channels to inform the community of upcoming visits, including Facebook, text messaging, direct community engagement, and in some cases, radio broadcasts. This multi-channel approach aims to maximise awareness and engagement. The MMTs provide comprehensive health services to the communities they visit. These services include ECG screening, diagnosis, care management, laboratory testing, counselling, first aid, information distribution and health advice. The MMTs operate daily and travel from one region to another. The MMTs are open from 9:00 to 17:00, providing convenient access to healthcare services throughout the day. By following a consistent schedule, the MMTs ensure that people in the regions receive the medical care and support they need.

2.3 Study subjects and Setting

The exclusion criteria were as follow: (i) non-consent, (ii) missing data in the variables including age, height, and weight. After applying the exclusion criteria, 12,092 subjects were eligible for analysis.

Figure 1: Eligibility Criteria for Research



2.4 Measures

2.4.1 Self-Reported Risk Factors

Self-reported risk factors assessed in this study included smoking, alcohol use, sedentary behaviour, being overweight, and unhealthy eating habits. Patients provided self-reports of these factors during an initial consultation with the mobile team. The questionnaire used in this consultation was designed to comprehensively assess participants' lifestyle choices and health behaviours. Clear and straightforward language was used to make it easy for participants to understand and respond. During the data collection process, we did not pre-define specific definitions or criteria for each risk factor. Lifestyle factors were coded dichotomously as 'no' (0) or 'yes' (1), indicating the presence or absence of each risk factor.

Example Question: "Do you currently smoke cigarettes, cigars, or use any form of tobacco?"

2.4.2 Risk Score

The risk score was measured using self-developed item. The risk score is calculated by summing participant's responses to various risk factors as assessed in the questionnaire. These factors included smoking, alcohol consumption, sedentary behaviour, overweight, and unhealthy diet. Each factor is given a score ranging from 0 (indicating none of the mentioned behaviours) to 5 (indicating the presence of all the mentioned behaviours). Lower scores indicated a self-perceived healthier lifestyle status, while higher scores indicated a self-perceived unhealthier lifestyle status. This scoring system facilitated the quantification of participants' overall risk level based on their reported behaviours.

2.4.3 Disease Determination

If patients visiting the MMTs were overweight or obese, they were screened by a physician. T2D was defined as random blood glucose ≥ 11.1 mmol/L (200 mg/ dl) (World Health Organization, 2019), and included patients who were taking diabetes medication or self-reported. The dependent variable, T2D, was encoded as 'no' (0) and 'yes' (1).

2.4.4 BMI and Weight Group

BMI was calculated using self-reported height and weight. The formula is **BMI = kg/m^2**

Group is divided into 4 different nutritional status categories based on WHO criteria (*The SuRF Report 2*, 2005). BMI < 18.5 kg/m^2 = Underweight, 18.5 kg/m^2≤ BMI < 25 kg/m^2 = Normal weight, 25 kg/m^2≤ BMI < 30 kg/m^2 = Overweight, BMI ≥ 30 kg/m^2 = Obese.

2.4.5 Sociodemographic Data

In this study, sociodemographic data are used for a comprehensive understanding of participants and for the analysis. The variables used are gender (female, male), age, age group and migration status (local, internally displaced person (IDPs)).

Table1: Variables and their definitions

Measures	Definition
Smoking (Self-reported)	Not smoking (0)
	Smoking (1)
Alcohol consumption (Self-reported)	Not drinking alcohol (0)
	Drinking (1)
Sedentary Lifestyle (Self-reported)	Active lifestyle (0)
	Sedentary lifestyle (1)
Overweight (Self-reported)	Healthy weight (0)
	Overweight (1)
Unhealthy Diet (Self-reported)	Eating healthy (0)
	Eating unhealthily (1)
Risk Score	The sum of participant's responses to various risk factors (0~5)
T2D	No T2D (0)
	Prevalence of T2D (1)
BMI	kg/m^2
Underweight	< 18.5 kg/m^2
Normal weight	18.5 $kg/m^2 \leq$ BMI < 25 kg/m^2
Overweight	25 $kg/m^2 \leq$ BMI < 30 kg/m^2
Obese	≥ 30 kg/m^2
Gender	Male (0)

	Female (1)
Age Group	Under 10 years old
	11~20 years old
	21~30 years old
	31~40 years old
	41~50 years old
	51~60 years old
	61~70 years old
	71~80 years old
	81 years old and over
Migration Status	Local (0)
	IDPs (1)

2.5 Statistical analysis

For this study, all statistical analyses were conducted by using Statistical Package for the Social Science (SPSS) version 29 (IBM Corp., Armonk, NY). Descriptive statistics were performed for each indicator and sociodemographic variable to understand the basic features of the data disaggregated by gender and T2D prevalence. Independent samples t-tests were performed to compare BMI and lifestyle score by gender and prevalence of T2D. Multiple logistic regression was computed to examine which risk factor variables effects T2D. All variables except BMI were treated as binomial. The dataset included 12,092 in the analyses. Logistic regression models were constructed with T2D as the dependent variable and gender, BMI, overweight, unhealthy diet, sedentary lifestyle, alcohol consumption and smoking as independent variables. Significance levels were denoted as follows: $p < .05$ (significant), $p < .01$ (highly significant), $p < .001$ (extremely significant).

3 Results

3.1 Baseline Demographics

The analysed sample comprised 12,092 participants, with the mean age was 59.75 (SD=15.88) years and 72.7% were female, with the largest proportion in their sixties and seventies. Women were more likely to be classified as overweight or obese. For both men and women, the obese, normal weight category for women and the normal weight, obese category for men were the most common weight groups after overweight. While objective measure classifies 70.2% percent of women and 63.9 % of men as overweight, only 47 % of women and 36.8% of men described themselves as overweight. Men were significantly more likely than women to smoke and drink alcohol, and more than half of both sexes reported having unhealthy eating habits 63.6% in female and 67.6% in male respectively. (See Table 2)

Table 2: Characteristics of the participants in Ukraine (n=12,092)

Variables		**Both Sexes**		**Female**		**Male**	
		n	**%**	**n**	**%**	**n**	**%**
Total(n)		12,092	100.0%	8,793	72.7%	3,299	27.3%
T2D	No	10,506	86.9%	7,556	85.9%	2950	89.4%
	Yes	1,586	13.1%	1,237	14.1%	349	10.6%
Migration Status	Local	11,327	93.7%	8,186	93.1%	3,141	95.2%
	IDPs	765	6.3%	607	6.9%	158	4.8%
Age		59.75 ± 15.88		60.55±15.22		57.59±17.33	
Age group	Under 10	74	0.6%	33	0.4%	41	1.2%
	11~20	292	2.4%	151	1.7%	141	4.3%
	21~30	363	3.0%	244	2.8%	119	3.6%
	31~40	775	6.4%	554	6.3%	221	6.7%
	41~50	1,361	11.3%	951	10.8%	410	12.4%
	51~60	2,316	19.2%	1,712	19.5%	604	18.3%
	61~70	3,730	30.8%	2,757	31.4%	973	29.5%

Variables		Both Sexes		Female		Male	
		n	%	n	%	n	%
	71~80	2,554	21.1%	1,899	21.6%	655	19.9%
	81 over	627	5.2%	492	5.6%	135	4.1%
BMI		27.89 ± 5.28		28.22±5.46		27.03±4.60	
Weight group	Underweight	207	1.7%	145	1.6%	62	1.9%
	Normal	3,606	29.8%	2,479	28.2%	1,127	34.2%
	Overweight	4,477	37.0%	3,130	35.6%	1,347	40.8%
	Obese	3,802	31.4%	3,039	34.6%	763	23.1%
Smoking	No	10,692	88.4%	8,506	96.7%	2,186	66.3%
	Yes	1,400	11.6%	287	3.3%	1,113	33.7%
Alcohol consumption	No	11,720	96.9%	8,742	99.4%	2,978	90.3%
	Yes	372	3.1%	51	0.6%	321	9.7%
Unhealthy Diet	No	4,272	35.3%	3,204	36.4%	1,068	32.4%
	Yes	7,820	64.7%	5,589	63.6%	2,231	67.6%
Overweight	No	6,743	55.8%	4,657	53.0%	2,086	63.2%
	Yes	5,349	44.2%	4,136	47.0%	1,213	36.8%
Sedentary Lifestyle	No	6,139	50.8%	4,458	50.7%	1,681	51.0%
	Yes	5,953	49.2%	4,335	49.3%	1,618	49.0%
Risk score		1.73 ± 1.10		1.64±1.06		1.97±1.18	
	0	1,999	16.5%	1,588	23.7%	411	12.5%
	1	3,020	25.0%	2,276	24.9%	744	22.6%
	2	3,715	30.7%	2,722	29.2%	993	30.1%
	3	3,032	25.1%	2,150	21.6%	882	26.7%
	4	282	2.3%	57	0.5%	225	6.8%
	5	44	0.4%	0	0%	44	1.3%

3.2 Characteristics of subjects from Diabetic and Nondiabetic

The proportion of patients with T2D among all subjects was around 13.1 %. People in their 60s had the highest rate of diabetes, but this is hardly an outlier, as this is also the age group with the highest rate of demographic characteristics. Among diabetics, the prevalence of hypertension and cardiovascular disease was high, at 82.0 % and 68.6 %, respectively. In the weight group, the proportion of obese patients was much higher in the diabetic group, and the proportion of people who reported eating an unhealthy diet, describing themselves as obese or overweight, and being sedentary was higher in the diabetic group than in the nondiabetic group. (See Table 3)

Table 3: Characteristics of subjects from Diabetic and Nondiabetic (n=12,092)

Variables		Diabetic		Nondiabetic	
		n	%	n	%
Total(n)		1,586	13.1%	10,506	86.9%
Gender	Female	1,237	78.0%	7,556	71.9%
	Male	349	22.0%	2,950	28.1%
Migration Status	Local	1,493	94.1%	9,834	93.6%
	IDPs	93	5.9%	672	6.4%
Age		65.14±10.02		58.93±16.43	
Age group	Under 10	0	0%	74	0.7%
	11~20	5	0.3%	287	2.7%
	21~30	3	0.2%	360	3.4%
	31~40	21	1.3%	754	7.2%
	41~50	94	5.9%	1,267	12.1%
	51~60	331	20.9%	1,985	18.9%
	61~70	622	39.2%	3,108	29.6%
	71~80	452	28.5%	2,102	20.0%
	81 over	58	3.7%	569	5.4%
Hypertension	No	286	18.0%	3,585	34.1%

Variables		Diabetic		Nondiabetic	
		n	%	n	%
	Yes	1,300	82.0%	6,921	65.9%
CVD	No	498	31.4%	3,887	37.0%
	Yes	1,088	68.6%	6,619	63.0%
BMI		30.54±5.0		27.49±5.19	
Weight group	Underweight	1	0.1%	206	2.0%
	Normal	184	11.6%	3,422	32.6%
	Overweight	576	36.3%	3,901	37.1%
	Obese	825	52.0%	2,977	28.3%
Smoking	No	1,442	90.9%	9,250	88.0%
	Yes	144	9.1%	1,256	12.0%
Alcohol consumption	No	1,550	97.7%	10,170	96.8%
	Yes	36	2.3%	336	3.2%
Unhealthy Diet	No	417	26.3%	3,855	36.7%
	Yes	1,169	73.7%	6,651	63.6%
Overweight	No	422	26.6%	6,321	60.2%
	Yes	1,164	73.4%	4,185	39.8%
Sedentary Lifestyle	No	764	48.2%	5,375	51.2%
	Yes	822	51.8%	5,131	48.8%
Risk score		2.10±0.94		1.67±1.1	
	0	61	3.8%	1,938	18.4%
	1	370	23.3%	2,650	25.2%
	2	560	35.3%	3,155	30.0%
	3	542	34.2%	2,490	23.7%
	4	46	2.9%	236	2.2%

Variables		Diabetic		Nondiabetic	
		n	%	n	%
	5	7	0.4%	37	0.4%

3.3 Independent samples t-test

Independent samples t-tests were performed to explore differences in BMI and risk score by gender and prevalence of T2D. For BMI, there were significant differences between gender and T2D prevalence. The results were t=-11.89, p<.001 and t=-21.90, p<.001 in gender and T2D prevalence respectively. Females had a mean BMI of 27.04, while males had a slightly higher mean BMI of 28.21, highlighting a gender-related variance with males having a higher mean BMI.

Furthermore, in relation to T2D prevalence, participants without T2D had a mean BMI of 27.49, while those with T2D had a significantly higher mean BMI of 30.54. This difference underlines a significant association between T2D prevalence and elevated BMI levels.

Table 4 : BMI differences by Gender and T2D prevalence

Variables		BMI			t(p)
		N	Mean	SD	
Gender	Female	8793	27.04	5.46	-11.89(<.001) ***
	Male	3299	28.21	4.60	
T2D	No	10506	27.49	5.19	-21.90(<.001) ***
	Yes	1586	30.54	5.04	

*p<.05, **p<.01, ***p<.001

Similarly, significant differences in risk scores were observed based on both gender and T2D prevalence. The calculated values were t=14.88, p<.001 and t=-16.67, p<.001 in gender and T2D prevalence respectively. Females had a mean risk score of 1.97, while males had a slightly lower mean score of 1.64, indicating a gender difference with females having a higher mean risk score. In addition, participants without T2D had a mean risk score of 1.67, while those with T2D had a higher mean score of 2.10. This observation suggests a notable association between T2D prevalence and elevated risk scores, implying that participants with T2D tend to have higher risk scores.

Table 5: Risk score differences by Gender and T2D prevalence

Variables		Risk Score			t(p)
		N	Mean	SD	
Gender	Female	8793	1.97	1.18	14.88(<.001) ***
	Male	3299	1.64	1.06	
T2D	No	10506	1.67	1.11	-16.67(<.001) ***
	Yes	1586	2.10	0.94	

*p<.05, **p<.01, ***p<.001

3.4 Multiple Logistic Regression Analysis

In this study, a multiple logistic regression model was applied to identify predictors that can explain variance in the increasing risk of developing T2D. The Omnibus tests of model coefficients indicated a significant model fit (Chi-square = 719.236, *df* = 7, p < .001). The Cox & Snell R^2 and Nagelkerke R^2 values were .058 and .107, respectively, suggesting that the model explains a moderate proportion of the variance in T2D. Our analysis revealed that Gender, Unhealthy Diet, Overweight, Sedentary Lifestyle and BMI were significant predictors of T2D. (See Table 6) Of these, being overweight emerged as the most influential factor. (Wald (1) =233.1, p < .001) Those who reported being overweight were 3.016 times with 95%CI (2.618,3.476) more likely to have T2D than their non-overweight counterparts. Additionally, a 1 increase in BMI was associated with a 1.046-fold increase the likelihood of T2D. (Wald (1) =56.26, p< .001) Regarding diet, individuals who reported unhealthy eating habits were 1.286 times more likely to have T2D than who did not (Wald (1) =13.99, p < .001). In terms of gender differences, women were found to have a 1.157 times higher prevalence of T2D than men (Wald (1) =3.93, p<.05). However, the model indicated that sedentary individuals were 16.1% less likely to have T2D compared to active individuals (Wald (1) =8.69, p < .01).

Table 6: Coefficients of multiple logistic regression model

Variable	B	S.E.	Wald	*df*	Sig.	Exp(B)	95% C.I for Exp(B)	
							Lower	Upper
Gender (1)	0.146	0.074	3.929	1	0.047*	1.157	1.002	1.337
Smoking (1)	-0.020	0.107	0.035	1	0.851	0.980	0.794	1.209
Alcohol (1)	-0.123	0.191	0.413	1	0.520	0.884	0.608	1.286
Unhealthy Diet (1)	0.252	0.067	13.998	1	<.001***	1.286	1.127	1.468
Overweight (1)	1.104	0.072	233.092	1	<.001***	3.016	2.618	3.476
Sedentary Lifestyle (1)	-0.176	0.060	8.689	1	0.003**	0.839	0.746	0.943
BMI	0.045	0.006	56.255	1	<.001***	1.046	1.034	1.059
Constant	-5.499	1.004	29.977	1	<.001	0.004		

*p<.05, **p<.01, ***p<.001

Reference group: Gender*Male, Smoking, Alcohol, Unhealthy Diet, Overweight, Sedentary Lifestyle*No

4 Discussion

The objective of this thesis was to delineate the relationships between socio-economic factors (such as gender), health-related factors (BMI), self-perceived risk factors (including smoking, alcohol consumption, sedentary lifestyle, overweight and unhealthy diet), and the prevalence of T2D amidst the humanitarian crises in Ukraine. Results from the investigation revealed significant associations between T2D and several factors: gender, unhealthy diet, overweight status, sedentary lifestyle, and BMI.

This study confirms the notion that BMI and self-perceived overweight status are significantly associated with T2D. The association between BMI and T2D can be also found in previous studies in Ukraine, Korea, and China (Bai et al., 2022; Hyun et al., 2021; Lushchak et al., 2023). However, the discussion of BMI as a universal risk indicator is nuanced by the 'obesity paradox', which questions the reliability of BMI as a measure of fat in all patient groups, especially when compared to waist circumference (WC) or waist to height ratio (WHtR) in diabetics (Feller et al., 2010; Zhang et al., 2021). A previous study involved 9,753 men and 15,491 women aged 35 to 65 years from a large European study called European Prospective Investigation into Cancer and Nutrition (EPIC). The research found a significant interaction between BMI and WC in determining the risk of T2D. They found that individuals with a lower BMI (BMI<25), but a larger WC had a similar risk of developing diabetes to people who were overweight but had a smaller WC. The RR and its 95% confidence intervals (CI) for developing T2D was 3.62 [1.67-7.83] for men and 2.74 [1.52-4.94] for women of low or normal weight with a large WC. Meanwhile, overweight men and women with a small WC had a RR of 2.26 [1.51–3.37], 1.40 [0.61–3.19] respectively. These findings suggest that a large waist circumference is a significant risk factor for diabetes, even in people who are not considered overweight by BMI standards (Feller et al., 2010). Another study conducted in China with 4,052 participants aged 40 years and older found that WC and WHtR were more strongly correlated with the prevalence of diabetes, especially in women. The area under the curve (AUC) values of WHtR, WC, waist-to-hip ratio (WHR), and BMI were 0.710 [0.679-0.741], 0.701 [0.670-0.732], 0.684 [0.648-0.719], and 0.633 [0.596-0.669], in women and 0.634 [0.590-0.679] and 0.639 [0.593-0.685], 0609 [0.565-0.654], and 0.629 [0.581-0.676], in men, respectively (Zhang et al., 2021).

Among these considerations, self- perceived overweight status in Ukraine during the humanitarian crisis appears to be a potential valuable criterion for T2D. This aspect becomes even more compelling when considering the gap between the actual prevalence of overweight and obesity, as indicated by BMI measurements during our study (70.2 % for women and 63.9 % for men) and the lower proportion of individuals who perceive themselves to be overweight (47 % for women and 36.8 % for men). This observation aligns with findings from other study noting that as individuals get older, even those who are classified as overweight or obese are more likely to think they are a healthy weight, suggesting that perceptions of ideal weight change with age (Jackson et al., 2020). The previous study conducted in England with 5,240 participants over the age of 50, part of the English Longitudinal Study of Ageing, explored how older adults perceive their body weight. The findings revealed that 44.8% of older adults who were classified as overweight (25≤ BMI<30) and 10.3% of those classified as obese (BMI≥30) felt that their weight was about right. The study found that older age independently increased the odds of older adults perceiving their weight as about right, in both men and women. Specifically, for each additional year of age, the odds increased by 4% in men (OR = 1.04 [1.02-1.06]), and 6% in women (OR = 1.06 [1.04-1.09]). This suggests that older individuals are more likely to view their weight as appropriate, regardless of their actual BMI (Jackson et al., 2020).

The study also identified significant gender differences in health-related behaviours and the prevalence of T2D. In our study, 72.7% of participants who visited the MMTs were female, possibly reflecting a higher health seeking behaviour of the female (Lim et al., 2019) and high levels of bonding among Ukrainian women (Karhina et al., 2019). Furthermore, our findings indicate that men were more likely than women to smoke and drink alcohol. Correspondingly, the average risk score was higher for men (1.97) than for women (1.64), consistent with trends observed in the WHO STEPS survey among Ukrainian population (WHO Regional Office for Europe, 2020). The prevalence of the T2D was found to be higher in the women, a finding that aligns with previous research. According to a previous study conducted in Korea with a large scale cohort of 4,205,006 individuals revealed females who are older than 40years old are 1.145 times higher to converse from non-diabetes to diabetes (Hyun et al., 2021). However, it is essential to consider that this result could be caused by disproportion of gender among study participants.

The association between unhealthy diets and T2D prevalence was evident in this study, with those having unhealthy diets are at a higher risk of developing T2D. This result is found in previous systematic review and meta-analysis of studies (Neuenschwander et al., 2019; Schwingshackl et al., 2017). A previous report also showed that two-thirds of Ukrainians do not consume the recommended amount of fruit and vegetables. In that study, women (40.6%) ate more than five portions of fruit and vegetables a day, compared to 26.8% of men (WHO Regional Office for Europe, 2020), and in our study, women (36.4%) reported healthier diets than men (32.4%). However, in our study, the self-reported concept of 'healthy diet' remains subjective that varies greatly by age, culture, and geography, as the perception of healthy eating is highly individualised (Cena & Calder, 2020). Future research should aim to establish a more uniform definition of healthy eating to reduce the variability in dietary assessments and better understand its relationship with T2D.

Our study presents a result that being physically active emerged as the risk factor for T2D. In contrast, Whitehall II study, which included 9,987 participants, found that those who were moderate-to-vigorous exercisers were less likely to develop T2D (Yerramalla et al., 2020). This inconsistency likely reflected the unique situation in Ukraine, where physical activity levels are among the highest in the WHO European Region (WHO Regional Office for Europe, 2020) and from previous study it was found that there was no statistically significant difference in physical activity levels between different weight groups (Lushchak et al., 2023). An earlier study of 400 adults in the Ivano-Frankivsk region of western Ukraine examined physical activity levels in different weight classes. In the study, the International Physical Activity Questionnaire (IPAQ) was used to measure physical activity levels. The results showed that there was no statistically significant difference in physical activity levels between those with a normal BMI, those classified as overweight and those classified as obese (Lushchak et al., 2023)

In the present study, smoking and drinking alcohol were not statistically significant risk factors in the incidence of T2D. However, in the previous studies, smoking and alcohol consumption are identified as risk factors of T2D prevalence. A large cohort study in Korea, involving approximately 1.24 million participants, revealed that male smokers who currently smoke 20 or more cigarettes/ day had a significantly increased risk of developing diabetes in the outpatient setting. Specifically, compared with men who had never smoked, the adjusted hazard ratio for these heavy smokers was 1.55 [1.51-1.60], indicating that smokers were 55% more likely to develop diabetes than those who had never smoked (Jee et al., 2010). Moreover, a comprehensive systematic review and meta-analysis of studies conducted in Japan unveiled that pooled RR of T2D was determined to be 1.38 [1.28-1.49] for current smokers and 1.19 [1.09-1.31] for individuals with a history of smoking, compared to those who had never smoked (Akter et al., 2017). However, our result can be aligned with previous study that have not found an association between smoking and diabetes, which also using only binary (smoking /not smoking) responses rather than detailed criteria for smoking have failed to show statistically significant differences (Ali et al., 2022). This discrepancy may be due to the possibility of underreporting in studies based on self-reporting without specific criteria for smoking. Finally, given the complex relationship between alcohol consumption and T2D risk (Baliunas et al, 2009), the results of our study may explain why it did not show a statistically significant association. This finding may be due to the use of dichotomous responses (drinker/non-drinker) rather than detailed alcohol consumption per day.

5 Strengths and Limitations

The study was conducted in a conflict-affected country during an acute crisis phase and collected extensive data (12,092 cases) on a range of risk behaviours, representing an important effort to fill a knowledge gap on the epidemiology of diabetes in humanitarian settings. Unlike most existing studies that focus on conflict-affected populations in the Eastern Mediterranean (Colberg, Albright, et al., 2010), this study targeted areas directly affected by conflict, providing valuable insights into the epidemiology of diabetes in these challenging contexts.

Despite its significant contribution, the findings have several limitations. Firstly, as it relies on self-reported data on risk factors presented in a dichotomous format without detailed criteria, the data might omit relevant information and may be affected by the subjective nature of individual responses. In addition, the significantly higher proportion of female participants compared to males may induce bias, which could lead to distorted results and affect the generalisability of the findings to other populations. It is also essential to acknowledge the inherent limitations of cross-sectional studies, which cannot establish causal relationships or examine temporal relationships. Finally, sampling strategies that focus only on individuals accessing health services through mobile teams in crisis situations may limit the generalisability of findings to the wider population affected by conflict.

6 Conclusion

This study examines the association between type 2 diabetes (T2D) and several risk factors, including gender, body mass index (BMI), self-perceived risk factors including smoking habits, alcohol consumption, unhealthy eating habits, physical inactivity, and overweight in the context of the humanitarian crisis in Ukraine. The study is significant in that self-perceived overweight status was found to be the most important risk factor associated with T2D prevalence. These findings provide important guidance for organisations seeking to support T2D diagnosis and management efforts in Ukraine and highlight the need to recognise self-perceived overweight status as an important consideration.

The findings also suggest a strategic approach for during and post-crisis policy makers to campaign for standardised recommendations for people who perceive themselves to be overweight to visit a clinic for diabetes screening. Such proactive measures aim to improve the early detection and management of T2D, thereby improving patient outcomes.

Further research is needed to establish the bidirectional relationship between CVD, hypertension, and T2D. In Ukraine, CVD stands out as the leading cause of death from NCDs (WHO Regional Office for Europe, 2020). In addition, CVD is a well-known complication of T2D (Cole & Florez, 2020), also findings from our study showing a high prevalence of CVD and hypertension in individuals with T2D. In addition, future studies conducted in the aftermath of the crisis will be invaluable in enriching our understanding of the impact of this crisis on health outcomes through comparative analysis with current findings. This ongoing research will not only broaden our understanding of the multifaceted nature of T2D risk factors but will also inform more effective health policies and interventions in similar situations in Ukraine and around the world.

7 List of abbreviations

BMI	Body Mass Index
CVD	Cardiovascular Disease
IDF	International Diabetes Federation
IDP	Internally Displaced Person
LMIC	Low- and Middle-Income Country
MMT	Mobile Medical Team
NCD	Non-Communicable Disease
PA	Physical Activity
RR	Relative Risk
T1D	Type 1 diabetes
T2D	Type 2 Diabetes

8 List of Figures

9 List of Tables

10 Declarations

- Ethics approval and consent to participate
  This thesis solely made use of secondary data available in field reports and database, and so, there was no need to seek ethical approval.

- Consent for publication

  Not applicable.

- Availability of data and materials

  The dataset used and analysed in the study is provided as an additional file. Please see the appendix. When it is not available, please contact the author. Jeongwon.richter@gmail.com

- Competing interests

  The author declares that they have no competing interests.

- Funding
  No funding was received for this research.

- Author's contributions
  JR analysed data, interpreted the results, and wrote the main manuscript of the text.

- Acknowledgements

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12 Statutory Declaration

I declare that this thesis is entirely my own work, that I wrote it myself without the assistance of others, and that I have used only the materials and sources declared as such within it. I further declare that I have fully referenced all ideas and verbatim quotations taken from other works.

[redacted]

Jeongwon Richter 02.07.2024 Elmshorn