

**DISSERTATION FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
(PHD)**

**Policy surveillance of prevention and treatment of type 2 diabetes mellitus
across the member states of the European Union**

by Nour Mahrouseh

UNIVERSITY OF DEBRECEN

DOCTORAL SCHOOL OF HEALTH SCIENCES

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Abbreviations

API	Twitter's application programming interface
BMI	Body mass index
CI	Confidence intervals
COPD	Chronic obstructive pulmonary disease
CVD	Cardiovascular disease
DALY	Disability-adjusted life years
DM	Diabetes mellitus
EC	European Commission
EFTA	European Free Trade Association
EHIS	European Health Interview Survey
EPHA	European Public Health Alliance
EU	European Union
FEND	Federation of European Nurses in Diabetes
FIC	Food information to consumers
FOPL	Front of pack labelling
GDP	Gross domestic product
IDF Europe	International Diabetes Federation—European Region
ICC	Intra-class Correlation Coefficient
NCD	Non-communicable diseases
NUTS	Nomenclature of Territorial Units for Statistics
OR	Odds ratio
SDGs	Sustainable Development Goals
SSB	Sugar-Sweetened Beverages
T1DM	Type 1 diabetes mellitus
T2DM	Type 2 diabetes mellitus
TFEU	Treaty on the Functioning of the European Union
UK	United Kingdom
WCRF	International World Cancer Research Fund International

WHO World Health Organization
WOM Word of mouth

1. Introduction

1.1 Diabetes mellitus burden in the EU

Diabetes mellitus (DM) is one of the four main non-communicable diseases (NCDs) (Table 1). DM results from insufficient pancreatic insulin production or from improper insulin usage in the body, both of which have an impact on blood sugar regulation. Uncontrolled DM may cause the body to develop many systemic diseases [1, 2]. The prevalence of DM has grown in the European Union (EU) from 6.63 % in 2000 to 10.66% in 2019 [3], and this trend is predicted to keep on rising in the upcoming decades [4-6]. Disability-adjusted life years (DALY) rate of DM has increased from 955.57 DALYs per 100,000 in 2010 to 1098.57 in 2019 in the EU member states, which is fairly unusual among other NCDs like neoplasms, cardiovascular and respiratory diseases, are declining or remaining stable in the majority of EU member states during the last decade [3, 7]. In addition, projections propose a rise in the prevalence of DM among adults in the EU member states in the upcoming years [2, 5]. When comparing this tendency to other main NCD, it is quite unfavorable.

Non-Communicable Disease	Etiology and Pathogenesis	Common Risk Factors
Diabetes Mellitus (DM)	Type 1: Autoimmune destruction of insulin-producing beta cells. Type 2: Insulin resistance often associated with obesity where the body's reduced ability to use insulin effectively, a condition known as insulin resistance. This reduced sensitivity to insulin results in elevated blood sugar levels [1].	Obesity, unhealthy diet, lack of physical activity, genetics, family history [1].
Cardiovascular Diseases (CVD)	Fatty deposits in blood vessels due to factors like high blood pressure, high cholesterol, and smoking [8].	Hypertension, high cholesterol, smoking, obesity, sedentary lifestyle [8].
Chronic Respiratory Diseases	Including chronic obstructive pulmonary disease (COPD) and asthma, have diverse etiologies. COPD is primarily caused by smoking. Asthma can be triggered by allergies or environmental factors [9].	Smoking, exposure to air pollutants, occupational dust and chemicals, family history of respiratory conditions [9].
Cancer	Genetic mutations, exposure to carcinogens (e.g., tobacco and radiation), viral infections (e.g., hepatitis) [10].	Tobacco use, excessive alcohol consumption, poor diet, physical inactivity, certain infections [10].

Table 1. Four main non-communicable diseases with their etiology, pathogenesis and common risk factors

Such an increase in DM burden has major effects on premature mortality rates and quality of life, along with its growing economic burden. According to estimates, the cost of DM accounts for nearly 9% of all EU healthcare spending in 2019 [2, 11].

According to the World Health Organization (WHO), there is three main types of DM, which are type 1 diabetes mellitus (T1DM), type 2 diabetic mellitus (T2DM), and gestational diabetes. By far the most prevalent of DM classification, accounting for 90% of the disease is T2DM [1]. By tackling health determinants and risk factors such as smoking, drinking, poor diets, and insufficient physical exercise, T2DM is largely preventable. Policies and programs focusing on the prevention of DM primarily address T2DM due to its frequency and preventability [12].

The WHO states that a healthy body weight, exercising, a nourishing diet, and abstaining from tobacco use can delay the onset of T2DM [1]. One of the main factors contributing to the prevalence of T2DM is a poor diet. Increasing use of foods high in sugar, like sweetened beverages, increase DALYs [13]. In order to prevent the development of T2DM, behaviors such as increase in physical activity, exercise and reduction in sedentary behavior are necessary [14].

Socioeconomic and demographics factors have also an impact on the development of T2DM. There are also an association between old age groups, low labor position, and education status and occurrence of T2DM, which has been found in population-based researches [15]. In the EU, T2DM burden varies considerably between member states, and this variety is visible both at the national and regional levels [16, 17], which may require EU efforts to enforce programs that promote healthy lifestyle and tackle socioeconomic inequalities [18].

1.2 History of DM management in the EU

The St. Vincent Declaration, which was adopted by 45 European countries in 1989, outlines a unified DM approach [19]. In accordance with this declaration, a number of EU countries have

introduced national plans that address DM or include it as part of larger NCD policies. The International Diabetes Federation—European Region (IDF Europe) and the Federation of European Nurses in Diabetes (FEND) worked hard to get the European Parliament to adopt in 2006 a Written Declaration on Diabetes. In accordance with the declaration, the Commission and Council were obligated to prioritize DM by enabling the creation of national DM plans and by creating an EU diabetes strategy in the form of a “Council Recommendation on Diabetes Prevention, Diagnosis and Control”. The “Conclusions on the Promotion of Healthy Lifestyles and Prevention of Type 2 Diabetes” were approved also by the EU Ministers of Health in 2006 [20]. According to this document, member states must design and carry out national diabetes plans, as well as improve the collecting and reporting of epidemiological and economic data on DM, and must use a multi-sectoral and multidisciplinary approach to manage DM. The Council also urged the European Commission (EC) to promote and aid DM research and collaboration in the EU.

The European Parliament published a resolution entitled “Resolution on addressing the EU diabetes epidemic” in 2012, urging the EC to create and carry out a targeted EU DM strategy with a focus on prevention, diagnosis, treatment, education, and research [21]. Additionally, demands were made for the involvement of member states in the coordination, collection, recording, monitoring, and administration of complete epidemiological data on DM as well as economic statistics on the direct and indirect costs of DM prevention and treatment [22].

1.3 EU efforts to tackle DM

In the EU, member states are mostly autonomous and in charge of making decisions about health-related laws and regulations. However, in addition to the member states, the EU itself is accountable for safeguarding and maintaining the health of its citizens through the application of a broad and varied range of laws. Under the “Treaty on the Functioning of the European Union (TFEU)” Article 168 on public health, great protection for human health must be

provided in formulating and implementing of all Union laws and initiatives, this may be accomplished by monetary legislation, common market regulations, or public health legislations [23]. The EU institutions are required by the EU treaties to consider health objectives and aspects in all legislations. However, in many areas of EU legislation, this obligation is rarely observed at best [24].

Currently, in the EU, it is up to both member states and the EU to establish laws and regulations aimed at preventing NCDs. However, the EU has competence in well-defined areas of public health, but the burden of health mandate is not equally distributed between the EU and its states. With the exception of a few areas, the EU lacks the authority to implement legally binding measures in the area of health. Despite not being legally binding, EU soft law exerts normative influence and holds significant power. The EU primarily passes soft legislation that its members may choose to implement [25]. The legal foundation provided by Article 168 TFEU does not permit binding harmonized national laws across the EU to prevent NCDs. Several non-binding policies to prevent NCDs were published since Article 168 TFEU which gives the EU the opportunity to produce non-binding, supportive actions and mandates in the field of health. The member states bear main accountability for health protection and other healthcare system responsibilities (Article 168). [26-29]

However, as previously mentioned the EU manages to regulate health by regulating different legal areas as monetary legislation, common market regulations, etc. [23]. For example Article 114, which addresses the internal market's harmonization, is crucial to the control of public health. Article 114 (3) was used as the foundation for legislation of the tobacco directive or the regulation on the provision of food information to consumers [30, 31]. One of the EU tools to prevent DM is through supporting and funding research to minimize the burden of DM—for example, by assisting the construction of comparable datasets for the identification and adoption of effective health policy measures. The most important tool for gathering health data

is the European Health Interview Survey (EHIS). It makes data comparison between the member states easier by providing information on the health status, health determinants, and healthcare services [32]. These similar data enable stakeholders to measure the burden of NCDs including DM and investigate their potential risk factors.

Another tool that is used by the EU to prevent DM is the regulation of food information to consumers (FIC) which according to the standards outlined in Articles 30-34 of the regulation, all prepackaged foods currently available on the EU market must have a nutrition declaration [33]. This strategy focuses on tackling food and nutrition related risk factors associated with NCDs including DM. Articles 32 and 33 state that the nutrition declaration must be presented in a certain format. Article 35 of the FIC, permits the voluntary inclusion of further repetitions of the energy value and/or the number of nutrients in various expressions and/or in the form of visuals or symbols to be placed in the front of the label. However, consumers should not be misled by such front-of-pack nutrition labeling (FOPL), which should instead be based on scientific findings.

The EC adopted a report in May 2020 to evaluate the effects of FOPL schemes and came to the conclusion that the EU needed a standardized and obligatory FOPL system [34]. The use of color-coding, with or without a graded indicator, seems to be most promising for enhancing the nutritional quality of food options, according to the EC report, although the ideal option has not yet been determined [34, 35]. The EU's Farm to Fork strategy (draft action plan) aims to make food systems equitable, healthy, and environmentally sustainable, empowering consumers to remain informed, stay healthy, and make sustainable food choices. The EC has announced a proposal to harmonize mandatory FOPL within this framework. By the end of 2023, the EC proposal will be expected [36].

2. Literature review

DM is a growing public health concern in the EU. The burden of DM is substantial in the EU, making it one of the most common NCDs [37]. A study based on the KORA survey, conducted in the Augsburg region in Germany, found that approximately 40% of individuals between the ages of 55 and 74 exhibited impaired glucose tolerance or were diagnosed with DM. Moreover, the study revealed that half of the total cases of DM identified in this population were previously undiagnosed [38]. In 2010, Germany was among top 10 countries with the highest DM prevalence in the world with 7.5% [11]. Certain EU countries, like Slovakia, have reported specific challenges in DM management. Slovakia faces a higher prevalence of DM compared to the EU average [39]. In a recent systematic review by Andrade et al. in 2023, which examined the burden of DM in the EU, the review included studies from 12 member states only. It found the highest number of articles on the burden of DM was in the UK, followed by Germany. Moreover, the year 2002 had the highest number of studies carried out. However, it concluded that the number of studies was not sufficient to have a clear overview of DM burden in the EU [40].

DM prevalence in the EU is closely associated with lifestyle factors. Research suggests a strong correlation between high body mass index (BMI), low physical activity, and inadequate fruit and vegetable consumption with DM risk. Promoting healthier eating habits, regular physical activity, and weight management are key strategies in reducing DM prevalence in the EU [41]. A study was carried out using EHIS 2014 confirmed the association between lifestyle and socioeconomic variables with DM prevalence in Europe, which resulted in the association of DM with poor self-perceived general health. The study concluded that effective prevention of DM requires major public health programs that incorporate patients' perspectives, and changes of lifestyles and socioeconomic status [42].

Recent studies have been instrumental in assessing the effectiveness of EU policies and country-specific efforts in tackling DM and NCDs within the EU. Chrissini.M and colleagues conducted a literature review to evaluate policies related to childhood obesity in Greece, describing, for example, the EU Action Plan on Childhood Obesity (2014), which has made progress in reducing childhood obesity - a major risk factor for DM and NCDs - through sugar reduction campaigns, school interventions and better food labelling, leading to a reduction in childhood obesity rates in different EU member states [43]. The EAT-Lancet Commission on Food, Planet, Health (2019) emphasized the importance of sustainable food systems to promote healthy diets and prevent NCDs, including DM. The Commission's report found that a global shift to a healthy diet, which is also sustainable and affordable, is necessary and European governments should invest in sustainable agriculture and promote the consumption of healthy foods, and discourage the consumption of unhealthy foods [44]. In another example, the HEPAHEALTH project, which examined physical activity policies in Europe, underlined the role of exercise in preventing diabetes and NCDs and emphasized the need for comprehensive policies to promote physical activity [45]. A SWOT analysis was conducted in 2022 to assess policies and programs addressing DM in the frame of the European Joint Action on Chronic Diseases and Promoting Healthy Ageing across the Life Cycle (JA-CHRODIS) which found that most policies are medical centered and focused on one disease and NCD action plan that is clear with guiding steps is needed to reach the goals. The study also found that there is not much attention is giving to women [46].

Social media platforms like Twitter are increasingly being used to advocate for public health policies in the EU. Advocacy and information-sharing on social media play a critical role in raising awareness and mobilizing support for EU policies to combat DM [47].

2.1 Objectives

The following objectives were set according to the four topics of the dissertation

1. Identification of available EU legislations that include DM, obesity and NCDs to gain a comprehensive representation of the EU's legal system in this area.
2. Content analysis of legislations focusing on DM, obesity and NCDs including their assessment according to DM specific guidelines, target groups and functional categories.
- 3- Examination of the impact of nutritional and physical activity policies, national DM plans and national DM registries on prevalence of DM in the EU member states.
- 4- Examination of the association between demographic and socioeconomic status as well as the lifestyle choices, taking into account available nutritional and physical activity policies, national DM plans and national DM registries.
- 5- Description of changes of DM prevalence in the adult population of Slovakia through the three EHIS waves.
- 6- Assessing the association between DM and socioeconomic and/or lifestyle characteristics through the three EHIS waves in Slovakia.
- 7-Evaluation of the public discourse on FOPL in the EU via Twitter by analyzing tweet content, sentiment, and mapping network characteristics.

3. Methodology

3.1 How the European Union legislations are tackling the burden of diabetes mellitus: a legal surveillance study

The research was carried out in two sections: identification of EU legislations and analysis of their text, which includes evaluation in accordance with DM specific guidelines, target groups, and functional categories.

3.1.1. Identification of EU legislations

By using the EUR-Lex database [48], two researchers (Nour Mahrouseh and Anggi Septia Irawan) conducted a systematic search to find and evaluate relevant laws. Currently, the term “legislation” is used to refer to a wide range of soft laws, legal acts, and treaties. The search was expanded to include obesity and NCDs as well, due to the significant connection between the laws of DM prevention and the ones for obesity and NCDs. The search was divided into two stages, the first concentrating on DM and the other on obesity and NCDs. The search was conducted in English with no time restriction, using the terms “obes* OR: non-communicable illnesses” and “diabet*” in the title or text.

Treaties, legal actions, consolidated texts, international agreements, preparatory documents, and documents from the European Free Trade Association (EFTA) were exclusively extracted; description of the above mentioned legislations are available in the Appendix 1.

Between October 2021 and January 2022, the screening procedure was carried out by Nour Mahrouseh and Anggi Septia Irawan. A manual screening of the legislations' relevance was assessed after duplicates were removed (using an excel spreadsheet); the first step of the selection was based on titles, and the second phase was based on full-text. Figure 1 displays the screening process.

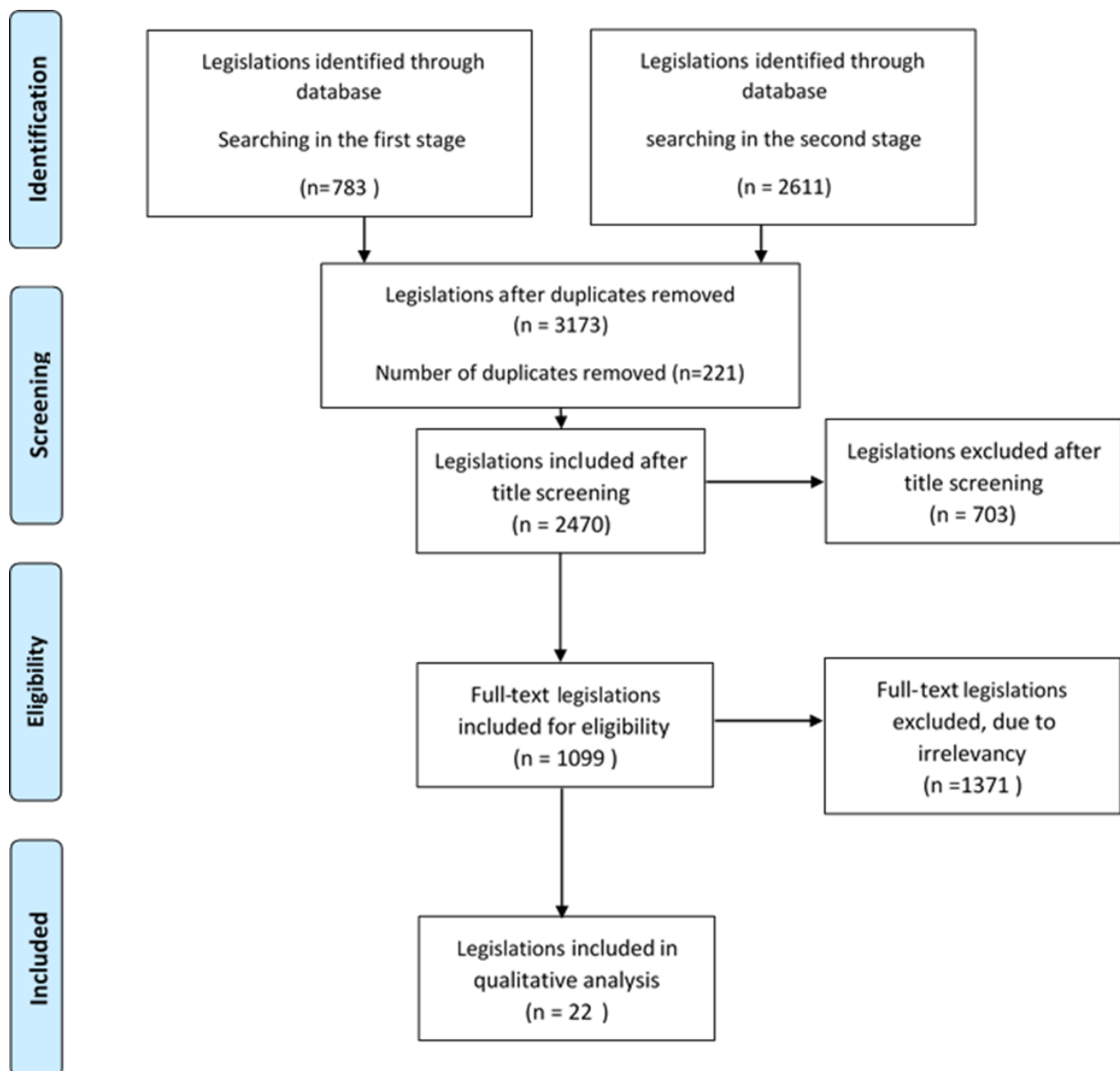


Figure 1. Screening procedure of EU legislations collected from EUR-Lex database

As part of the EU's approach of health in all policies, legislations have been categorized as either direct or indirect. Direct legislations specifically target DM, NCDs, or obesity prevention in their text. All recognized legislations were categorized according to their EuroVoc terms and authorship. EuroVoc terms are developed for documenting information which are produced by EU institutions. EuroVoc terms are a multilingual vocabulary list that includes many topics and domains that cover the EU's activities. It allows the creation of semantic

networks between concepts and the conducting systematic search for the legal documents. EuroVoc consist of 21 domains and a large number of subdomains [49].

3.1.2 Content analysis

Only legislations that were expressly adopted to prevent DM, NCDs, or obesity directly were examined for content analysis. MonQcle, a platform for analyzing legal text documents, was used to study the content of the identified documents [50]. Each document was added as a record to the MonQcle database and independently coded by two coders (Nour Mahrouseh and Anggi Septia Irawan). A list of themes on which each of legislation should be categorized was established following the preliminary reviewing the legislations. This initial worklist of themes discussing the objectives and strategies partly resulted from “Toward an EU Strategic Framework for the Prevention of NCDs”, a joint publication by the European Public Health Alliance (EPHA) [51] and the WHO “Global Report on Diabetes” [12].

The original themes from the guidelines were revised repeatedly, and new themes were added. With each change, the legislations were reviewed over to confirm that all existing data were coded. Themes included several forms of enforcement, including binding as regulations, non-binding as white papers, and conditionally binding as decisions. In order to better understand the themes, legislations were coded also based on target populations in accordance with the modified classification of Timpel et al [52]. Functional categories were employed to address risk factors of DM, NCDs, and obesity used by Abiola, S.E et al. [53]. Based on the primary data retrieved from Eur-Lex, the validity of the documents (where relevant) and legislator/author are recorded. The final list of themes, target population and functional categories are available in Appendix 2.

3.1.3 Statistical analysis and internal validity

Descriptive analysis was used to present the frequency of legislations by themes, target populations, and functional categories. The following programs were used to carry out the

analyses' visualization: a cluster network analysis was created using Gephi 0.9.5 and a heatmap was produced using TIBCO Cloud Spotfire analyst.

Two independent reviewers (Nour Mahrouseh and Anggi Septia Irawan) conducted a systematic evaluation of each legislation on similarity of coding as part of the quality appraisal (internal validity). Conflicts were resolved through open dialogue and the participation of an impartial reviewer (Orsolya Varga). Inter-rater reliability for each legislation was evaluated using Cohen's kappa (k) inter-rater reliability test.

3.2 Impact of policies in nutrition and physical activity on diabetes and its risk factors in the 28 member states of the European Union

3.2.1 Data sources

Four sources are used to gather the dataset: The World Cancer Research Fund International (WCRF International) “NOURISHING” and “MOVING” policy databases [54], the European Coalition for Diabetes report “Diabetes in Europe policy puzzle: the state we are in” [55], and the 2014 European Health Interview Survey (EHIS).

3.2.2 Policies, national plans and national DM registries

Policies that focus on good nutrition and physical activity were extracted from the “NOURISHING” and “MOVING” policy databases. These policies were gathered by the WCRF International [56]. Every policy listed in the databases has been examined and verified by professionals from national governments. Different legislative tools aimed at promoting healthy eating or physical activity were considered policies in this context.

Policy categories, policy areas, and sub-policy areas are the three levels at which policies are categorized; policy categories and policy areas are shown in Table 2 and Table 3.

For more information on list of policy categories, policy areas and sub-policy areas, see Appendix3. Policies that were in effect in 2014 that partially or exclusively targeted adult populations in the 28 EU member states were extracted for analysis.

National DM plans, which included governmental plans on preventive treatment strategies that target DM exclusively or as part of a plan for NCDs, were introduced in many EU countries to combat the rise in DM prevalence over the past few decades.

National DM registries are databases that allow the tracking and monitoring of the clinical progress of individuals with T1DM and/or T2DM and based on these data targeted preventive strategies could be implemented. Databases that exclude T2DM were not taken into account when conducting the analysis. The 4th edition of “Diabetes in Europe policy puzzle: the state we are in” contains information on national DM plans and national DM registries that were in effect in 2014; which to acquire the most reliable data regarding each nation's profile in managing DM, established on a uniform inquiry form that was issued to and gathered data from experts and government officials [55].

DM Burden		Nutritional policies										
		Categories										
		Food Environment					Food System		Behaviour Change Communication			
		Policy Areas										
Member States of the European Union	Prevalence %	95% CI	Nutrition label standards and regulations on the use of claims and implied claims on food	Offer healthy food and set standards in public institutions and other specific settings	Use economic tools to address food affordability and purchase incentives	Restrict food advertising and other forms of commercial promotion	Improve nutritional quality of the whole food supply	Set incentives and rules to create a healthy retail and food service environment	Harness supply chain and actions across sectors to ensure coherence with health	Inform people about food and nutrition through public awareness	Nutrition advice and counselling in healthcare settings	Give nutrition education and skills
France	9.98	(9.45-10.54)	2	0	1	1	1	0	0	3	0	0
Portugal	9.33	(8.76-9.93)	2	0	0	0	1	0	0	1	0	0
Greece	9.24	(8.56-9.97)	2	0	0	0	1	0	0	1	0	0
Malta	8.25	(7.49-9.09)	2	0	0	0	0	0	0	0	0	0
Hungary	8.06	(7.37-8.81)	1	0	1	0	3	0	0	1	0	0
Finland	7.73	(7.07-8.44)	3	1	0	0	0	0	1	1	0	0
Czech Republic	7.67	(7.06-8.32)	3	0	0	0	1	0	0	0	0	0
Germany	7.17	(6.80-7.56)	2	1	0	0	0	0	0	1	1	0
Croatia	7.13	(6.47-7.86)	2	0	0	0	1	0	0	1	0	0
Slovakia	6.86	(6.25-7.53)	2	0	0	0	0	0	0	0	0	0
Slovenia	6.85	(6.21-7.56)	3	0	0	0	0	0	0	1	0	0
Spain	6.83	(6.47-7.22)	2	0	0	0	1	0	0	1	1	0
Italy	6.66	(6.34-6.98)	2	0	0	0	1	0	0	0	0	0
Poland	6.64	(6.30-6.98)	3	0	0	0	0	0	0	1	0	0
Bulgaria	6.37	(5.81-6.98)	2	0	0	0	1	0	0	1	0	0
Cyprus	6.06	(5.45-6.73)	2	0	0	0	0	0	0	1	0	0
United Kingdom	5.8	(5.47-6.14)	6	2	0	0	2	2	2	2	3	0
Luxembourg	5.57	(4.90-6.33)	2	0	0	0	0	0	0	0	0	0
Estonia	5.49	(4.91-6.14)	2	0	0	0	0	0	0	1	0	0
Netherlands	5.38	(4.90-5.91)	3	0	0	0	2	0	0	1	0	0
Belgium	5.34	(4.73-6.01)	3	0	0	1	1	0	0	0	0	0
Austria	4.93	(4.48-5.42)	2	0	0	0	2	0	0	1	0	0
Romania	4.79	(4.44-5.15)	2	0	0	0	0	0	0	1	0	0
Sweden	4.75	(4.21-5.37)	3	0	0	0	0	0	0	0	0	0
Latvia	4.66	(4.21-5.16)	1	1	1	0	0	0	0	1	0	0
Ireland	4.63	(4.22-5.08)	1	0	0	0	1	0	0	0	0	0
Denmark	4.62	(4.14-5.15)	4	0	0	0	1	0	0	1	0	0
Lithuania	4.41	(3.92-4.97)	2	0	0	0	0	0	0	0	0	0

Table 2. Number of implemented nutritional policies and national DM plans in effect in the EU member states, 2014 based on policies from the NOURISHING dataset, national DM plans from 4th edition of “Diabetes in Europe policy puzzle: the state we are in” and prevalence of DM from EHIS 2014.

Legend: DM: Diabetes mellitus. CI: Confidence interval.

Member States of the European Union	DM Burden		Physical activity policies					
			Categories					
	Prevalence % 95% CI		Active Societies		Active Environments		Active People	
			Policy Areas					
			Make opportunities and initiatives that promote physical activity in schools, the community and sport and recreation	Offer physical activity opportunities in the workplace and training in physical activity promotion across multiple professions	Visualise and enact structures and surroundings which promote physical activity	Implement transport infrastructure and opportunities that support active societies	Normalise and increase physical activity through public communication that motivates and builds behaviour change skills	Give physical activity training, assessment and counselling in healthcare settings
France	9.98	(9.45-10.54)	0	2	3	1	1	0
Portugal	9.33	(8.76-9.93)	3	1	2	1	0	0
Greece	9.24	(8.56-9.97)	0	0	0	0	0	0
Malta	8.25	(7.49-9.09)	0	0	0	0	0	0
Hungary	8.06	(7.37-8.81)	0	0	0	0	0	0
Finland	7.73	(7.07-8.44)	0	0	0	0	0	0
Czech Republic	7.67	(7.06-8.32)	0	0	0	0	0	0
Germany	7.17	(6.80-7.56)	1	1	2	5	0	0
Croatia	7.13	(6.47-7.86)	0	0	0	0	0	0
Slovakia	6.86	(6.25-7.53)	0	0	0	0	0	0
Slovenia	6.85	(6.21-7.56)	0	0	0	0	0	0
Spain	6.83	(6.47-7.22)	0	2	1	0	4	1
Italy	6.66	(6.34-6.98)	1	0	0	0	1	0
Poland	6.64	(6.30-6.98)	2	0	0	0	1	0
Bulgaria	6.37	(5.81-6.98)	0	0	0	0	0	0
Cyprus	6.06	(5.45-6.73)	0	0	0	0	0	0
United Kingdom	5.8	(5.47-6.14)	2	1	2	3	3	4
Luxembourg	5.57	(4.90-6.33)	0	0	0	0	0	0
Estonia	5.49	(4.91-6.14)	0	0	0	0	0	0
Netherlands	5.38	(4.90-5.91)	1	0	1	1	0	1
Belgium	5.34	(4.73-6.01)	0	0	0	0	0	0
Austria	4.93	(4.48-5.42)	0	0	0	0	0	0
Romania	4.79	(4.44-5.15)	0	0	0	0	0	0
Sweden	4.75	(4.21-5.37)	0	0	0	0	0	0
Latvia	4.66	(4.21-5.16)	1	0	1	0	0	0
Ireland	4.63	(4.22-5.08)	0	0	0	0	0	0
Denmark	4.62	(4.14-5.15)	0	0	0	0	0	0
Lithuania	4.41	(3.92-4.97)	0	0	0	0	0	0

Table 3. Number of implemented physical activity policies and national DM registries in operation in the EU member states, 2014 based on policies from the MOVING dataset, national DM registries from 4th edition of “Diabetes in Europe policy puzzle: the state we are in” and prevalence of DM from EHIS 2014.

Legend: DM: Diabetes mellitus. CI: Confidence interval.

3.2.3 Study sample

Data was collected for 28 member states of the EU, including the United Kingdom (UK), from Eurostat's 2014 EHIS. EHIS is a crucial component of the EC's tools, gathered every five years in the area of health and wellbeing, and collects data of participants above the age of 14 and residing in private households; providing similar data between countries on health status, health care, and health factors [57-59].

The dataset included (304,168) observations. Based on a self-reported response to the following question: "Have you had diabetes during the past 12 months?" Individuals that responded "Yes" were considered as having DM. Appendix 4, contains the list of the used variables and their definitions.

3.2.4 Statistical analysis

The distributions of the variables for respondents with and without DM were described and compared. The DM prevalence in 2014 was computed for each of the EU member states using sample weight.

Chi-square analysis was utilized to identify significant DM variables. Correlation between the prevalence of DM for the entire study population, stratified by age and sex, and the number of first-level policies of nutrition and physical activity, as well as the availability of national plans and/or registers in each state, were calculated using point-biserial correlation analysis. Point-biserial correlation coefficient, ranges from -1 to +1, measures the strength of correlation; -1 denotes a negative association, +1 denotes a positive association, and 0 denotes no association [60]. A multi-level logistic regression model for DM as the dependent variable was used to account for the data's hierarchical structure while controlling for individual and national-level covariates.

Country (place of residence) was regarded as a level-2 factor. The main objective of multi-level logistic regression was to calculate the probability that an event will occur while accounting for data dependencies. STATA version 16.0® was used for all statistical analyses.

3.3 Diabetes mellitus and associated factors in Slovakia: results from the European Health Interview Survey 2009, 2014, and 2019

Microdata from Slovakia's EHIS from 2009 (n = 4972), 2014 (n = 5490), and 2019 (n = 5527) were used to conduct cross-sectional analyses. The microdata for the EHIS 2009 and 2014 and 2019 were collected from “Eurostat” and “The Statistical Office of the Slovak Republic”, respectively. The samples in the 3 waves are representative of the Slovakian population who live in private households and are at least 15 years old [32]. Questions that were asked in the 2009, 2014, and 2019 EHIS served as the basis for our study variables. People who answered yes to the question “Have you had diabetes during the past 12 months?” were included in the group with DM, which includes all forms of DM. Self-reported sociodemographic and lifestyle factors were examined as independent variables; a definition of each variable as it emerged from the survey is provided in Appendix 5.

Variable distributions for respondents with and without DM were reported and compared. Descriptive statistics were conducted using proportions. Based on the study sample, the expected prevalence of DM for each year was calculated. Chi-square test was used to conduct bivariate comparisons and examine the relationship between the study variables and DM. A multivariable unconditional logistic regression model was used, incorporating variables from the bivariate analysis that were statistically significant and variables from the epidemiological perspective that were not statistically significant but nonetheless of interest. The odds ratios (ORs) represent the regression results, along with a 95% confidence interval (CIs). For analysis, we analyzed each of the three datasets independently. The database contained

sampling weights, and Stata's svy function was used to maintain the EHIS survey weight and was used only in the multilevel analysis.

3.4 Analysis of content, social networks, and sentiment of Front-of-pack nutrition labeling in the European Union on Twitter

3.4.1 Study settings

Data was collected via Twitter using “Twitter's application programming interface (API)” between November and December of 2021. Both tweets and retweets were included in the data set. This covered tweets posted in EU member states as well as the UK, since the UK was a member of the EU. No time or language filter was used. The search terms are available in the Appendix 6.

3.4.2 Data collection

In order to obtain the data from Twitter, Twitter API V2.0 was used to conduct a systematic archive search [61]. The data were gathered using keywords associated with the EU FOPL and the names of all EU countries from the time Twitter was founded, until 1st of December 2021. The relevant data, including user ID, user description, tweet text, location, date, Retweet, Reply-to, tweets-ID, and user type, were extracted and imported into Microsoft Excel 365. The translation to English was necessary via Google Translate since the tweets were written in eight different languages: English, Spanish, French, German, Czech, Croatian, Italian, and Dutch. Following the development of the coding, manual and training of six coders was conducted, 10% of the Twitter dataset was tested using the detailed guidelines and definitions made accessible to the study team (available in Appendix 7). The tweets were manually classified into the following categories: relevance, announcement, opinion, science, and EU legislation/policy in accordance with the study's research questions. If a tweet contained any information about food labeling, it was categorized as relevant. If a person offered an opinion

on a subject connected to FOPL systems in the EU, that opinion was categorized under the opinion category. If a tweet contained only a declaration or factual statement regarding FOPL, it was categorized as an announcement. If the tweet was based on or connected to science, it was given categorized under the scientific category. If the tweet addressed FOPL EU policies and included any commentary on EU FOPL regulation, it was taken into account as EU legislation/policy. One or more categories could apply to a tweet.

A third party moderator (Orsolya Varga) who was not part of the coding process supervised a public discussion to settle disagreements. The six investigators then categorized the remaining tweets independently. Intra-class correlation coefficient and Cronbach's alpha correlation coefficient were determined for 10% of the total number of tweets in order to evaluate the internal consistency and inter-rater reliability of the classification for tweets classified by six raters using SPSS 23.

Then, using QSR NVivo, automatic coding of the relevant tweets was conducted. Automatic coding was used in order to understand and develop the process related to FOPL. Two researchers (Anggi Septia Irawan and Orsolya Varga) collaborated during the content analysis using a combination of inductive and deductive approaches in the production of codes after analyzing the automatically generated codes [62]. Themes and subthemes were manually created from the scripts, and this framework served as the basis for the study.

Discussions or dialogues were identified and examined independently. Two coders (Anggi Septia Irawan and Diana Wangeshi Njuguna) classified around 20% of the total sample of dialogues, with the assistance of an outside investigator (Orsolya Varga) for the themes already described.

3.4.3 Sentiment Analysis

Natural language processing is used in the sentiment analysis to extract and quantify affective and subjective information, which is then utilized to describe attitudes and emotions in texts.

Users' opinions were identified and divided into three categories: positive (very positive), neutral (moderately positive and negative), and negative (very negative). Using the NVivo software, sentiment analysis of relevant tweets was conducted [62]. The automatic sentiment analysis of NVivo software bases its findings on the expressions of sentiment found in the content.

3.4.4 Network analysis

Network analysis is an approach that is becoming more and more used which connects the original tweets with the retweets and reply tweets in order to provide information on the flow and relationship between tweets. By examining the relationships between the nodes that reflect the object of interest, using Gephi 9.2, an open source program, facilitates additional qualitative analysis. In the context of this study, a tweet and their edges, which reflect the ties such as the ties between the tweet and its retweet is used to illustrate one or more relationships related to the tweet.

The analysis aids in comprehension of how the conversation and interaction were represented on Twitter, which involved the usage of the primary tweet and conversation ID for this analysis [63]. Only the relevant tweets were included in the network analysis. A network analysis was also carried out for tweets with a similar conversation ID that were included in the conversations and chains of tweets (such as replies and retweets).

3.4.5 Geographic heat map

Geographic heatmaps show how information are localized based on their density. The country and city at the time the tweet was published are indicated by the Twitter data sheet geo location-ID. With the help of the map function in Microsoft Excel, a heat map was created.

4. Results

4.1 How the European Union legislations are tackling the burden of diabetes mellitus: a legal surveillance study

4.1.1 Description of the identified legislations

The data collection included 1099 relevant legislations related to DM, NCDs, and obesity, and of these 1099 laws, 22 were focused primarily on the direct prevention of DM, NCDs, and obesity. Only five legislations were designed to prevent DM. The identified legislations covered the time span from 1968 until 2022. 366 of these legislations are currently in effect. EuroVoc terms were available in 853 legislations. 853 different legislations contained a total of 6189 Eurovoc terms, of which 1486 were unique due to the fact that some terms were repeatedly used in several legislations. The distribution of EuroVoc terms is shown in Figure 2, and it demonstrates that the “social questions” domain, which includes the subdomains of “family”, “health”, “social framework”, “social affairs and protection”, “culture” ,“religion”, “construction”, and “town planning” is the most prevalent. “Public health”, however, was the subdomain with the most records. The distribution of EuroVoc phrases over time is represented in Figure 3, which demonstrates how the regulatory focus has evolved over time.

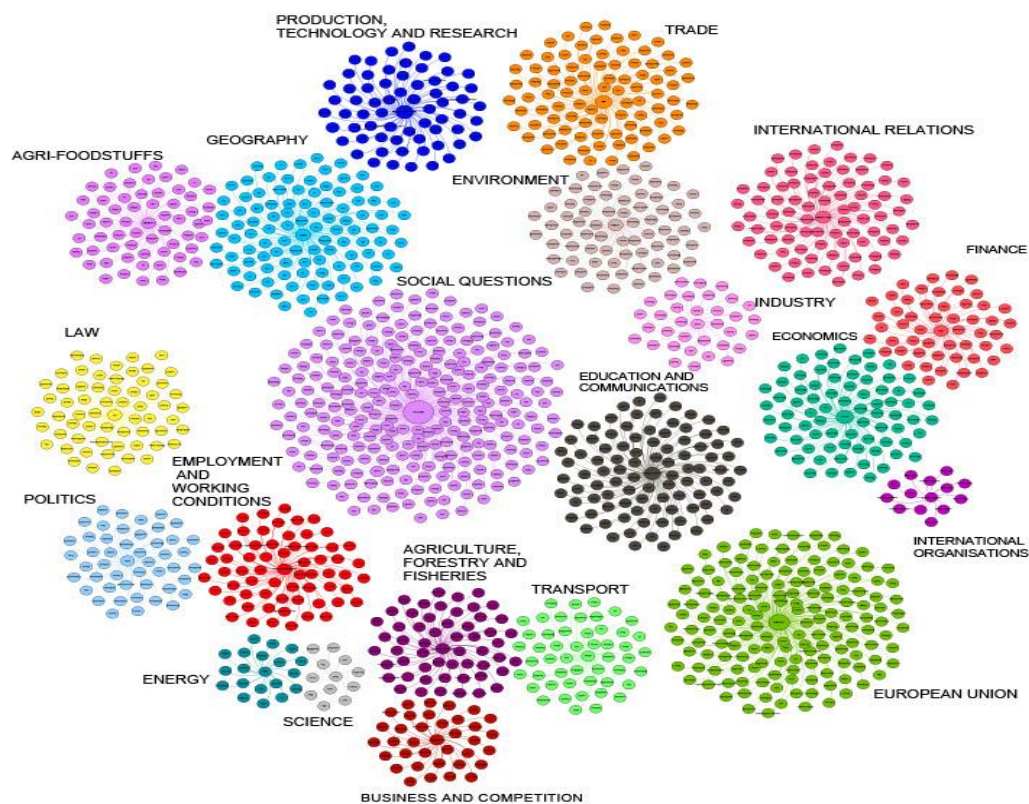


Figure 2. EuroVoc classifications and the cluster structure based on EuroVoc terms collected from included legislations through EUR-Lex database.

Legend: EuroVoc terms are presented in clusters using a network analysis. Each cluster represents a EuroVoc domain. Nodes in the center of the cluster are the domain, and subdomains are presented by each branch (edge). The size of the node presents the frequency of the term used by the legislations. High quality Figure 2 is available through the following link:

https://unidebhu-my.sharepoint.com/:b:/g/personal/nour_mahrouseh_med_unideb_hu/EbplxL9adURFiQwNA/GseTHEBtRzge7vHAit0e30Q-bzaMg?e=HAuJe6

Since 2005, there have been a substantial number of new legislations passed. The most popular subdomains in 2021 were varied and focused on areas related to “social questions” domain such as “epidemic”, “corona virus”, “disease prevention”, etc., in addition to other domains such as “economics” and the “European Union”. In 1973, the most popular subdomains focused on “trade” as “custom duties”, “trade agreements”, etc.. At the following link: <https://eu.spotfire-next.cloud.tibco.com/spotfire/wp/OpenAnalysis?file=4499a74c-a743-4844-bde1-81b018f81f96>, an interactive heatmap of the most frequently used EuroVoc terms over time can be which allows filtering by year, domains, or sub-domains.

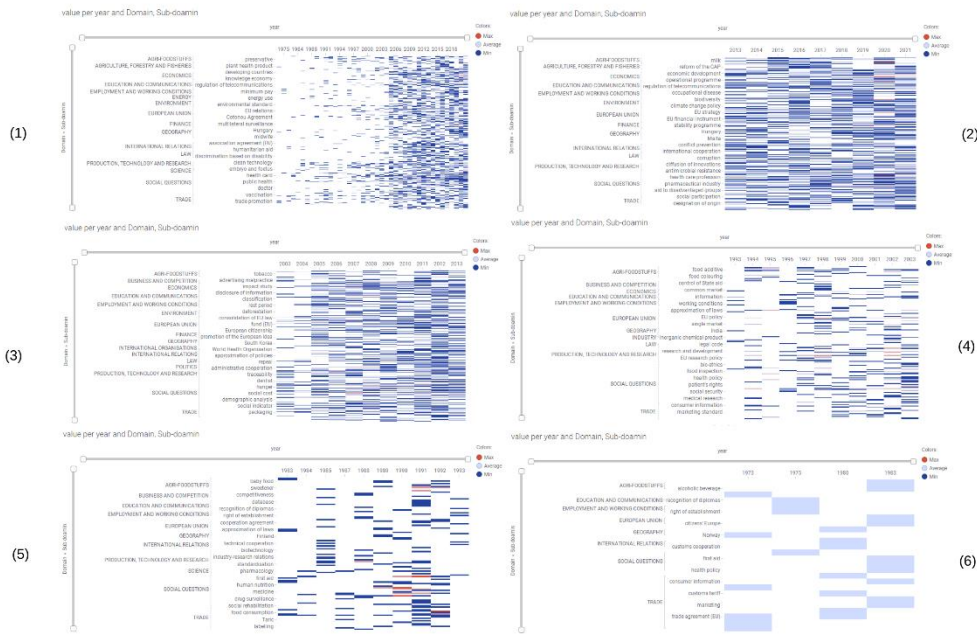


Figure 3. Interactive heatmap's snapshots of the EuroVoc terms that have been used most frequently over the years based on EuroVoc terms collected from included legislations through EUR-Lex database.

Legend: Snapshots of the interactive heatmap comprises domains and subdomains in the columns and years span in the rows. Users can filter the interactive heatmap by years, domains, and subdomains.

Figure 3.1 shows the heatmap for EuroVoc terms from 1973 to 2021. Figure 3.2 shows the heatmap for EuroVoc terms from 2013 to 2021. Figure 3.3 shows the heatmap for EuroVoc terms from 2003 to 2013. Figure 3.4 shows the heatmap for EuroVoc term 1993 to 2003. Figure 3.5 shows the heatmap for EuroVoc term from 1983 to 1993. Figure 3.6 shows the heatmap for EuroVoc term from 1973 to 1983. The number of EuroVoc terms is indicated by the colors.

The interactive heatmap is available at the following link: <https://eu.spotfire-next.cloud.tibco.com/spotfire/wp/OpenAnalysis?file=4499a74c-a743-4844-bde1-81b018f81f96>

4.1.2 Content analysis

There were 6 binding legislations (five regulations and one conditional binding decision) and 17 non-binding legislations that focused on DM, NCDs, or obesity prevention, as shown in Table 4. Appendix 8 includes the whole list of documents and their validity period.

The legislations authors were diverse, with one or more EU establishments were acknowledged as legislators. The EC has generated the majority of the documents with 13 legislations, available in Appendix 8.

Themes	Binding	Non-binding	Total
A life-course approach to preventing diabetes	2	18	20
Improving early childhood nutrition	1	11	12
Supportive environments for physical activity	0	11	11
Settings-based interventions	1	9	10
Fiscal, legislative and regulatory measures for healthy diet	2	12	14
Trade and agricultural policies that promote healthy diets	3	11	14
Regulation of marketing of foods high in sugars, fats and salt.	3	11	14
Education, social marketing and mobilization	2	12	14
Preventing diabetes in people at high risk	0	12	12
Implement the WHO 'Best buys'	2	11	13
Tackle health inequalities and Adopt a rights-based approach	0	4	4
Elaborate a pan-European system for data collection, policy evaluation and accountability	0	3	3
Ensure inter-institutional coordination on health and well-being and a policy home for health within the European Commission structure	0	5	5
Launch a 'Health in All Policies' online policy portal	0	0	0
Pursue 'EU flagship initiatives' in areas that can deliver co-benefits for NCD prevention and other SDGs	1	7	8

Table 4. Categorization of legislations collected using EUR-Lex according to the WHO global report on diabetes and EU strategic framework for the prevention of NCDs guidelines.

Legend: Each legislation may have been categorized under many categories during coding.

WHO: World Health Organization, NCDs: Non-communicable diseases. The WHO's "Global Report on Diabetes" [12] and the European Public Health Alliance's joint paper, "Towards an EU Strategic Framework for the Prevention of NCDs," are the sources of the variables listed in the first column [51].

4.1.3 Assessment of legislations according to the WHO Global Report on Diabetes and EU Strategic Framework for the Prevention of NCDs Guidelines

"A life-course approach to preventing diabetes" (n = 20), which frequently included non-binding legislations, was the most common classification type. "Elaborate a pan-European system for data collecting, policy evaluation and accountability" were the themes that received the least attention. All EU legislations did not address the "Launch a "Health in All Policies"

online policy portal”. There are no mandatory legislation available for the six themes. Food-related laws, such as “Trade and agricultural policies that promote healthy diets” (n = 3) and “Regulations of marketing of foods high in sugars, fats, and salt”, were the most common binding laws. See Table 4.

4.1.4 Assessment according to target groups and functional categories

The target groups varied depending on the legislations, with the majority of them focusing on the general population or communities, Table 5. Only a few non-binding legislations focused on pregnant women, organizations, or countries (governments).

Themes	Binding	Non-binding	Total
General	3	15	18
Children	1	12	13
Pregnant women		1	1
Organizations		6	6
Community	2	14	16
Countries		7	7

Table 5. Target populations are categorized by type of legislation according to the modified classification of Timpel et al

Legend: Each legislation may have been categorized under several categories during coding.

The functional categories employed in legislations extensively included the topic of energy intake for example, Table 6. In our dataset, DM, NCDs, and obesity were targeted directly through the application of energy intake mechanisms that included food labeling and the provision of nutritious food. Energy expenditure legislations that regulated physical activities

such as community running programs or building essential infrastructure. Information legislations offer strategies for promoting health, education, research, and innovation. EU strategies included screen and treatment legislations related to detection, early diagnosis, and treatment, and enhancing patients' quality of life. Only in the areas of energy expenditure and screening and treatment are non-binding legislations only.

Themes	Binding	Non-binding	Total
Energy intake	3	16	19
Energy expenditure		13	13
Information	2	11	13
Screening and treatment		9	9

Table 6. Functional categories according to the type of legislation were employed to address risk factors of DM, NCDs, and obesity used by Abiola, S.E et al.

Legend: Each legislation may have been categorized under several categories during coding.

4.1.5 Internal validity

The degree of agreement or disagreement between the two raters was used to determine how similar the main themes were coded. Cohen's kappa analysis of the themes derived from WHO Global Report on Diabetes and the EU Strategic Framework for the Prevention of NCDs, and functional categories had excellent agreement of 0.805 and almost perfect agreement of 0.945 consequently between the two coders (NM, ASI); the level of agreement for the target group was interpreted as substantial agreement (0.788).

4.2 Impact of policies in nutrition and physical activity on diabetes and its risk factors in the 28 member states of the European Union

4.2.1 Overview of the study population

The distribution of the study sample by numbers and relative frequencies, comparing respondents with and without DM, is shown in Table 7. According to the results of the chi-square test, there are significant relations between the study variables sex, age, educational level, employment status, net monthly equalized income of the household the respondent belongs to, BMI, and frequency of fruit and vegetable consumption and the prevalence of DM. 22,566 participants were reported to have DM. In the EU, DM prevalence was predicted to be (6.94%, 6.82-7.06%) in 2014. The highest values were reported by Portugal (9.33%, 8.76–9.93%), Greece (9.24%, 8.56–9.97%), and France (9.98%, 9.45–10.54%). Lithuania had the lowest prevalence percentage at (4.41%, 3.92-4.97%), followed by Denmark at (4.62%, 4.14-5.15%), and Ireland at (4.63%, 4.22–5.08%).

Variable	Nondiabetic N(%)	Diabetic N(%)	p-value
Sex			
Male	125,981(42.05%)	10,782(3.6%)	
Female	151,068(50.42%)	11,784(3.93%)	<0.001
Age			
15-44	115,822(38.66%)	1,430(0.48%)	
45-64	96,805(32.31%)	7,506(2.51%)	
65 and above	64,422(21.5%)	13,630(4.55%)	<0.001
Degree of urbanization			
Cities	97,386(32.54%)	7,902(2.64%)	
Towns and suburbs	82,304(27.5%)	6,652(2.22%)	
Rural areas	97,042(32.43%)	7,995(2.67%)	0.488
Educational attainment			
Primary/less than primary education	87,937(29.58%)	11,734(3.95%)	
Secondary education	134,882(45.37%)	8,441(2.84%)	
Higher education	52,130(17.53%)	2,176(0.73%)	<0.001
Labour status			
Employed	135,716(45.54%)	4,378(1.47%)	
Unemployed	19,134(6.42%)	899(0.3%)	
Other	120,725(40.51%)	17,169(5.76%)	<0.001
Net monthly equalized income of the household			
Between 1st quintile and 2nd quintile	99,920(35.78%)	10,075(3.61%)	
Between 2nd quintile and 4th quintile	104,990(37.6%)	8,320(2.98%)	
Between 4th quintile and 5th Quintile	53,161(19.04%)	2,758(0.99%)	<0.001
BMI (kg/m ²)			
<25	129,699(45.25%)	4,723(1.65%)	
25-29.9	96,098(33.52%)	8,721(3.04%)	
≥30	39,362(13.73%)	8,056(2.81%)	<0.001
Frequency of eating fruits			
One and more per day	149,727(51.2%)	14,049(4.8%)	
1 to 6 times a week	100,480(34.36%)	6,660(2.28%)	
Less than once a week and never	20,120(6.88%)	1,386(0.47%)	<0.001
Frequency of eating vegetables			
One and more per day	136,385(46.66%)	11,793(4.03%)	
1 to 6 times a week	123,066(42.1%)	9,353(3.2%)	
Less than once a week and never	10,812(3.7%)	917(0.31%)	<0.001

Table 7. The distribution of demographic, socioeconomic and lifestyle characteristics of the study population based on EHIS 2014 based on DM status.

Legend: BMI body mass index (kg/m²)

4.2.2 Overview of nutrition and physical activity policies, national DM plans and national DM registries in the EU member states

Tables 2 and 3 show the existence of nutrition and physical activity policies, national DM programs, and DM registries in addition to the prevalence of DM and its 95% confidence interval in the 28 EU member states in 2014.

According to the WCRF International database, the United Kingdom (34) had the highest number of implemented policies, while Malta (2), Slovakia (2), Luxembourg (2), and Lithuania (2) had the lowest number of implemented policies during that year. The only policy that was introduced in all 28 member states on “nutrition label standards and regulations on the use of claims and implied claims on food”.

The least frequently used policies were those that provide addressing “Set incentives and rules to create a healthy retail and food service environment” and “Give nutrition education and skills”. In 2014, the latter was not made available in any member state.

Seven of the 28 member states operated a national DM registries, while 17 of the 28 member states had an active national DM strategy in 2014.

4.2.3 Individual level correlation between national policies, DM plans and registries and DM prevalence

Results of point-biserial is presented in Table 8. The prevalence of DM was positively correlated with “Food environment” and “Food system” policies, according to the findings of point-biserial correlation analyses. These findings were significant for the general population, men, and the age ranges of 15 to 44 and 45 to 64. “Food environment” policies and “Food systems” policies for people 65 and above showed a weak significant negative correlation with DM.

All sex and age groups, with the exception of those 65 and above, exhibited a weak negative significant link with DM. “Behavior change communication” policies had a positive weak correlation with the prevalence of DM.

In our total population and its sex and age subgroups, “Active society” policies had only a marginally significant negative correlation with the prevalence of DM.

In our total sample, including males and the age ranges of 15–44 and 45–64, there was a weak positive correlation between a higher number of “Active environment” policies and DM that was statistically significant. In the total population, the male group, and the age range of 15 to 44, higher number of “Active people” policies showed a weak positive correlation with DM. A significant negative association between the age group of 65 and older and “Active people” policies was also found. According to Table 8, an increase in national DM plans and registries had a negative correlation with the total population, women, and the age groups of 15–44 and 45–64.

	Food environment	Food system	Behaviour change communication	Active society	Active environment	Active people	National DM policies and registries
Total							
coefficients	0.009	0.009	0.017	0.035	0.018	0.011	-0.003
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.110
Females							
coefficients	-0.003	-0.004	0.007	0.032	0.004	0.002	-0.006
p-value	0.265	0.119	0.006	<0.001	0.116	0.375	0.021
Males							
coefficients	0.022	0.024	0.029	0.038	0.034	0.021	<0.001
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.946
Age between 15-44							
coefficients	0.023	0.008	0.035	0.017	0.028	0.006	-0.026
p-value	<0.001	0.006	<0.001	<0.001	<0.001	0.046	<0.001
Age between 45-64							
coefficients	0.008	0.005	0.015	0.029	0.014	0.002	-0.002
p-value	0.014	0.146	<0.001	<0.001	<0.001	0.433	0.577
Age 65 and above							
coefficients	-0.027	-0.025	-0.014	0.027	0.006	-0.015	0.006
p-value	<0.001	0.000	<0.001	<0.001	0.094	<0.001	0.104

Table 8. Point biserial correlation coefficient between policy type based on policies from the NOURISHING and MOVING dataset, national DM plans and national DM registries from 4th edition of “Diabetes in Europe policy puzzle: the state we are in” and prevalence of DM of EHIS 2014 in the total population, stratified by sex and age categories.

Legend: DM: Diabetes mellitus. P-value < 0.05 indicates a significant association between prevalence of DM and the total population, sex and age categories.

4.2.4 Country level correlation between national policies, DM plans and registries and DM prevalence

The multilevel logistic regression analysis model included variables of epidemiological relevance and were significant in the study's bivariate analysis. Table 9 reports the results of the multilevel logistic regression and the intra-class correlation coefficient.

The variation attributed to countries as a grouping factor for DM was minimal (ICC: 1.3%) after adjusting for individual variables. The observed variation in DM prevalence between countries was caused by demographic, socioeconomic, and lifestyle factors rather than by variations in the availability of preventive policies. The risk of having DM was not significantly correlated with any of the policy types. The multilevel analysis' findings revealed that females,

less urbanized environments (suburban and rural), higher levels of education (secondary and tertiary), middle and lower household income (between quintiles 2 and 4 and between quintiles 4 and 5), and fruit consumption 1-6 times a week significantly influenced the prevalence of the disease, with lower odds of being effected compared to their reference group.

Contrary to participants in the older age groups (45–64 and 65 and above), higher BMI ranges (25–29.9 and 30) and labor status (unemployed and others) significantly increased the likelihood of disease prevalence in comparison to their comparable reference group. Contrary to participants in the older age groups (45–64 and 65 and older), higher BMI ranges (25–29.9 and 30) and labor status (unemployed and others) significantly increased the likelihood of DM prevalence in comparison to their comparable reference group.

Variable	Odds Ratio	95% Confidence Interval	p value
ICC		0.013	
Food environment	0.98	(0.91-1.06)	0.688
Food system	1.06	(0.75-1.49)	0.753
Behaviour change communication	1.11	(0.94-1.31)	0.224
Active society	1.04	(0.93-1.17)	0.52
Active environment	1.00	(0.92-1.09)	0.96
Active people	0.93	(0.84-1.02)	0.133
National DM policies and registries	0.98	(0.86-1.11)	0.705
Sex (ref: Males)			
Females	0.77	(0.75-0.80)	<0.001
Age groups(ref: Age group 15-44)			
45-64	4.95	(4.65-5.27)	<0.001
65 and above	8.74	(8.17-9.34)	<0.001
Degree of urbanization(ref: Cities)			
Town and suburbs	0.91	(0.87-0.94)	<0.001
Rural areas	0.85	(0.82-0.88)	<0.001
Educational attainment (ref: Primary/less than primary education)			
Secondary education	0.76	(0.73-0.79)	<0.001
High education	0.65	(0.62-0.69)	<0.001
Labour status(ref: employed)			
Unemployed	1.32	(1.22-1.43)	<0.001
Others	1.91	(1.82-2.00)	<0.001
Net monthly equalized income of the household(ref: between 1st quintile and 2nd quintile)			
Between 2nd quintile and 4th quintile	0.90	(0.87-0.94)	<0.001
Between 4th quintile and 5th quintile	0.78	(0.74-0.82)	<0.001
BMI (kg/m ²)(Ref: <25)			
25-29.9	1.74	(1.67-1.81)	<0.001
≥30	3.76	(3.61-3.92)	<0.001
Frequency of eating fruits (ref: one and more per day)			
1 to 6 times a week	0.90	(0.87-0.94)	<0.001
Less than once a week and never	0.93	(0.87-1.00)	0.051
Frequency of eating vegetables(ref: one and more per day)			
1 to 6 times a week	0.99	(0.96-1.03)	0.606
Less than once a week and never	1.01	(0.93-1.10)	0.745

Table 9. The association between DM and several demographic, socioeconomic, lifestyle, and policy types based on policies from the NOURISHING and MOVING dataset, national DM plans and national DM registries from 4th edition of “Diabetes in Europe policy puzzle: the state we are in”.

Legend: BMI body mass index (kg/m²), ICC = intra-class correlation.

4.3 Diabetes Mellitus and associated factors in Slovakia: Results from the European Health Interview Survey 2009, 2014, and 2019

In the 2009 EHIS, the prevalence of DM was 6.1%, 8.2% in 2014, and 9.8% in 2019. Table 10 displays the distribution by numbers and relative frequencies of the study population divided by the presence of DM according to demographic, socioeconomic, and lifestyle characteristics. Bivariate analysis revealed that in 2009, the number of people with DM varied by gender (p-value < 0.05); female respondents had a greater percentage of the DM group than male respondents. In 2009, 2014, and 2019, frequencies by age groups were statistically significantly different; DM responses belonged to the elder age categories of 65 and above which were 3.59%, 4.81%, and 6.06%, respectively. It has been found that respondents with secondary education were significantly more affected by DM than respondents with other education levels. Only in 2009 and 2014 the degree of urbanization did show a significant correlation with DM; in 2009, more respondents had DM and lived in rural areas. In 2014, the highest number of DM patients lived in towns and suburbs.

The prevalence of DM varied according to labor status; respondents who had DM were more likely to be in the other categories (such as students and pensioners). In 2009, 2014, and 2019, there was a substantial correlation between the prevalence of DM and BMI, as shown by the frequencies in the cross-tabulated Table 10. The majority of people with DM fell into the category of being overweight or obese. In 2009 and 2014, the BMI group between 25 and 29.9 had a greater proportion of people with DM, while in 2019, the BMI group ≥ 30 had a higher prevalence of the disease. The DM participant had different frequencies of number of days walking for at least 10 minutes a week.

Most of the DM respondents walked one to six times a week for 10 minutes to get to and from their destinations in 2009 and 2014. In 2009 and 2014, more people walked for transportation had walked every day, while fewer people with DM never walked. For 2019, in comparison to

those who walked one to six times a week for 10 minutes or never, individuals with DM were more likely to walk for transportation on a daily basis. In 2009, 2014, and 2019, a correlation between the presence of DM and various physical activity categories was observed. In 2009, 2014, and 2019, persons who never engaged in any sort of physical activity each week had higher rates of DM than those who did. Only in 2009 did the association between eating fruits and vegetables and having DM become significant. Compared to eating one to six times a week or less than once a week or never, diabetic respondents had the highest frequency of eating one or more fruits and vegetables per day in 2009. See Table 10.

Category		EHIS 2009		EHIS 2014		EHIS 2019	
		With diabetes (N%)	Without diabetes (N%)	With diabetes (N%)	Without diabetes (N%)	With diabetes (N%)	Without diabetes (N%)
sex ^a	Male	132(2.66%)	2,257(45.47%)	184(3.35%)	2,270(41.35%)	233(4.04%)	2,087(37.77%)
	Female	183(3.69%)	2,392(48.19%)	265(4.83%)	2,771(50.47%)	317(5.74%)	2,898(52.45%)
Age ^{a,b,c}	15-44	Below 20	2,689	Between 20-49	2,467	Between 20-49	1,933
	45-64	118(2.38%)	1,427(28.75%)	149(2.71%)	1,673(30.47%)	180(3.26%)	1,843(33.36%)
	65 and older	178(3.59%)	533(10.74%)	264(4.81%)	901(16.41%)	335(6.06%)	1,209(21.88%)
Region*	Bratislavský kraj					Between 20-49	621
	Západné Slovensko					194(3.51%)	1,674(30.30%)
	Stredné Slovensko					138(2.50%)	1,220(22.08%)
	Východné Slovensko					160(2.90%)	1,470(26.61%)
Degree of urbanization ^{a,b}	Cities	54(1.09%)	1,109(22.34%)	92(1.68%)	1,415(25.77%)	113(2.05%)	1,127(20.40%)
	Towns and suburbs	120(2.42%)	1,445(29.11%)	196(3.57%)	2,045(37.25%)	178(3.22%)	1,721(31.15%)
	Rural areas	141(2.84%)	2,095(42.20%)	161(2.93%)	1,581(28.80%)	249(4.51%)	2,137(38.68%)
Educational level ^{a,b,c}	primary /less than primary education	Below 20	68	Below 20	Between 20-49	Below 20	Below 20
	Secondary education	270(5.44%)	3,724(75.02%)	405(7.38%)	4,009(73.02%)	482(8.72%)	3,930(71.13%)
	Higher education	Between 20-49	857(17.26%)	Between 20-49	991	51(0.92%)	1,027(18.59%)
Labour activity status ^{a,b,c}	Employed	66(1.33%)	2,730(55%)	59(1.07%)	2,393(43.59%)	86(1.56%)	2,503(45.30%)
	Unemployed	Below 20	299	Below 20	476	Below 20	263
	Others	241(4.85%)	1,620(32.63%)	372(6.78%)	2,172(39.56%)	437(7.91%)	2,219(40.16%)
BMI ^{a,b,c}	<25	62(1.29%)	2,366(49.35%)	89(1.62%)	2,337(42.57%)	86(1.58%)	1,985(36.50%)
	≥30	109(2.27%)	598(12.47%)	138(2.51%)	816(14.86%)	243(4.47%)	971(17.85%)
	25-29.9	130(2.71%)	1,529(31.89%)	222(4.04%)	1,888(34.39%)	1,929(35.83%)	205(3.77%)
Frequency of walking for at least 10 minutes continuously per week ^{a,b,c}	1 to 6 days	116(2.44%)	1,989(41.78%)	188(3.42%)	2,114(38.51%)	195(3.54%)	1,690(30.64%)
	Everyday	113(2.37%)	2,049(43.04%)	176(3.21%)	2,381(43.37%)	245(4.4%)	2,864(51.93%)
	Never	65(1.37%)	429(9.01%)	85(1.55%)	546(9.95%)	99(1.80%)	422(7.65%)
Physical activity ^{a,b,c}	2 days and more	138(2.94%)	2,996(63.89%)	Between 20-29	1,503	53(0.96%)	1,406(25.45%)
	Never	143(3.05%)	1,132(24.14%)	399(7.27%)	3,308(60.26%)	476(8.62%)	3,378(61.15%)
	one day per week	Between 20-49	259	below 20	230	Below 20	200
Frequency of eating fruits ^a	1 to 6 times a week	69(1.39%)	1,492(30.13%)	204(3.72%)	2,353(42.86%)	226(4.09%)	1,993(36.09%)
	Less than once a week and never	Below 20	193	Below 20	286	Between 20-49	308
	one and more per day	230(4.64%)	2,953(59.63%)	210(3.83%)	2,402(43.75%)	281(5.09%)	2,682(48.56%)
Frequency of eating vegetables or salad ^a	1 to 6 time a week ²	104(2.10%)	2,023(40.87%)	230(4.19%)	2,539(46.25%)	255(4.62%)	2,333(42.24%)
	Less than a week and never 0	Below 20	247	Between 20-49	282	Between 20-49	287
	once and more a day ¹	191(3.86%)	2,366(47.80%)	192(3.50%)	2,220(40.44%)	248(4.49%)	2,363(42.78%)

Table 10. Distribution of the study population using 2009, 2014 and 2019 Slovakian EHIS.

Legend: ^a Significant association ($p < 0.05$) between with diabetes and without diabetes in 2009. ^b Significant association ($p < 0.05$) between with diabetes and without diabetes in 2014. ^c Significant association ($p < 0.05$) between with diabetes and without diabetes in 2019. “Below 20” indicates that there are fewer than 20 observations in the corresponding cell, while “Between 20 and 45” signifies the presence of observations ranging from 20 to 45 within the cell. The usage of “below 20” and “between 20 and 45” aligns with the guidelines of the database regarding statistical disclosure control. *Sorted based on the gross domestic product (GDP) at current market prices of NUTS 2 regions in Slovakia, expressed in Euros (€) per inhabitant. The regions are listed as follows: Bratislavský kraj with €39,700 per inhabitant, Západné Slovensko with €15,800 per inhabitant, Stredné Slovensko with €14,100 per inhabitant, and Východné Slovensko with €12,200 per inhabitant. The BMI (body mass index) is measured in kg/m^2 .

Table 10 displays the outcomes of the multivariable model. According to the findings, women were 24% less likely than men to have DM in 2019. In all three surveys, there was a low association between DM and the age categories of 15 to 44 and 45 to 64 compared to the reference age group (65 and older). There was no correlation between the degree of urbanization and the occurrence of DM. Comparing respondents with higher education to those with primary or less than primary education, DM was positively associated with having DM in 2019.

In comparison to the reference group of other labour status, employment had a significantly decreased likelihood of developing DM in the years 2009, 2014, and 2019.

Lower BMI (18.5 to 24.9) was associated with a low probability of having DM in 2009, 2014, and 2019, respectively. People with a BMI of 30 or higher had a greater likelihood of developing DM compared to the overweight group (BMI 25 to 29.9).

Regarding physical activity, it was discovered that in the years 2014 and 2019, walking for at least 10 minutes daily or for at least one to six times a week was associated with a lower risk of developing DM compared to our reference category of “never”. A lack of physical activity, "never," increased the likelihood of developing DM in 2014. The frequency of eating fruits and the presence of DM were not associated. In comparison to our reference category of eating vegetables one or more a day, eating vegetables one to six times a week reduced the probability of having DM in 2009. Regarding Slovakian regions, there was no statistically significant association (data from 2019, exclusively). See Table 11.

Variable	Category	EHIS 2009 OR (95%CI)	EHIS 2014 OR (95%CI)	EHIS 2019 OR (95%CI)
Sex (ref: Males)	Female	0.86(0.65-1.13)	0.91(0.73-1.14)	0.76 (0.61-0.93)*
	15-44	0.06(0.03-0.10)*	0.13(0.09-0.20)*	0.13(0.08-0.20)*
Age (Ref: 65 and older)	45-64	0.48(0.34-0.68)*	0.53(0.40-0.70)*	0.71 (0.53-0.94)*
Region (Ref: Bratislavský kraj)	Západné Slovensko			(0.53-1.29)
	Stredné Slovensko			(0.58-1.42)
	Východné Slovensko			(0.59-1.43)
Degree of urbanization (Ref: Rural areas)	Cities	0.85(0.58-1.25)	0.81(0.6-1.10)	1.22(0.89-1.66)
	Towns and suburbs	1.27(0.94-1.72)	1.14(0.89-1.45)	1.02(0.81-1.29)
Educational level (Ref: Higher education)	primary/ less than primary education	0.49(0.15-1.60)	1.21(0.47-3.16)	3.86(1.40-10.67)*
	Secondary education	0.75(0.51-1.11)	1.29(0.89-1.87)	1.41(1-1.98)
Labour status (Ref: Others)	Employed	0.40(0.28-0.59)*	0.36(0.25-0.50)*	0.36(0.26-0.51)*
	Unemployed	0.65(0.30-1.41)	0.56(0.33-0.96)*	0.65(0.36-1.17)
BMI (Ref: 25-29.9)	<25	0.63(0.45-0.88)*	0.54(0.41-0.71)*	0.66(0.49-0.87)*
	25-29.9	1	1	1
	≥30	1.81(1.30-2.50)*	1.11(0.86-1.44)	2.07(1.64-2.61)*
Frequency of walking for at least 10 minutes continuously a week (Ref: Never)	1 to 6 days	0.76(0.52-1.12)	0.71(0.52-0.97)*	0.66(0.49-0.90)*
	Everyday	0.73(0.5-1.06)	0.67(0.49-0.93)*	0.56(0.41-0.76)*
Physical activity (Ref: one day a week)	2 days and more	0.68(0.41-1.15)	1.54(0.59-4)	0.66(0.32-1.35)
	Never	1.02(0.60-1.73)	2.6(1.04-6.48)*	1.43(0.73-2.80)
Frequency of eating fruits (Ref: one and more per day)	1 to 6 times a week	0.91(0.64-1.29)	0.99(0.73-1.33)	1.11(0.82-1.52)
	Less than once a week and never	1.25(0.59-2.61)	1.5(0.85-2.64)	1.09(0.61-1.94)
Frequency of eating vegetables or salad (Ref: one and more per day)	1 to 6 time a week	0.71(0.52-0.97)*	1.07(0.80-1.44)	0.81(0.60-1.11)
	Less than a week and never	0.57(0.29-1.13)	0.81(0.42-1.55)	0.78(0.45-1.36)

Table 11. Association between DM occurrence and related factors 2009, 2014 and 2019 Slovakian EHIS.

Legend: Legend: * indicates a significant association (p-value < 0.05) observed between individuals with DM and those without DM in the regression model. The BMI (body mass index) is measured in kg/m².

4.4 Analysis of content, social networks, and sentiment of front-of-pack nutrition labeling in the European Union on Twitter

4.4.1 Overall description

A total of 4,073 tweets were published by the quest, of which 2,278 (or 56%) were original tweets, 1,321 (or 32%) were reply tweets, and 474 (or 12%) were quoted tweets. There were 2,819 different accounts that associated with these tweets. In all, 229 accounts (4.6%) belonged to institutions or organizations, whereas 278 accounts (6.8%) belonged to people (individuals). Twitter defines entity annotations as references to people, organizations, locations, products, and others.

3,202 tweets in all were relevant to our scope of the study, whereas 871 were deemed as unrelated. A total of 493 items were classed as announcements, 2,624 as opinions, 68 as science and 165 related to EU policies. The result of measuring the internal consistency of the set of questions used to categorize the tweets was 0.70, which was a generally satisfactory Cronbach's alpha value [64, 65]. The intra-class correlation coefficient, which was used to test the inter-rater reliability, was 0.876, which was considered a good level of reliability. The inter-rater reliability of dialogues and conversations was 0.949, which was regarded as an excellent level of reliability. [66, 67].

Over the previous ten years, social networking participation has increased throughout the EU countries on average (creating user profiles, posting messages, etc.). With 81% of the population using social networks on average over the past five years, Denmark has led the way. In the previous five years, countries other than Denmark that have appeared in the top five include the United Kingdom, Belgium, Cyprus, Malta, and Sweden. Over the past five years, Poland, Germany, Bulgaria, France, and Slovenia have had the lowest frequencies, but the lowest rates have consistently been more than 40%. In the last five years, 63% of people from

Spain, a nation that has been very active on this subject, used the internet to social networking [68].

The UK (n = 1,434, 44.8%), Spain (n = 582, 18.2%), France (n = 468, 14.6%), Belgium (n = 244, 7.6%), Germany (n = 131, 4.1%), Ireland (n = 113, 3.5%), the Netherlands (n = 97, 3%), and Italy (n = 72, 2.2%) were the major geographical origins of the accounts, while 15 countries had <1% and five countries had no tweets. Figure 4 represents the evolution of tweeter activity by country use over time. Since 2010, the UK has had a significant portion of tweeters, with a peak in 2016 followed by Spain and France. The top 10 users with the most influence are listed in Appendix 9.

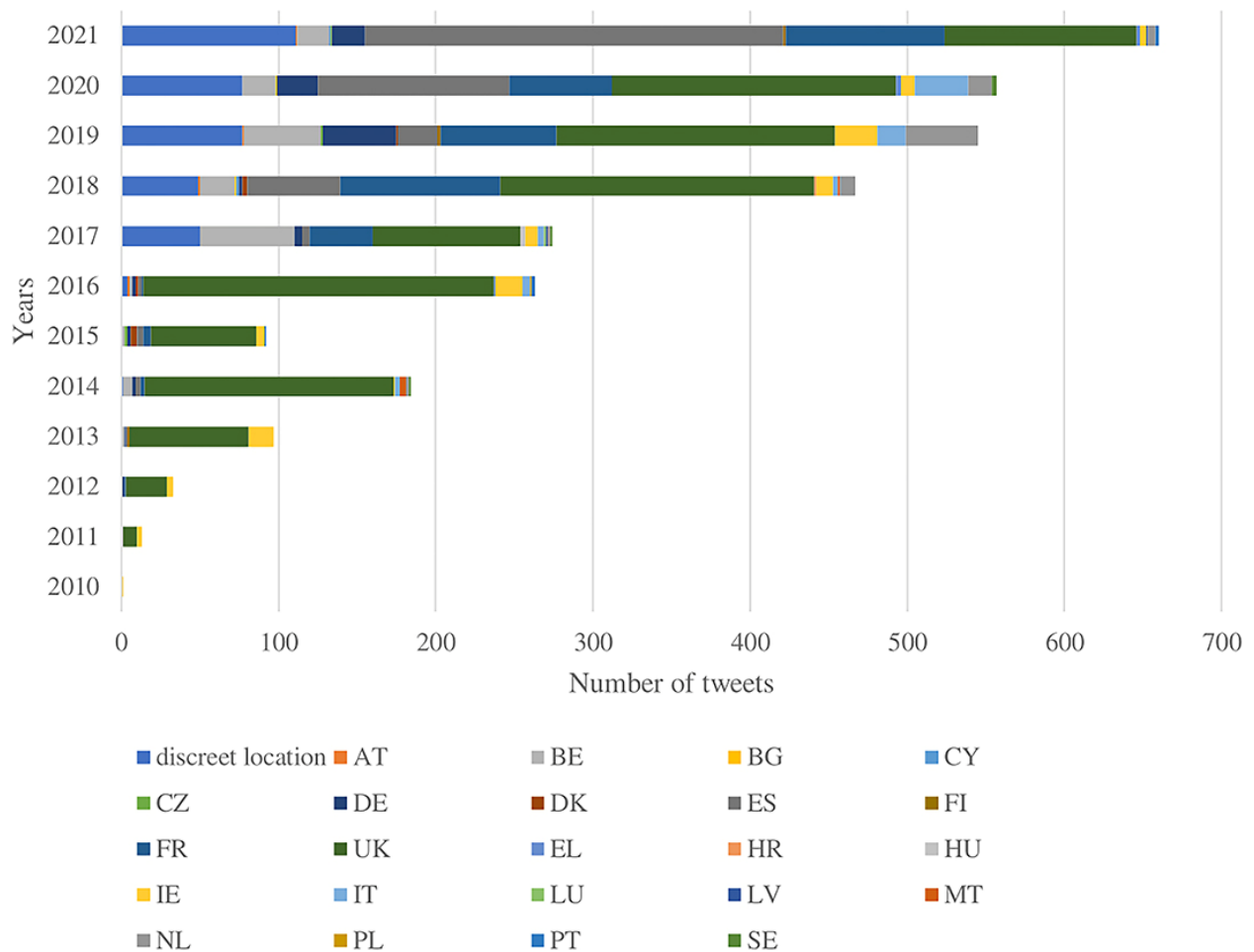


Figure 4. Tweets collected per country over time.

Legend: The graph shows the number of tweets per year stacked for each country. Two-letter country codes: Austria (AT), Belgium (BE), Bulgaria (BG), Cyprus (CY), the Czech Republic (CZ), Germany (DE), Denmark (DK), Greece (EL), Spain (ES), Finland (FI), France (FR), Croatia (HR), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Luxembourg (LU), Malta (MT), The Netherlands (NL), Poland (PL), Portugal (PT), Sweden (SE), and the United Kingdom (UK).

4.4.2 Content analysis

The main topics include different types of nutritional food labeling, the food industry, healthy vs. unhealthy foods in the context of food labeling, EU regulation, political conflict, science and education, Table 12.

Themes	Definitions	Subthemes
Nutritional food labeling types	Tweets discussing any type of FOPL or food labeling.	Nutri-Score and others (Multiple Traffic Lights, warning symbols, allergen, alcohol, environmental front-of-package, origin, etc.)
Healthy food vs. unhealthy food	The theme describes how FOPL relates to different food types.	Unhealthy (junk, fast, UPF, meat), healthy (organic, high nutritional value, vegetable, olive oil, fruits).
Food industry	Tweets on how companies related to food production, manufacturing or selling packaged food are linked to FOPL.	Companies support and accept Nutri-Score, Interests of food industry
EU Regulation	Legislation and regulations with respect to food labeling related to the EU.	Brexit, mandatory/voluntary labeling
Political conflict	Some arguments for or against the FOPL are projected onto countries	-
Science and education	Scientific facts, publications, appearing on FOPL in tweets.	Evidence about Nutri-Score, scientific articles, value of science, education

Table 12. Definition of themes and their subthemes.

Legends: Tweets were divided into themes and Subthemes.

The most representative food label in the studied dataset is Nutri-Score. Six of the top 10 influencers are Nutri-Score supporters, while only two are opponents. Appendix 9 contains information on the influencers, who include both corporate and individual representatives. The other subthemes of Nutri-Score covered a variety of traffic lights, warning signs, allergies, alcohol, the environment, CO2 emissions labels, indication of origin, etc. Within this theme, the usefulness of the Nutri-Score has received the most discussion; however, there were tweets in favor of and against it. The encouraging tweets were general but also were founded on first-hand experience. The primary topics of skeptic tweets concerning effectiveness were personal accountability and inconsistent food labeling. Additionally, food labeling was generally rejected by some tweets. Both encouraging and discouraging tweets are present for Nutri-Score. The justification for the claim is that Nutri-Score has been shown to have a favorable impact on consumers' product preferences. However, the problem and discussion were sparked

by a lack of consistency: Can a soft drink be categorized in the same way as a natural juice or a sweetened soft drink?

The healthy food subtheme, from healthy vs. unhealthy food theme, usually featured ingredients from Mediterranean cuisine, such as olive oil, packaged fruits and vegetables, or dairy products. The subtheme of unhealthy foods included goods, such as junk food, ultra-processed foods, packed and packaged meals, and fast foods that are described to be discriminated exclusively by food labeling. This topic has mostly been explored in relation to Nutri-Score, and some individuals believe that Nutri-Score encourages people to make healthier decisions. Some tweets assume that Nutri-Score promotes industrial companies at the expense of healthy food. One of the two main subthemes of the food industry was to celebrate the beginning of the use of Nutri-Score by food companies. However, some tweets discussed as previously mentioned, that food companies are less interested in promoting healthy eating and may take action against FOPL. The interests of the food business can also be regarded as the defense of regional and local producers. For instance, other people brought up the cost of the new food labeling system, relativizing the effects on public health.

The food industry is frequently held firmly accountable for the effects of consuming unhealthy foods. Some have expressed skepticism toward officials because they think that even if regulation does occur, it may be because they were able to come to an agreement with them. Others, on the other hand, think that the food business is preventing Nutri-Score from being successfully implemented. Tweets also reflected the political and food industry's mutual interests.

Moreover, tweets about EU legislation primarily featured conferences, events, and announcements. Because of how EU legislation affects the internal market or has a good impact on people, those who were evaluative in their tweets tended to support it. Most tweeters support

a single-market strategy and the harmonization of FOPL, even though some disagree with the symbolic Nutri- Score's value.

In some tweets, the mandatory versus optional application of the regulation is also discussed, with a sizable portion of the participants favoring mandatory while others disagreed.

Several tweets brought up the Brexit subtheme, which had a big impact on UK FOPL regulation.

The tweets, taken in a broader context, represented a political confrontation in which the interests of agribusiness and the public health conflict, with varying responses from private, political, and governmental actors. The majority of tweets included doubtful, critical, and unfavorable remarks. The conflict seems between the countries that support NutriScore and those in the Mediterranean region. The significance of local product protection seems to be influential. Differences in politics have been found not only across nations, but also against certain politicians. A comparatively small number of tweets with a science topic highlighted the foundations of Nutri-Score science, while others made references to academic articles and discussed the importance of science. Some tweets were encouraging action relating to the population's health education made up another subtheme. After the FOPL was implemented, some people emphasized the importance of education. Some tweets explained how this education should be delivered.

The dialogues were located and examined to determine which themes appeared frequently in order to be more specific. There were 327 dialogues or conversations that were found. Label type (97.55%) was the most often mentioned tweet topic, followed by the food industry (26.91%), bad food (18.96%), EU regulations (14.06%), science (11%), political conflict (10.09%), and healthy food (9.78%).

Organizations and individuals were also evaluated using the major themes for a clearer understanding; the analytical table is presented in Table 13. The following table presents the

distribution of tweet discussions across seven themes, categorized into organizations and persons. It was observed that individuals labeled as "persons" exhibited a higher tendency to concentrate on topics related to science and food quality. On the other hand, organizations were found to engage more in discussions regarding EU regulations and political conflicts.

	organization	person
Bad food	52.45%	47.55%
EU regulation	74.14%	25.86%
Food industry	52.78%	47.22%
Healthy food	51.05%	48.95%
Label types	59.72%	40.28%
Political conflicts	65.41%	34.59%
Science	41.76%	58.24%

Table 13. The distribution of Tweets collected based on their original tweeter by themes.

4.4.3 Sentiment analysis

We analyzed the sentiments associated with the main themes. Sentiments were divided into four categories based on the frequencies: very negative, moderately negative, moderately positive, and positive, Table 14. Neutral or mixed feelings were defined as a combination of both moderately negative and moderately positive. The tone of the text was generally negative sentiment. Tweets on the food industry generated more positive feedback than tweets about political conflict. The description of the sentiment analysis of tweets for organizations and individuals can be found in Appendix 10.

	Very negative	Moderately negative	Moderately positive	Very positive
Label types	18.33%	37.12%	29.17%	15.38%
Healthy vs. unhealthy foods	23.63%	32.63%	28.05%	15.7%
Food industry	17.02%	26.95%	31.06%	24.98%
EU regulation	22.92%	36.87%	20.43%	19.78%
Political conflict	26.11%	34.28%	20.41%	19.2%
Science	16.6%	39.74%	26.66%	17%

Table 14. Sentiment analysis of themes of collected Tweets.

Legend: Themes were divided based on their sentiment into (very negative, moderately negative, moderately positive and very positive).

4.4.4 Network analysis

The communications both within and across countries were represented in the chord diagram of Figure 5. There were a total of 3,138 nodes and 626 edges in the network study. The graph indicates that there were few international links and that most tweets were domestic in nature. The majority of connections were observed in France.

The network analysis of the conversations/dialogues resulted in 736 nodes and 581 edges. The tweets were represented by the nodes, while the connections between tweets that were a part of dialogues were represented by the edges. Each conversation was broken down into a number of coded topics, as seen in Figure 6.

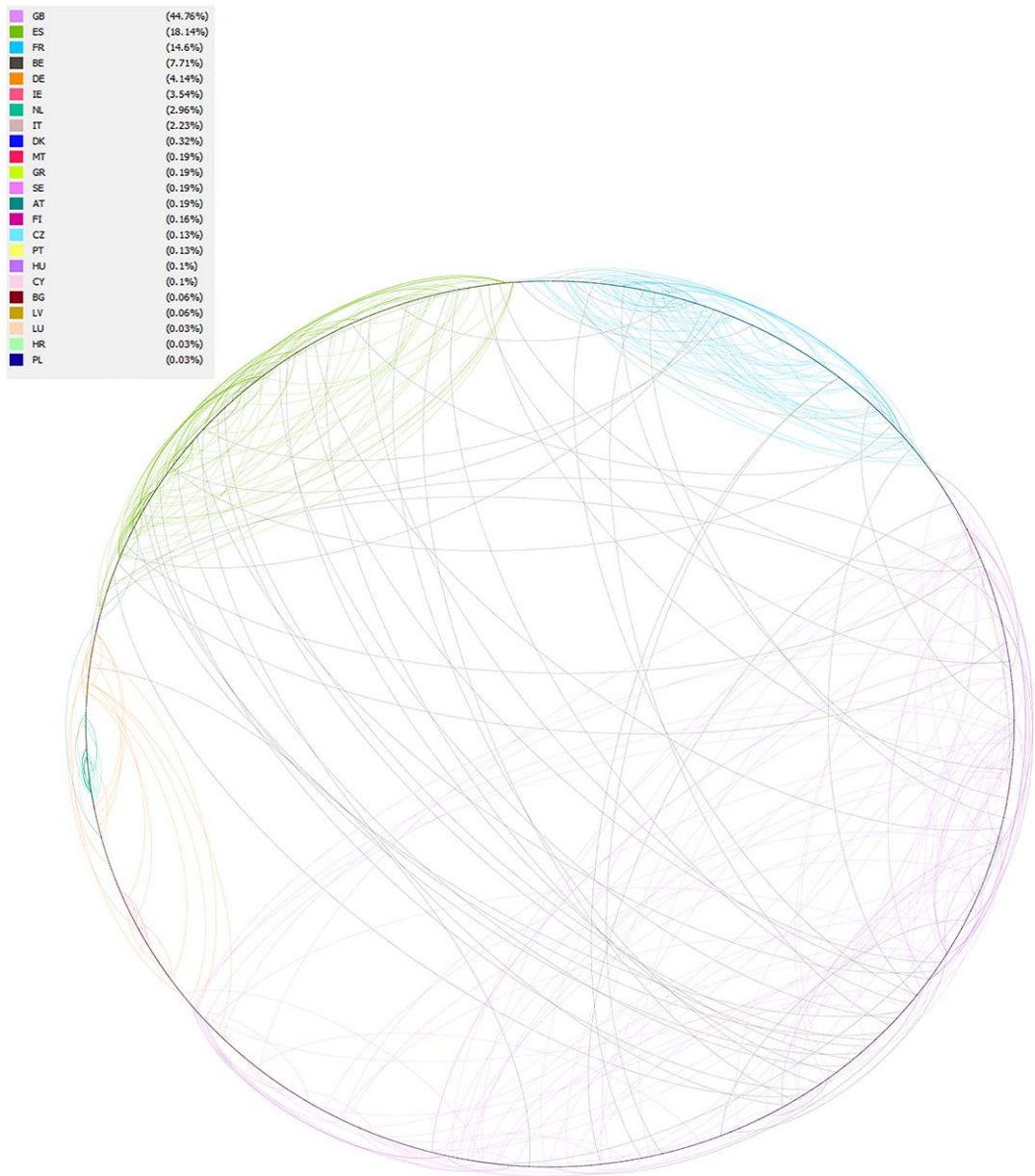


Figure 5. Network analysis of tweets connections by country

Legend: The circumference of the circle shows the total amount of tweet data. The circumference is divided into segments, each color corresponds to a country and each dot is associated with their conversation ID. The segments are connected by chords that illustrate the relationship within/between countries. Each tweet relationship is symbolized by a separate chord. High quality Figure 5 is available at: https://unidebhu-my.sharepoint.com/:b:/g/personal/nour_mahrouseh_med_unideb_hu/Eby04ggUgGlCsvQpVlARXUcBjomzCAHfM56uvggVlkuVlg?e=4G9m2b.

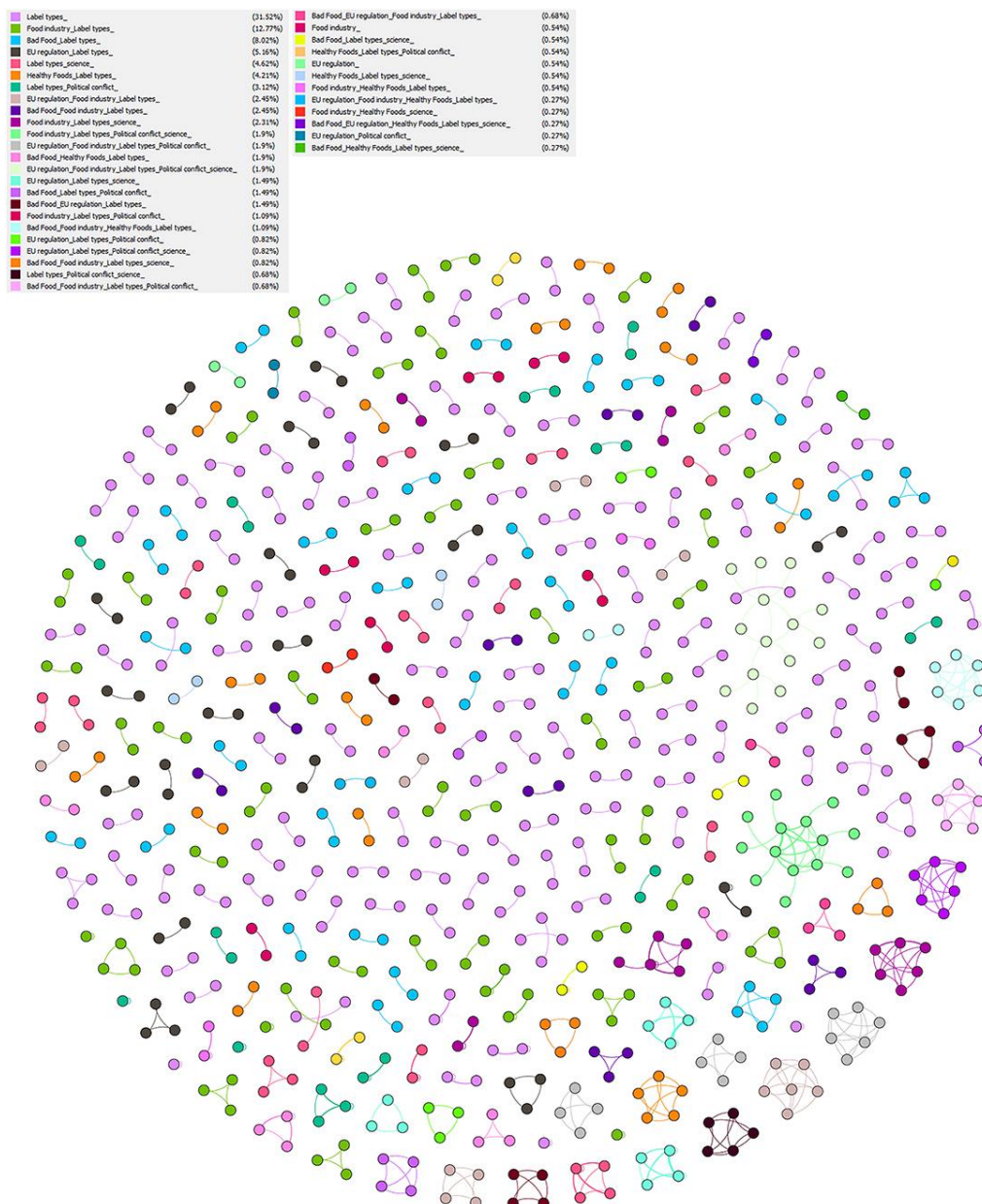


Figure 6. Network analysis of dialogues of the Tweets collected.

Legend: The Fruchterman–Reingold layout algorithm shows tweets belonging to dialogues and having similar conversation IDs. The dialogues are represented by colors, each corresponds to the different themes in which the dialogues were coded. The nodes (tweets) are connected by lines, representing their connections. High quality Figure 6 is available at: https://unidebhu-my.sharepoint.com/:b/g/person/nour_mahrouseh_med_unideb_hu/EQgWfX-BpShEi53L0QNlXlsBnUX9bLqSWPnI_XLS-J_0JQ?e=d5pb6P.

4.4.5 Geographic heat map

The heatmap illustrates Twitter activity across EU member states from 2006 to 2021, showcasing the density of tweets based on the location of the users when the tweets were posted, Figure 7. The United Kingdom (UK) stands out with the highest density of tweets.

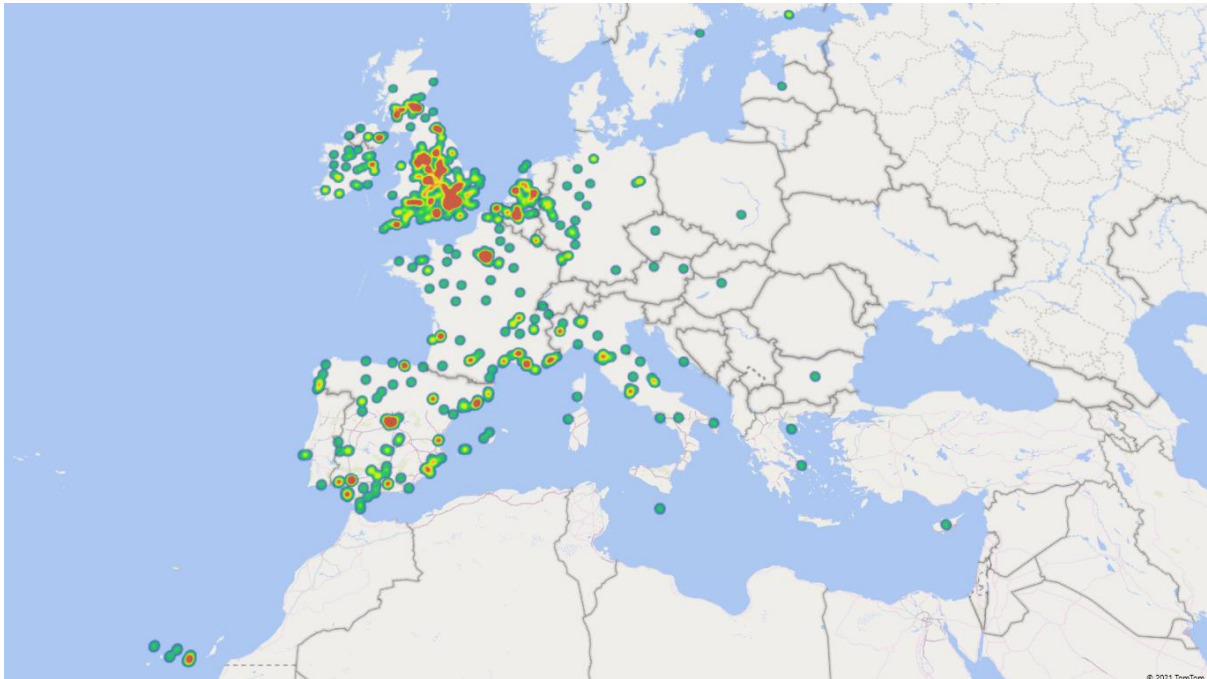


Figure 7. Geographical heat map represent the density of tweets based on the location of the users for each country in the EU.

Legend: The colors on the heat map, ranging from red to yellow and green, represent high to low tweet density respectively.

5. Discussion

5.1 How the European Union legislations are tackling the burden of diabetes mellitus: a legal surveillance study

The aim of the article was to present a thorough summary of the legislations affecting DM prevention in the EU. This research is the first that, to the best of our knowledge, analyzes EU initiatives and legislations in the area of DM prevention.

Our main conclusion demonstrates that numerous EU legislations included the prevention of DM as a part of NCDs or through risk factors. A relatively small number of non-binding legislations particularly between 2006 and 2012 addressed DM. The Council stressed the significance of encouraging healthy lifestyles and preventing T2DM as the Austrian conference on “Prevention of type 2 diabetes” concluded DM is a significant cause of premature death as well as a factor addressing the quality of life of the EU population [20]. This conclusion was followed by a report from the EC on the provision of foods for persons suffering from DM that contained dietary advice for those with the condition, details on the current EU legislations governing these foods, and additional dietary recommendations [69-71].

The European Parliament released a resolution in 2012 that addresses the DM epidemic and urges the EU to prioritize DM [21]. Nevertheless, DM was never given the spotlight it deserved during the legislative procedure. A recent initiative “The Blueprint for Action on Diabetes in the European Union by 2030” demands for DM to be placed at the top of the legislative upcoming plans [72] and could result in the creation of EU soft laws focused on DM in the near future.

The goal of the health programs has been to battle diseases and enhance the health of residents in the EU ever since they were introduced. Health programs should focus on DM as it can be prevented as other NCDs by altering risk factors like obesity and a sedentary lifestyle and by prescribed medications. The first established health program was successful, and had a great

influence on member states health systems [73, 74]. Due to the increased emphasis on health, the ongoing health program, EU4Health, has been funded more than earlier programs [75]. The recent COVID-19 pandemic has disproportionately affected the poor, older age groups and individuals suffering from chronic illnesses which include significant high rates of obesity and DM, highlighting the necessity for future efforts to focus more on prevention [76].

The EU's strategies for combating NCDs, particularly DM, have evolved over time. Early laws tended to be more concerned with EU market rules. The movement of goods as well as food products, and imposition of customs tariffs on these goods between the EU and other countries are regulated by the EU common market [77]. These legislations govern the food production, how the food market changes, and which goods are available for EU citizens to purchase. Since 2010, the EuroVoc terminology has evolved to include more preventive strategies for NCD risk factors.

A well-established fact that targeting risk factors is the foundation for effective preventive health policy; a large percentage of EuroVoc terms focus on obesity, health programs, etc. Another common type of legislation is ensuring the right to health while laying guidelines, educating the general public about disease management, symptoms, and risk factors. Future public health initiatives were modeled after the Commission's 1993 publication of a communication on a framework for action in the field of public health, which listed eight areas for action, comprising health promotion [78].

Most of the legislations were in focus of a life course approach strategy that was proposed by the WHO diabetes report. This strategy has demonstrated its effectiveness through reducing risk factors and boosting protective behaviors and characteristics during crucial stages of an individual's life, from the antenatal period and childhood and adolescence to adulthood. EU strategies also included trade, agricultural, and fiscal regulations to promote a healthy diet. The EU's single market strategy has impacts on health. A few tools in the EU, such as health

program funds [73, 74] directly support public health, and DM was on the health program's agenda as stated above. Informational legislations cover areas including promoting health, education, and research and innovation, which have lately ranked highly on the EU's priority list and received major funding [79].

Unfortunately, food taxation as a sort of fiscal legislation has not been implemented at the EU level. In some states, taxing is only implemented as a voluntary measure [80]. The tax on sugar-sweetened beverages (SSBs), which was enacted in France in 2011, is an illustration of current taxes [81]. According to a Mexican study, the taxation of SSBs has decreased consumption, particularly in the poorest segments of society [82], which may reduce the burden of DM disease. Similar outcomes have been produced by sugar legislation in other contexts as well [80]. The adoption of such laws should be promoted in the member states.

The EU's strategy to subsidizing with better options includes using legislation as a tool to target energy intake. This included promotion, educating, and regulating the marketing unhealthy foods. Consumer education through labeling is the primary method of nutritional legislation in the EU, according to the findings of a comprehensive review [83]. Food labeling has been shown to be successful in several countries [84], which is supported by a meta-analysis on the subject, which found that food labels and nutritional claims can promote healthy consumption [85] by influencing consumers' purchasing decisions [86]. This justifies a focus on food information and labeling in EU legislations. The setting in which food is consumed is crucial in determining eating choices. Numerous studies conducted worldwide have shown that making nutritious food and food produced for specific purposes available can enhance a population's quality of life and eating habits, thus reducing the risk of NCDs. Changing one's diet early in childhood can potentially stop the onset of obesity and DM in adulthood [87].

As shown by the functional category of energy expenditure, an environment supportive of physical activity should be at the center of EU regulations which included legislation governing

physical activity and its structure. According to literature, the success of physical activity laws around the world is low to moderate [88]. Policies promoting physical activity should be changed if they have proven ineffective as it is the most effective preventive measure against DM [88]. The EU's member states are responsible for enacting physical activity laws; the Commission's role is limited to supporting and coordinating these efforts.

In Europe, a prominent and constant health gradient exists between socioeconomic groups. Social legislations that focus on socioeconomic concerns may have indirect health effects [89]. One of the included legislations in our study, the White Paper on “Strategy for Europe on Nutrition, Overweight, and Obesity Related Health Issues”, had underlined the significance of addressing socioeconomic determinants and lowering disparity to diminish obesity and other NCDs as DM in the EU [90]. Focusing at-risk groups may assist to reduce the socioeconomic disparity and prevent DM. The general population was the most frequent target group. The numbers alone demonstrate that the legislation's structure is simple and that subgroups, particularly pregnant women, receive no special consideration. The "Council conclusions to contribute toward halting the rise in Childhood Overweight and Obesity" is an example of a law specifically designed for children, which targets persons at-risk to avoid the early onset of DM by modifying the individual's specific behaviors [91].

Screen and treat strategies, which cover detection, early diagnosis, and treatment as well as enhancing patients' quality of life, were part of the EU strategies. In the EU, more than 38% of people with DM go undiagnosed, and by the time they are diagnosed, many have already experienced one or more complications [72]. These issues have catastrophic effects on individuals and are quite expensive for health systems. The development of a screening tool and framework for people at risk across the EU to be used by 2024 has been suggested in the document “Blueprint for Action on Diabetes in the European Union by 2030”; that “early

interventions should be consistent, sustainable, and start as early as possible, in a supportive environment, targeting risk factors” [72].

The theme focused on launching a 'Health in All Policies' online policy portal did not yield any legislation, but a number of stakeholders lobbied for its foundation. Such an online policy portal might enable online debate and collaboration between health and other stakeholders, as well as provide transparency on relevant health legislations and instruments and aid and guide the application of all health policies. This may also aid in achieving the second objective, which is to provide health a political home within the EC and to guarantee inter-institutional coordination on health and well-being. The EU recently built a new interactive platform called the "EU Health Policy Platform" to gather laws under the EU4Health fund, which might be a step toward creating the online policy for Health in All Policies [92, 93].

In conclusion, there is not much binding regulation regarding DM prevention. Despite the fact that there are many relevant soft laws, the EU does not take use of the already available legislations. For instance, there is no "Health in All Policies" online policy to track the effects of EU legislation. All DM-specific laws are soft laws that have been in effect for at least ten years. The EU has begun to concentrate on risk factors, but mostly through mechanisms related to energy intake rather than addressing the complete range of preventive measures. High-risk populations that might have severe repercussions in the event of a future outbreak receive limited attention.

How will EU legislation on DM prevention and control change? is a crucial question. As previously stated, member states could not successfully address today's public health concerns; nonetheless, under the TFEU, health policy is basically a national competence, and the 27 member states have long insisted that this should be the case. With the long-term goal of developing shared, or at least common, health competences between member states and the EU

in a variety of sectors, the EC announced a vision and a set of actions for a European Health Union in Fall 2020, building on the experience of COVID-19 [94]. A report of a series of public consultations on the future of Europe in 2022 concluded that it is no longer ruled out that the founding documents of the EU might be changed [95]. It will take time to achieve this, but doing so will prevent future EU health policy and health law from being operated solely using soft tools in order to protect the quality of life and health security of EU members.

This study had several limitations. Despite the fact that not all types of DM are thought to be preventable, legislations did not differentiate between DM subtypes and instead regulated the area as a whole. Legal mapping has limits, despite the fact that this qualitative research offers fresh insights on the application of the “WHO Global Report on Diabetes” and the “EU Strategic Framework for the Prevention of NCDs”. There are worries that current EU legislation does not accurately reflect how it is being employed in the member states. There is a gap between what is suggested and launched and how much of it is really implemented. Furthermore, while EU legislation may be beneficial, it may take time for changes to take effect. Finally, based on our analysis, it is unclear if EU legislations are effective in preventing, detecting, and responding to disease. Accordingly, more "legal epidemiology" research will be required to examine how laws affect national health systems and public health outcomes [96]. To conclude, legislations aimed at DM prevention are few in number and narrowly focused. Since the 1960s, the EU has made enormous efforts to combat obesity, NCDs, and DM, yet the prevalence of DM is still rising in the majority of EU member states. This increase may be due to a decline in physical activity and reliance on a western diet, as well as socioeconomic factors and how these combine with an aging population [2]. Laws must be supported by a variety of political groups since DM is a complicated disease. To ensure that DM and its associated risk factors are incorporated in all new relevant initiatives, programs, and legislation, it is imperative to ensure that DM is high on the agenda of various EU institutions. In our opinion,

more advanced and comprehensive legislative network suggested by the WHO should be adopted in the EU.

5.2 Impact of policies in nutrition and physical activity on diabetes and its risk factors in the 28 member states of the European Union

EU members have directly aimed at tackling DM through national plans and operating DM registries, or indirectly by implementing nourishing, food-related and moving policies that address the primary risk factor for obesity, in an effort to lessen the burden of DM. Despite the fact that some relevant policies have been implemented in each member state, the results of our analysis reveal significant disparities in their types and numbers. However, having more policies—of any kind—do not appear to guarantee a decline in the burden of DM; poor association between the prevalence of DM and preventative strategies was found. The socioeconomic and lifestyle features of people living in the EU are more likely to cause disparities in DM prevalence between countries than policy implemented.

The difference between the highest and lowest DM prevalence rates among the member states was 5.57% in 2014, the "Global Burden of Disease 2019" report further indicates a consistence upward trend in these rates ever since[3]. National governments are being pressured more and more to put DM preventive policies and procedures into effect [52]. Implementing measures that either encourage healthy diet or increase physical activity are the two main methods used by governments to prevent DM [97]. According to the literature, law has been essential in preventing chronic illnesses and the actions that lead to them [98, 99]. The use of a systematic legal framework, which covers a variety of possible factors that influence the DM environment, can significantly aid in its prevention.

In our study, nutritional policies that had been implemented ranged from 2 to 34; only four countries had policies that were solely concerned with nutritional labeling. The use of

economic instruments for food affordability and restrictions on food advertising were the more underutilized nutrition policy categories, which present governments' reluctance to implement regulatory measures and their preference for educational strategies. This type of legislative preference has already been documented, for instance by an analysis of England and Southampton City policies of maternal and child health [100].

The number of countries with adopted physical activity policies ranges from 0 to 15, with the majority of countries having none at all. The least used category of moving policies was the provision of an environment for physical activity at work, which may present a reflection of governments' detachment from the industrial sector.

Similar to our findings in the EU, Kaselitz [101] noted a wide range of DM laws and action programs in Latin America, highlighting that most policy actions are based on evidence and that additional research is required to “determine their effectiveness, cost, and scalability”.

According to the study's findings, there is no or very little link between the prevalence of DM and any type of nutrition or physical activity policies, existing DM plans, or DM registries. The sole legal category that was used across all member states was product labeling, emphasizing the EU's legislative role. In reality, labeling may influence human behavior, such as encouraging the consumption of healthier foods. The mandatory application of “Regulation (EU) No. 1169/2011” resulted in widely use of labeling systems in EU member states; nevertheless, additional labeling systems may be used by member states. Labeling is highly informative; however, if it is not integrated in context, it may provide little help in the interpretation. For instance, nutrition labels for portion sizes [102] or health warnings are rarely used for substances other than allergies, which is advised for products with excessive sugar content [103].

“Upstream” dietary and multi-component programs, for example, pricing modifications, are to be unfailingly successful in encouraging healthy eating [104], despite economic tools for food

affordability and advertisement restrictions were scarcely used in EU countries. It has been observed that the successful of actions, such as labeling or restrictions on the availability or marketing of unhealthy food, are less effective and provide fewer firm long-term benefits [104]. Some EU members (such as France and Hungary) have imposed taxes on beverages with added sugar, however these taxes have only had a minor impact on the retail price. Introduction of plain packaging, warning labels, and a 20% tax on SSBs have predicted a significant behavior change [105].

Comprehensive research is also done on how effective policies are at encouraging physical activity. A recent systematic analysis reported solid evidence supporting the efficacy of policies in some areas, such as supporting walking and cycling policies and school environments for kids. The data is conflicting for a number of different interventions mentioned in the systematic review; while many interventions seem to be effective, others merely find weak or insufficient evidence. This appears to be the true for policies related to children's out-of-school environments, other settings or target audiences, and built environment/active transportation regulations [106].

Our analysis did not find evidence of a relationship between the prevalence of DM and school related legal policies, likely because the EHIS dataset only includes people over the age of 15. Future study should undoubtedly take into account that while physical activity policies for children in a school environment are effective, programs adopting similar approaches for adults in workplace settings are not as effective [107]. This difference demonstrates how age and other demographic factors affect the efficacy of initiatives.

Populations are not homogenous collections of individuals. Our outcomes were divided by age groups and gender in order to better understand how policies affect certain groups. The effectiveness of initiatives promoting good eating and exercise is influenced by population structure. Age and gender, for instance, were discovered to be associated with the effectiveness

of policy actions addressing NCDs [108]. An article evaluating the impact of the SSB tax on the occurrence of obesity in Portugal, by simulation model, reported the relationship between age groups and taxation strategies. According to this simulation study, adolescents between the ages of 10 and 18 were likely to experience the greatest projected impact [109]. Further research is crucial as our work was unable to identify any subgroup that is consistently linked to the nourishing and moving policies. Refining policy in accordance with characteristics of population subgroups may be necessary for cost-effective policy interventions.

In 2014, only 25% of the member states maintained national registries for DM, and nearly half of them had no DM plans. The number of policies was not related to the existence of DM plans and/or registries; for instance, in 2014, neither a national diabetes plan nor a national diabetes registry existed in the United Kingdom, which had the most policies in effect. The focus on risk factors of NCDs rather than DM itself may help in explaining this disparity. Since population-based registries are regarded as a pillar of assessment of policy interventions, the frequent absence of registries, however, shows clearly that DM is not at the core of public health policies in many EU countries [110].

Living in a particular country might be a risk factor of itself. For instance, the SCORE chart for cardiovascular risk levels uses a low- or high-risk scale depending on the country of residency [111]. As a grouping factor for DM in our analysis, the difference attributed to countries was minimal. In contrast to disparities in the availability and variety of different preventive strategies, discrepancies in disease prevalence between member states were caused by differences in demographic, socioeconomic and lifestyle variables.

There was no significant association between any policy type and the likelihood of DM occurrence. The findings of the multilevel analysis showed that female gender, younger age groups, higher levels of urbanization, mid/low income, and higher levels of education were substantially associated with a reduced risk of DM prevalence. In contrast to some good eating

behaviors, such as eating fruits 1 to 6 times a week, which may strongly correlate with reduced disease burden, having a higher BMI has a considerable consequence on the likelihood of DM occurrence.

Prior to our research, no study has been conducted to investigate the relationship between policies and DM prevalence among EU member states. This research has two significant ramifications. One, it is important to emphasize the influence of socioeconomic policies on the health of the population. Policymakers addressing DM may achieve notable results by tackling poverty, promoting education, etc. The second result is that marginalized policies are unable to have the desired effect of reducing the DM occurrence.

Our analysis revealed that no member state has completely addressed all the WCRF's suggested areas for nutrition and physical activity policies. Forecast studies are increasingly being used to evaluate the effects of policy on DM prevention [112, 113]. A simulation analysis confirmed the requirement for a network of policies in order to achieve the intended outcomes. When all the interventions in that model were combined, the population risk ratios for both obesity and T2DM decreased [114]. Although isolated regulatory actions aimed at population diet and nutrition may improve intermediate results, a clinically significant level of change is not achieved. For instance, a policy's impact on dietary intake may lower the occurrence of obesity or NCDs [115].

According to Sisnowski's systematic review of six diverse forms of actions, there was no proof that the examined policies had the expected effect on risk variables and health outcomes [115]. Similarly, a review of systematic reviews showed no proof that any of the fragmented interventions investigated had an impact on the prevalence of overweight, obesity, or T2DM, while presenting intermediate successes [116].

In conclusion, it implies the necessity to establish international treaties or other binding legislation because the only area of policy that was genuinely regulated across member states

was labeling, which is a result of an EU regulation. It would appear essential to work with international organizations to create effective policies and oversee their implementation [117-119].

However, the study had several limitations. The cross-sectional design of the study, which prevents the establishment of causation, is a significant disadvantage.

The most recent EHIS dataset accessible at the time of the manuscript's creation was the 2014 data, which we used in our analysis. Since the survey relied on self-reported questionnaires, the results and conclusions may not be accurate. Unfortunately, the study was unable to evaluate the physical activity characteristics since Belgium and the Netherlands did not provide data on them. Additionally, policy databases might not include all of the policies that were in force in 2014, and policies might require more time to fully realize their potential.

Although DM includes all subtypes with a variety of pathophysiology, the publication did not take into account this diversity; instead, the analysis employed the broad category of DM. Since T2DM accounts for the vast majority of cases of DM, dietary and physical activity guidelines are designed to address T2DM risk factors. Due to the small number of policies, conclusions based on the study should be for careful implemented.

To conclude, our research suggests that a higher adoption of dietary and physical activity guidelines is not always linked to a reduced prevalence of DM. There is some variation in the policies regarding nutrition and exercise among EU member states, and those areas that are heavily regulated are always as a result of EU legislation. Undoubtedly, policies put into place up to 2014 had some effect on lowering the DM burden, but not enough to reverse the growing trend. In our opinion, a matrix of policies is required to control the burden of DM; interventions cannot be restricted to a few policy areas that are simpler to implement for political or other reasons. To determine the magnitude of policies' effects on the burden of DM, more research is required.

5.3 Diabetes mellitus and associated factors in Slovakia: results from the European Health Interview Survey 2009, 2014, and 2019

As far as we are aware, this is the original study to examine the DM burden throughout the course of the three waves of the EHIS. Our study establishes the necessary baseline data for subsequent evaluation by providing adult population-wide, representative data on a range of basic health monitoring markers. Our data shows that between 2009 and 2019, the prevalence of DM patients has increased. Similar increases in prevalence have been observed throughout the majority of EU member states and the EU average [3].

Contrary to findings from a meta-analysis, which suggested that living in metropolises would increase the risk of DM [120], the results revealed that the degree of urbanization was not associated with the risk of DM. Socioeconomic factors such lower educational attainment and employment position may have a role in increasing inequalities in the population [121, 122]. Results from Denmark and other European states show that those with less education are more likely to develop DM than people with higher education. In the three waves, employment is adversely associated with DM; research has shown that people with DM leave the workforce earlier and produce lower-quality outcomes [123]. According to studies, the risk of developing DM is influenced by the workplace, the type of work, and the numbers of worked hours [124-126].

Due to the globalization of food manufacturing and distribution, particularly in the Mediterranean countries, dietary preferences have shifted towards "Westernized" diet in all EU countries [127]. Between the middle of the 20th century and 2006, vegetable consumption in Europe climbed by about 20%. Southern European countries have historically consumed more vegetables than any other part of Europe, but after the turn of the century, this trend started to reverse. Along with vegetable consumption, fruit intake has increased in Europe during the

past 60 years. Fruit market sales rose in the beginning of the twenty-first century, after which they gradually decreased [128].

Our analysis has confirmed the already established information that obesity and overweight are linked with a higher risk of developing DM, as observed in the three waves. The intake of fruits and vegetables is frequently at the heart of health policies addressing DM. Consuming fruit and vegetables has been found to lower the risk of developing DM in various prospective studies [129, 130]. However, our cross-sectional analyses could not find a consistent association between their consumption and the development of DM. Based on healthcare recommendations, individuals suffering from DM can consume the same amount of fruits and vegetables as healthy people [131, 132]. This discrepancy is not unexpected based on a meta-analysis that previously revealed that there was no clear relationship between total vegetable and fruit intake and the prevalence of T2DM [133].

Obesity and physical inactivity may be more closely linked to the prevalence of DM in high-income countries like Slovakia than other socioeconomic factors and urbanization. The recent shift in food toward a Westernized diet may be a contributing factor to this. The availability of food locally, the food supply chain, traditional eating habits, and food policy are all interrelated variables that may affect a country's nutrition quality.

Much more has an influence on the occurrence of DM as more than a bad diet is a sedentary lifestyle and low physical activity, which are thought to be directly or indirectly linked to DM. According to a study that used data from the Sport and Physical Activity EU Special Eurobarometers, sedentary behavior increased in prevalence across the total population and among men and women in the EU member states from 2005 to 2017, with the exception of Finland. In addition, with the exception of Bulgaria, Estonia, Hungary, Latvia, and Lithuania, males were found to have a higher incidence of sedentary lifestyles than women [134].

Our findings are consistent with a dose-response meta-analysis, which showed that walking as part of active transportation reduces the risk of developing DM; however, walking for more than two to three hours per week had no additional protective effect [135]. Resistance training and aerobic exercise both show inverse relationships with the risk of developing DM, according to clinical trials and cohort studies [136].

Human studies have shown that DM can be prevented or controlled by incorporating a multi-component strategy that addresses the major socioeconomic and lifestyle factors that influence it. This strategy includes controlling food intake, altering behavior, and increasing physical activity. A recent randomized controlled trial discovered that comprehensive lifestyle changes led to significant weight loss over a 12-month period, and more than 60% of patients had their DM controlled, with 30% also achieving normoglycemia [137].

The burden of DM is still high even though Slovakia has already established legislative efforts in these areas [138, 139] including a policy on the launching sport in educational settings and endorsing sport and physical activity in children, as well as a national action plan to promote sport and physical activity, several nutritional and labeling policies directed at obesity and improving health, and a national DM plan [140]. However, there is debate regarding the effectiveness of population-level policy measures. While population-based interventions often show initial results, they do not always lead in long-term declines in the burden of disease.

For instance, a systematic review of regulatory interventions aimed at population nutrition discovered that while some “isolated regulatory interventions” may have a favorable effect on intermediate outcomes, this change has not yet reached clinically significant levels. For example, having an impact on food intake, but it may not be sufficient to lead to a decrease in the incidence of obesity or NCDs [115]. According to a systematic review, the prevalence of overweight, obesity, or T2DM has not been shown to be impacted by any of the studied interventions [116]. According to simulation studies, a network of interventions is required to

accomplish the decline in disease goals. The population risk ratios for both obesity and T2DM might be lowered in a model that included all feasible interventions [114].

The main shortcoming of this study is the inability to establish a causal link between DM and risk factors due to the cross-sectional methodology. The employment status was not taken into account in our analysis. Only level 2 of the nomenclature of territorial units for statistics (NUTS2) were available in wave 3, hence only 2019 was used to study the relationship between DM and residing in different regions of Slovakia. Since the EHIS is a self-reported survey, there is a possibility that the reported data and estimated associations may not be accurate or reliable. Additionally, despite the fact that each kind of DM has a different pathological background, the different types of DM were not identified in our analysis due to the uniform category of DM that was employed in the EHIS waves.

To conclude, results from 2009 showed that consumption of vegetables several times a week may decrease the occurrence of DM in addition to moving for at least 10 minutes, such as walking, may prevent DM. Lifestyle factors including eating fruit and vegetables were not linked to DM. To assess their involvement in the growing prevalence in Slovakia and in contrast to other EU countries, further lifestyle characteristics and socioeconomic factors need to be examined. The member states of the EU have a leading role in addressing DM and its risk factors, to establish legislation, and to provide healthcare services. Existing health policies and initiatives in Slovakia were unable to stop the steadily rising DM burden, demonstrating the need for a more methodical approach. To conclude, in order to achieve improvement, creating and implementing complex policy initiatives and legislative measures seem unavoidable, both at national and EU levels.

5.4 Analysis of content, social networks, and sentiment of front-of-pack nutrition labeling in the European Union on Twitter

This is the first manuscript that, to the best of our knowledge, evaluates the general discourse on Twitter about FOPL in the EU. Our study has revealed limited Twitter activity despite the subject matter's significant importance in the field of public health. According to the observations of Mazzu et al [141], the public dialogue on Twitter is primarily dominated by the issue of Nutri-Score when compared to topics such multiple traffic lights, warning labels, and reference intake and to more generic keywords (FOP, FOPL, and front-of-pack). Based on our findings, the discussion often revolves around the reliability of the Nutri-Score rather than FOPL system as a whole.

The question of whether it was worthwhile to use a basic color label with a clear message but no nutrition information was one of the major debates on Twitter [34]. Ultra-processed foods with minimal nutritional value, such as sugar-free soft drinks, can also be classified under a better FOPL, as has been frequently stated in tweets. FOPL systems that are based on an algorithm or score, like Nutri-Score, multiple traffic lights, and health star rating, may not always differentiate between foods that are nutritionally recommended and those that are less recommended, like whole grain and refined grain foods [142]. For instance, Israel has adopted an interpretive FOPL system that uses two colors to indicate negative or warning (red) and positive (green) labels in order to address the conflict between employing nutrition labels and suggesting traditionally healthy foods. The positive FOPL is optional, but the warning FOPL is required. However, a product's lack of a warning label does not imply that it is endorsed to consume [142, 143].

Olive oil, a staple of the Mediterranean diet, is the food at the center of the Nutri-Score controversy. The "Yellow C" label given to any olive oil by Nutri-Score is considered by several industry advocates to be misleading to consumers because it does not accurately reflect

the recognized health benefits of extra virgin olive oil. They contend that extra virgin olive oil belongs in the "Green A" food category, which is the greatest one for healthy foods [144]. In an effort to help customers choose healthier and more sustainable foods and to combat food waste, the EC has opened a public consultation on proposed changes to food labeling. The deadline for stakeholders to express their opinions was March 7, 2022. However, as of that date, 214 legitimate comments had already been received, many of which from olive oil-producing countries indicating lobbying activity [145].

FOPL nutrition systems significantly impact the marketing plans of large agribusinesses. For instance, in June 2021, Nestlé—often linked to nourishing foods—faced criticism after a company document revealed that 60% of its main food product collection was classified unhealthy [146]. According to tweets, the industry's technique is straightforward: the company replaced and modified the content of their products to rank them better without necessarily improving their nutritional value in the food chain [147].

Twitter users had negative perceptions of the subject in general, but some had favorable perceptions about the food industry. Positive opinions of the food industry were probably influenced by the food brands' Twitter activity as well as tweets praising the adoption of Nutri-Score by a number of food brands.

The lobbying power of the food industry is well known throughout the world, therefore it is not surprising that this theme has emergence in the Twitter discourse. An investigation was carried out to identify and monitor the use of political practices by the food sector during the introduction of nutritional warning labels in Colombia. They found that participants in the food sector pressured Congress and promoted their own agenda in the media to try to stop Colombia from adopting warning labels. Their findings were not only based on Twitter posts but also on document analysis, and interviews [148, 149].

The ultra-processed food sector has aggressively used Twitter to influence discussions about food and health policy, according to an Australian study. The study found that following seven general tactics were found in tweets: combining public health narratives; opposing regulation; promoting voluntary, co-regulation, or self-regulation; interacting with the political system and decision-makers; connecting the governing environment to the need for continued profitability; effecting public perceptions and value judgments; and using ignorance claims to distort policy narratives [150].

The EU suggests that better consumer education will lead to more precise, informed, and understandable food decisions [150]. Despite the EU's general FOPL objectives being outlined in a number of tweets, we observed no evidence of interaction between EU representatives and other stakeholders. Additionally, we could not find any proof of legitimate EU educational initiatives on Twitter for FOPL. It is alarming that there is a lack of trust in EU regulation, as it is not limited to a single area. For instance, as evidenced by the COVID-19 outbreak, trust between the two sides is necessary for people to adhere to government mandates [151]. The FOPL-related EU policy was a special case of the Brexit in the UK. The EU FIC was implemented in 2013 and aligned with the UK-wide voluntary approach, which incorporated color coding and percentage reference intakes. Two-thirds of the packaged food and beverage market have implemented the labeling. After Brexit, the UK government declared that it would implement FOPL nutrition labeling after evaluating its efficacy and looking at other programs [152].

Twitter serves as a word-of-mouth (WOM) network for online debates. Social media platforms like Twitter are more effective in disseminating information and holding in-depth discussions on topics of general interest than conventional communication and marketing methods primarily due to their large user bases and high volume of daily tweets. "Organic" communication, as defined by the Twitter WOM model, takes place without direct marketing,

influence, or measurement. Reasons for this include the condition in which an influencer and a follower are naturally connected and interact by reacting to or retweeting tweets. The person becomes a social influencer and their tweets become viral as a result of having a lot of retweets and followers on social media. It has been demonstrated that when these tweets become popular, it increases the visibility of campaigns and ongoing debates. Based on this information, it can be inferred that Twitter serves as a medium for WOM campaigns that can be successfully employed for FOPL's social network discourse [153, 154].

Many people are drawn to the WOM debates on social networks that revolve around FOPL discussions, as it facilitates the process of communication and information transfer. The customer experience, often known as the customer journey, has a significant impact on social networking debates about FOPL on Twitter. Customer journeys are important in how people use social networks to share ideas, follow certain issues, or solve problems. Regulations governing FOPL and consumer discourse are closely related [155]. There is no one-size-fits-all solution across Europe due to national preferences, and the flaws and inadequacies of FOPL have slowed its implementation [156, 157].

To combat obesity and other NCDs, the EU planned to establish a harmonized FOPL in the near future, although the optimal strategy is a subject of fierce debate among member states [158]. The Nutri-Score, most widely used and highly debated summary indicator-type, has been discussed at major political levels, particularly in Italy and other Mediterranean countries, as indicated above [159]. Even though there were little or no further political disputes between countries in the tweets, there are still other political debates with the harmonized FOPL.

Several EU member states, including Italy, Cyprus, Greece, Hungary, Latvia, Romania, and the Czech Republic, have expressed that if a new standardized nutrition labeling system with FOPL is adopted, it should adhere to the text of the FIC regulation, i.e., it should provide factual information on the individual nutrients in a product and, as a result, exclude any system that

would offer an overall assessment of food, such as the Nutri-Score. France, Belgium, Spain, Germany, the Netherlands, and Luxembourg are among the member states that support the exemption of products with protected origins and those with a single ingredient [160]. Political conflicts cover a wide range of negative emotions, as shown by the fact that this theme came up as the most negative in the sentiment study.

Although it is common for scientific results to be shared on Twitter, this is not the case for the data we have. Health claims must be reliable, understandable to consumers, and supported by science, but they should not employ overcomplicated technical language. Scientists believe that consumers' understanding of current health claims has to be enhanced [161]. Future studies should concentrate on the issues with FOPL systems and nutrition label education that enhances comprehension and implementation, since this could increase the influence of this knowledge on dietary health decisions [162].

In conclusion, an EU proposal calls for the implementation of a unified FOPL system throughout all EU member states starting in 2020 [36, 163]. As nutrition information should not be reliant exclusively on the ineffective ingredient list of prepackaged meals, such a system is seen as an important tool to combat obesity and NCDs. Whatever FOPL system shall be used [164], it is important to develop and deliver it as component of the response to obesity and disease. Our findings demonstrated that talks concerning FOPL on Twitter are restricted to a small group of users; as a result, consumers' FOPL education should be prioritized, informing people about current and prospective FOPL systems [165]. Consumers should be empowered by educational programs to comprehend what a healthy diet is and how FOPL systems are relevant to national nutritional guidelines.

The study had several limitations. Twitter's text limit is quite strict (280 characters maximum), which restricts the expressing of opinions and the inclusion of background information thereby inevitably impacting content analysis. The tweets were published in multiple languages, which

may have hindered interactions across countries. Additionally, some tweets original meanings may be changed by machine translation. It is important to note that NVivo does not categorize content based on sentiment in sentiment analysis. Without considering the context, sentiment analysis considers single words. NVivo lacks the ability to recognize sarcasm, double negatives, slang, dialect variations, idioms, ambiguity, etc. like the majority of text analysis tools. The network analysis, which was designed to represent the countries by displaying each user ID and the required coordinate data.

In particular, the majority of the tweets lacked coordinates to identify their posting location, which was one of several inconsistencies in the data gathered from the complete archive of Twitter API Postman investigation, covering the period from March 2006 to early December 2021. We did not characterize accounts due to limited access to user information, including the number of followers, which would have hindered our ability to identify false accounts. Another issue is the fact that trust surveys are context-dependent and display considerable variations, despite the significant overall lack of trust in internet and social media information sources across EU member states [166]. Analysis could not incorporate the impact of mistrust of various sources on discussions about EU policy due to a lack of information on this aspect.

5.5. New findings

New results are listed below:

1. A total of 1099 relevant legislations related to DM, NCDs, and obesity were collected. Among these, 22 legislations primarily focused on the prevention of DM, NCDs and obesity and only five legislations were specifically designed for DM prevention. The identified legislations spanned from 1968 to 2022, with 366 legislations currently in effect. Among the identified legislations, there were six binding legislations and 17 non-binding legislations.
2. EuroVoc terms were available in 853 legislations, with a total of 6189 terms identified. Over time, there has been an increase in the number of new legislations passed since 2005. In 2021, the most popular subdomains were related to "social questions" and "epidemic" areas, while in 1973, the focus was on "trade" subdomains.
3. The assessment of legislations based on the WHO Global Report on Diabetes and EU Strategic Framework for the Prevention of NCDs Guidelines revealed that the most common classification type was "a life-course approach to preventing DM." Food-related laws, such as trade and agricultural regulations supporting healthy diets, were the most common binding legislations.
4. The target groups of the legislations varied, with the majority focusing on the general population or communities. The functional categories employed in the legislations included topics like energy intake, food labeling, physical activities, health promotion strategies, and

screening and treatment. Non-binding legislations were only present in the areas of energy expenditure and screening and treatment.

5. The study analyzing the impact of policies in nutrition and physical activity on diabetes and its risk factors in the EU member states found that the prevalence of DM varied across countries. In the 28 member states of the EU, the prevalence of DM in 2014 was predicted to be 6.94%. Portugal, Greece, and France had the highest prevalence rates, while Lithuania, Denmark, and Ireland had the lowest rates.

6. Nutrition and physical activity policies, national DM plans, and national registries differed among member states. Seven out of the 28 member states had national DM registries, and 17 had active national DM strategies in 2014. Among the nutrition and physical activity policies in the EU, the policy on "Nutrition label standards and regulations on the use of claims and implied claims on food" was introduced in all 28 member states. However, policies addressing a healthy retail and food service environment and nutrition education and skills were less frequently implemented. Country-level regression indicated that demographic, socioeconomic, and lifestyle factors had a greater influence on DM prevalence than variations in policy availability.

7. The prevalence of DM in Slovakia increased from 6.1% in 2009 to 9.8% in 2019. Women had a lower likelihood of having DM compared to men. The age groups of 15-44 and 45-64 had a lower association with DM compared to the reference age group of 65 and older. Higher education and employment are associated with lower likelihood of DM. Higher BMI and lack of physical activity increased the likelihood of DM. There was no significant

association between the presence of DM and the frequency of fruit and vegetable consumption. The geographical regions in Slovakia did not show a statistically significant association with DM prevalence.

8. The study analyzed a large number of tweets related to front-of-pack nutrition labelling in the EU. A significant portion of tweets being opinions and announcements. Different countries, including the UK, Spain, were major contributors to the Twitter discussions. The network analysis revealed that most tweets were limited to same country, with few international links. France had the highest number of connections.

9. The main topics discussed in the tweets included different types of nutritional food labelling, the food industry and healthy vs. unhealthy foods. Nutri-Score emerged as the most representative food label in the dataset. The sentiment analysis showed a generally negative tone. Tweets related to the food industry received more positive feedback compared to tweets about political conflict.

5.6 Recommendations and Conclusions

The Results presented and discussed previously have great of repercussions on the burden of DM in the EU. Policy surveillance of existing and available policies in the EU that address obesity and NCDs including DM is very crucial to allocate resources for studying current actions and obstacles and to develop solutions that can benefit political society as a whole. Nonetheless, EU policies in this area are available but limited. A comprehensive and holistic approach, along with the adaptation of comprehensive network of actions as recommended by the WHO, is necessary due to the ongoing increase in the burden. Studying dietary and physical activity policies and their relationship to the burden and risk factors, taking into consideration

member states, was the first to be introduced in the EU, and the results have showed that even although dietary and physical activity policies are regulated in most member states, several modifiable risk factors, along with sex and age, are associated with the increasing burden. No association was shown with the current policies. This could be translated into that the policies were unable to alter or had significant effect on halting the prevailing rise of DM. Result from the most recent microdata available in the EU on DM burden, EHIS 2019, with Slovakia as an example of a member state demonstrated how the burden of DM has changed over the years and its association with different factors affecting this burden. All of these investigations have been conducted to accumulate evidence and aid in determining the most significant interventions and actions that could be made and assess EU actions that will be made in the upcoming years. One of the suggested interventions is the implantation of a unified front-of-pack nutrition labelling, as studied by evaluating the public disclosure on the topic, we found that educational program should be introduced along with new proposed policies to ensure its utmost success of the policy.

All in all, the result suggests that increase burden of DM in the EU needs to be addressed more by EU policies and current policies should be adjusted to fit the rising prevalence.

Recommendations include studying existing interventions implemented in different EU member states in order to gather evidence based results on best practices that can guide future actions.

6. Summary

In a comprehensive study on legislation targeting DM, obesity, and NCDs in EU, a total of 1,099 relevant legislations were collected and assessed against the "Toward an EU Strategic Framework for the Prevention of NCDs," a joint publication by EPHA[51] and WHO "Global Report on Diabetes"[12]. The analysis revealed that 22 legislations primarily focused on the prevention of DM, NCDs, and obesity, with only five specifically designed for DM prevention.

These legislations spanned from 1968 to 2022, with 366 currently in effect. Among the identified legislations, there were six binding legislations and 17 non-binding legislations, with the EC as the primary author of 13 of them. EuroVoc terms were available in 853 legislations, predominantly in the domain of "social questions" and "public health." A longitudinal perspective showed an increase in legislations over time, with a shift in focus from "trade" to "social questions" and "epidemic" subdomains. Additionally, the assessment revealed a life-course approach as the most common classification, with food-related laws playing a prominent role.

Further analysis examined the impact of nutrition and physical activity policies on DM and its risk factors across EU member states. The study found variations in DM prevalence, with a predicted 6.94% prevalence in the EU in 2014. Portugal had the highest rates, while Lithuania had the lowest. National DM plans and registries differed among member states, with policies like "Nutrition label standards and regulations on the use of claims and implied claims on food" implemented universally, while others were less frequently adopted. Country-level regression revealed that demographic, socioeconomic, and lifestyle factors had a greater influence on DM prevalence than policy availability.

In a separate assessment of diabetes prevalence in Slovakia between 2009, 2014, and 2019, the study found an increase from 6.1% to 9.8%. Notably, women had a lower likelihood of DM than men, and certain age groups exhibited lower associations with DM. Higher education and employment were linked to a lower likelihood of DM, while higher BMI and lack of physical activity increased the likelihood. Importantly, there was no significant association between DM and fruit and vegetable consumption, and geographical regions in Slovakia did not exhibit a statistically significant association with DM prevalence.

Finally, the study delved into the analysis of tweets in the EU regarding front-of-pack nutrition labeling. The study observed a multitude of tweets, with the majority being original and containing opinions and announcements. Different countries, including the UK, Spain, France, Belgium, Germany, Ireland, the Netherlands, and Italy, were major contributors to the discussions, although most tweets were contained within national boundaries. The topics covered various aspects of nutritional food labeling, the food industry, healthy vs. unhealthy foods, EU regulations, political conflict, science, and education. The Nutri-Score label emerged as the most discussed, with both supporters and opponents expressing their views. Sentiment analysis of the tweets generally indicated a negative tone, with tweets related to the food industry receiving more positive feedback compared to those involving political conflict.

Author's contributions:

The Author has contributed with other co-authors in the following:

1-How the European Union legislations are tackling the burden of diabetes mellitus: A legal surveillance study

Conceptualization, data curation and visualization, formal analysis, Methodology, writing: original draft, and writing: review and editing.

2-Impact of Policies in Nutrition and Physical Activity on Diabetes and Its Risk Factors in the 28 Member States of the European Union

Conceptualization, data curation, formal analysis, methodology, writing; original draft and writing: review and editing.

3-Diabetes Mellitus and Associated Factors in Slovakia: Results from the European Health Interview Survey 2009, 2014, and 2019

Conceptualization, data curation, formal analysis, methodology, writing: original draft, writing: review and editing.

4-Analysis of Content, Social Networks, and Sentiment of Front-of-Pack Nutrition Labeling in the European Union on Twitter

Conceptualization, data curation, formal analysis, methodology, writing: original draft, writing: review and editing.

7. References

7.1 Literature references

1. World Health Organization. *Diabetes*. 2021 [cited 2021 13-05]; Health Topics - Diabetes]. Available from: https://www.who.int/health-topics/diabetes#tab=tab_1.
2. International Diabetes Federation, *IDF Diabetes Atlas*. 9th ed. 2019. Available from: <http://www.diabetesatlas.org>.
3. Global Burden of Disease Collaborative Network, *Global Burden of Disease Study 2019 (GBD 2019) Results*. 2020, Institute for Health Metrics and Evaluation (IHME): Seattle, United States. Available from: <http://ghdx.healthdata.org/gbd-results-tool>.
4. Lin, J., et al., *Projection of the future diabetes burden in the United States through 2060*. *Popul Health Metr*, 2018. **16**(1): p. 9. DOI: 10.1186/s12963-018-0166-4.
5. International Diabetes Federation. *Diabetes report 2010 — 2045*. *IDF Diabetes Atlas 2019* [cited 2021 16-09]; Available from: <https://www.diabetesatlas.org/data/en/region/3/eur.html>.
6. Brinks, R., et al., *Prevalence of type 2 diabetes in Germany in 2040: estimates from an epidemiological model*. *Eur J Epidemiol*, 2012. **27**(10): p. 791-7. DOI: 10.1007/s10654-012-9726-2.
7. Lin, X., et al., *Global, regional, and national burden and trend of diabetes in 195 countries and territories: an analysis from 1990 to 2025*. *Sci Rep*, 2020. **10**(1): p. 14790. DOI: 10.1038/s41598-020-71908-9.
8. World Health Organization. *Cardiovascular diseases (CVDs)*. 2021 [cited 2023 04-11]; Health Topics - Diabetes]. Available from: [https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)).
9. World Health Organization. *Chronic respiratory diseases*. 2023 [cited 2023 04-11]; Health Topics - Diabetes]. Available from: https://www.who.int/health-topics/chronic-respiratory-diseases#tab=tab_1.

10. World Health Organization. *Cancer*. 2022 [cited 2023 04-11]; Health Topics - Diabetes]. Available from: <https://www.who.int/news-room/fact-sheets/detail/cancer>.
11. Zhang, P., et al., *Global healthcare expenditure on diabetes for 2010 and 2030*. *Diabetes Res Clin Pract*, 2010. **87**(3): p. 293-301. DOI: 10.1016/j.diabres.2010.01.026.
12. WHO NCD Management-Screening, D.a.T., *Global report on diabetes*, W.H. Organization:, Editor. 2016: France. p. 63. Available from: https://apps.who.int/iris/bitstream/handle/10665/204871/9789241565257_eng.pdf.
13. Schwingshackl, L., et al., *Intake of 12 food groups and disability-adjusted life years from coronary heart disease, stroke, type 2 diabetes, and colorectal cancer in 16 European countries*. *European Journal of Epidemiology*, 2019. **34**(8): p. 765-775. DOI: 10.1007/s10654-019-00523-4.
14. Carbone, S., et al., *Obesity, risk of diabetes and role of physical activity, exercise training and cardiorespiratory fitness*. *Progress in Cardiovascular Diseases*, 2019. **62**(4): p. 327-333. DOI: <https://doi.org/10.1016/j.pcad.2019.08.004>.
15. Seiglie, J.A., et al., *Diabetes Prevalence and Its Relationship With Education, Wealth, and BMI in 29 Low- and Middle-Income Countries*. *Diabetes Care*, 2020. **43**(4): p. 767-775. DOI: 10.2337/dc19-1782.
16. Schipf, S., et al., *Regional differences in the incidence of self-reported type 2 diabetes in Germany: results from five population-based studies in Germany (DIAB-CORE Consortium)*. *Journal of Epidemiology and Community Health (1979-)*, 2014. **68**(11): p. 1088-1095.
17. Du, Y., et al., *Factors associated with undiagnosed type 2 diabetes in Germany: results from German Health Interview and Examination Survey for Adults 2008–2011*. *BMJ Open Diabetes Research & Care*, 2020. **8**(1): p. e001707. DOI: 10.1136/bmjdr-2020-001707.
18. Rawshani, A., et al., *Association Between Socioeconomic Status and Mortality, Cardiovascular Disease, and Cancer in Patients With Type 2 Diabetes*. *JAMA Internal Medicine*, 2016. **176**(8): p. 1146. DOI: 10.1001/jamainternmed.2016.2940.
19. Felton, M.A.-M. and M. Hall, *Declarations and European Union Health Council Conclusions: a ray of hope?* *Practical Diabetes International*, 2006. **23**(6): p. 243-244. DOI: <https://doi.org/10.1002/pdi.961>.
20. Council conclusions on promotion of healthy lifestyles and prevention of Type 2 diabetes, (2006). Official Journal of the European Union: 52006XG0623(01). Available from: [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52006XG0623\(01\)](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52006XG0623(01)).
21. European Parliament resolution on addressing the EU diabetes epidemic (2011/2911(RSP)), (2012). Official Journal of the European Union: B7-0146/2012. Available from: https://www.europarl.europa.eu/doceo/document/B-7-2012-0146_EN.html.
22. United Nations, *World Diabetes Day : resolution / adopted by the General Assembly*. 2007. Available from: <https://digitallibrary.un.org/record/589515?ln=en>
23. Consolidated version of the Treaty on the Functioning of the European Union, (2012). Official Journal of the European Union: C 326 , 26/10/2012. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A12012E%2FTXT>.
24. Bartlett, O. and A. Naumann, *Reinterpreting the health in all policies obligation in Article 168 TFEU: the first step towards making enforcement a realistic prospect*. *Health Econ Policy Law*, 2021. **16**(1): p. 8-22. DOI: 10.1017/s1744133120000043.
25. European Observatory of Working Life. *European Industrial relations Dictionary: Soft Law*. 2011 [cited 2022 19-07]; Available from:

- <https://www.eurofound.europa.eu/observatories/eurwork/industrial-relations-dictionary/soft-law>.
26. Chauliac, M., et al., *Joint efforts against childhood obesity: EU Joint Action on Nutrition and Physical Activity 2015–2017*: Viktoria Anna Kovacs. *European Journal of Public Health*, 2015. **25**(suppl_3). DOI: 10.1093/eurpub/ckv172.080.
 27. Brug, J., *The European charter for counteracting obesity: a late but important step towards action. Observations on the WHO-Europe ministerial conference, Istanbul, November 15-17, 2006*. *The international journal of behavioral nutrition and physical activity*, 2007. **4**: p. 11-11. DOI: 10.1186/1479-5868-4-11.
 28. World Health Organization Regional Office for Europe, *Steps To Health A European Framework To Promote Physical Activity For Health*. 2007: Copenhagen Ø, Denmark. Available from: https://www.euro.who.int/_data/assets/pdf_file/0020/101684/E90191.pdf.
 29. World Health Organization Regional Office for Europe, *WHO European Action Plan For Food And Nutrition Policy 2007-2012*. 2008. Available from: https://www.euro.who.int/_data/assets/pdf_file/0017/74402/E91153.pdf.
 30. The European Parliament and The Council Of The European Union, *Directive 2014/40/EU Of The European Parliament And Of The Council of 3 April 2014 on the approximation of the laws, regulations and administrative provisions of the Member States concerning the manufacture, presentation and sale of tobacco and related products and repealing Directive 2001/37/EC*. 2014. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0040&from=EN>.
 31. The European Parliament and The Council Of The European Union, *Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers*. 2011.
 32. Eurostat. *Glossary: European Health Interview Survey (EHIS)*. [cited 2021 27-03]; Available from: [https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:European_health_interview_survey_\(EHIS\)](https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:European_health_interview_survey_(EHIS)).
 33. Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004 OJ L 304, 22.11.2011, pp.18-63) (2011). Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011R1169>.
 34. Report from the Commission to the European Parliament and the Council regarding the use of additional forms of expression and presentation of the nutrition declaration (2020). European Commission: COM(2020) 207. Available from: https://ec.europa.eu/food/system/files/2020-05/labelling-nutrition_fop-report-2020-207_en.pdf.
 35. European Commission. *Nutrition labelling*. 2021 [cited 2021 12.12]; Available from: https://ec.europa.eu/food/safety/labelling-and-nutrition/food-information-consumers-legislation/nutrition-labelling_en.
 36. Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee And The Committee of The Regions: A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system, (2020): COM(2020) 381. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0381>.

37. Saeedi, P., et al., *Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9(th) edition*. *Diabetes Res Clin Pract*, 2019. **157**: p. 107843. DOI: 10.1016/j.diabres.2019.107843.
38. Rathmann, W., et al., *High prevalence of undiagnosed diabetes mellitus in Southern Germany: target populations for efficient screening. The KORA survey 2000*. *Diabetologia*, 2003. **46**(2): p. 182-9. DOI: 10.1007/s00125-002-1025-0.
39. Mokán, M., et al., *Prevalence of diabetes mellitus and metabolic syndrome in Slovakia*. *Diabetes Research and Clinical Practice*, 2008. **81**(2): p. 238-242. DOI: <https://doi.org/10.1016/j.diabres.2008.04.002>.
40. Soares Andrade, C.A., et al., *The burden of type 2 diabetes mellitus in states of the European Union and United Kingdom at the national and subnational levels: A systematic review*. *Obesity Reviews*, 2023. **24**(9): p. e13593. DOI: <https://doi.org/10.1111/obr.13593>.
41. Altobelli, E., et al., *Lifestyle Risk Factors for Type 2 Diabetes Mellitus and National Diabetes Care Systems in European Countries*. *Nutrients*, 2020. **12**(9): p. 2806.
42. Fuentes-Merlos, Á., et al., *Quality-of-Life Determinants in People with Diabetes Mellitus in Europe*. *Int J Environ Res Public Health*, 2021. **18**(13). DOI: 10.3390/ijerph18136929.
43. Chrissini, M.K. and D.B. Panagiotakos, *Public health interventions tackling childhood obesity at European level: A literature review*. *Prev Med Rep*, 2022. **30**: p. 102068. DOI: 10.1016/j.pmedr.2022.102068.
44. Willett, W., et al., *Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems*. *Lancet*, 2019. **393**(10170): p. 447-492. DOI: 10.1016/s0140-6736(18)31788-4.
45. Whiting, S., et al., *Promoting health-enhancing physical activity in Europe: Surveillance, policy development and implementation 2015–2018*. *Health Policy*, 2021. **125**(8): p. 1023-1030. DOI: <https://doi.org/10.1016/j.healthpol.2021.05.011>.
46. Giusti, A., M. Maggini, and S. Colaceci, *The burden of chronic diseases across Europe: what policies and programs to address diabetes? A SWOT analysis*. *Health Research Policy and Systems*, 2020. **18**(1): p. 12. DOI: 10.1186/s12961-019-0523-1.
47. Stelfson, M., et al., *Evolving Role of Social Media in Health Promotion: Updated Responsibilities for Health Education Specialists*. *Int J Environ Res Public Health*, 2020. **17**(4). DOI: 10.3390/ijerph17041153.
48. European Commission. *EUR-Lex Access to European Union law*. 2021 [cited 2021 27-09]; Available from: <https://eur-lex.europa.eu>.
49. Office of the European Union. *EuroVoc - EU Vocabularies*. 2022 [cited 2022 02-07]; Available from: <https://op.europa.eu/en/web/eu-vocabularies/dataset/-/resource?uri=http://publications.europa.eu/resource/dataset/eurovoc>.
50. The Center of Public Health Law Research. *MonQcle*. 2021 [cited 2021 01-06]; Available from: <https://monqcle.com/>.
51. European Public Health Alliance, *Joint Paper Towards an EU strategic framework for the prevention of NCDs*. 2019, Brussels, Belgium: European Public Health Alliance. Available from: <https://alliancechronicdiseases.org/wp-content/uploads/Final-NCD-Paper-full-version.pdf>.
52. Timpel, P., et al., *What should governments be doing to prevent diabetes throughout the life course?* *Diabetologia*, 2019. **62**(10): p. 1842-1853. DOI: 10.1007/s00125-019-4941-y.

53. Abiola, S.E. and M.M. Mello, *Multilevel legal approaches to obesity prevention: A conceptual and methodological toolkit*. PLOS ONE, 2019. **14**(10): p. e0220971. DOI: 10.1371/journal.pone.0220971.
54. World Cancer Research Fund International's (WCRFINT) NOURISHING and MOVING policy databases. *NOURISHING and MOVING policy databases*. [cited 2021 28-08]; Available from: <https://policydatabase.wcrf.org/>.
55. European Coalition for Diabetes, *Diabetes In Europe Policy Puzzle: The State We Are In*. Fourth ed. 2014. Available from: <https://www.fend.org/wp-content/uploads/2021/04/Policy-Puzzle-PP4finalweb.pdf>.
56. World Cancer Research Fund International's (WCRFINT), *NOURISHING & MOVING Methods Document*. 2021. Available from: <https://www.wcrf.org/wp-content/uploads/2021/06/Methods-document-.pdf>.
57. Eurostat. *European Health Interview Survey (EHIS)*. [cited 2021 19-06]; Available from: <https://ec.europa.eu/eurostat/web/microdata/european-health-interview-survey>.
58. Lange, C., et al., *Implementation of the European health interview survey (EHIS) into the German health update (GEDA)*. Archives of Public Health, 2017. **75**(1): p. 40. DOI: 10.1186/s13690-017-0208-6.
59. Parikka, S., et al., *Implementation of the European health interview survey into the National FinSote survey in Finland*. European Journal of Public Health, 2020. **30**(Supplement_5). DOI: 10.1093/eurpub/ckaa165.186.
60. *The SAGE Encyclopedia of Communication Research Methods*. 2017. DOI: 10.4135/9781483381411.
61. Postman Enterprise, *Postman API Platform*. 2021. Available from: <https://www.postman.com/product/what-is-postman/>.
62. Wahbeh, A., et al., *Mining Physicians' Opinions on Social Media to Obtain Insights Into COVID-19: Mixed Methods Analysis*. JMIR Public Health Surveill, 2020. **6**(2): p. e19276. DOI: 10.2196/19276.
63. Felt, M., *Social media and the social sciences: How researchers employ Big Data analytics*. Big Data & Society, 2016. **3**(1): p. 2053951716645828. DOI: 10.1177/2053951716645828.
64. Gliem, J.A. and R.R. Gliem. *Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales*. in *Midwest Research to Practice Conference in Adult, Continuing, and Community Education*,. 2003. Columbus.
65. Tavakol, M. and R. Dennick, *Making sense of Cronbach's alpha*. International journal of medical education, 2011. **2**: p. 53.
66. Fleiss, J.L. and J. Cohen, *The equivalence of weighted kappa and the intraclass correlation coefficient as measures of reliability*. Educational and psychological measurement, 1973. **33**(3): p. 613-619. DOI: <https://doi.org/10.1177/001316447303300309>.
67. Gisev, N., J.S. Bell, and T.F. Chen, *Interrater agreement and interrater reliability: key concepts, approaches, and applications*. Research in Social and Administrative Pharmacy, 2013. **9**(3): p. 330-338. DOI: 10.1016/j.sapharm.2012.04.004.
68. *Individuals using the internet for participating in social networks*, Eurostat, Editor. 2023. Available from: <https://ec.europa.eu/eurostat/databrowser/view/tin00127/default/bar?lang=en>.
69. Report from the Commission to the European Parliament and the Council on foods for persons suffering from carbohydrate metabolism disorders (diabetes), (2008). Commission of the European Communities: 52008DC0392. Available from: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52008DC0392>.

70. Commission staff working document - Summary of dietary recommendations for people with diabetes, (2008): 52008SC2295. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52008SC2295&qid=1699165360615>.
71. Commission staff working document - Summary of main points of scientific basis of the dietary recommendation for diabetics, (2008): 52008SC2294. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52008SC2294&qid=1699165614486>.
72. The secretariat of the MEP Interest Group on Diabetes by IDF Europe, *MEPs Mobilising for Diabetes: Blueprint for Action on Diabetes in the European Union by 2030*. 2021. Available from: <https://www.mepinterestgroupdiabetes.eu/wp-content/uploads/2021/03/MMD-BLUEPRINT-FOR-ACTION-ON-DIABETES.pdf>.
73. European Commission. *Public Health, Funding*. 2021 [cited 2021 28-09]; Available from: https://ec.europa.eu/health/funding/key_documents_en#anchor2.
74. Seychell, M. and B. Hackbart, *The EU Health Strategy—Investing in Health*. Public Health Reviews, 2013. **35**(1): p. 4. DOI: 10.1007/BF03391689.
75. European Commission. *EU4Health 2021-2027 – a vision for a healthier European Union*. 2021 [cited 2021 27-09]; Available from: https://ec.europa.eu/health/funding/eu4health_en.
76. Gray, R. *How vulnerable groups were left behind in pandemic response*. 2021 07-06-2021 [cited 2021 27-09]; Available from: <https://ec.europa.eu/research-and-innovation/en/horizon-magazine/how-vulnerable-groups-were-left-behind-pandemic-response>.
77. European Parliament. *European Parliament: Fact Sheets on the European Union. The internal market: general principles*. 2021 [cited 2021 26-09]; Available from: <https://www.europarl.europa.eu/factsheets/en/sheet/33/the-internal-market-general-principles>.
78. Kurrer, C. *Public health | Fact Sheets on the European Union*. 2021 [cited 2022 07-07]; Available from: <https://www.europarl.europa.eu/factsheets/en/sheet/49/public-health>.
79. Charlesworth, K., et al., *Health research in the European Union: over-controlled but under-measured?* European Journal of Public Health, 2011. **21**(4): p. 404-406. DOI: 10.1093/eurpub/ckp212.
80. DG Enterprise and Industry, *Food taxes and their impact on competitiveness in the agri-food sector, a study*. 2014: Rotterdam, Nederland. Available from: https://ec.europa.eu/growth/content/food-taxes-and-their-impact-competitiveness-agri-food-sector-study-0_en.
81. Capacci, S., et al., *The impact of the French soda tax on prices and purchases. An ex post evaluation*. PloS one, 2019. **14**(10): p. e0223196-e0223196. DOI: 10.1371/journal.pone.0223196.
82. Colchero, M.A., M. Molina, and C.M. Guerrero-López, *After Mexico Implemented a Tax, Purchases of Sugar-Sweetened Beverages Decreased and Water Increased: Difference by Place of Residence, Household Composition, and Income Level*. The Journal of Nutrition, 2017. **147**(8): p. 1552-1557. DOI: 10.3945/jn.117.251892.
83. Sisnowski, J., E. Handsley, and J.M. Street, *Regulatory approaches to obesity prevention: A systematic overview of current laws addressing diet-related risk factors in the European Union and the United States*. Health Policy, 2015. **119**(6): p. 720-731. DOI: 10.1016/j.healthpol.2015.04.013.

84. Carreño, I., *Chile's Black STOP Sign for Foods High in Fat, Salt or Sugar*. European Journal of Risk Regulation, 2015. **6**(4): p. 622-628. DOI: 10.1017/S1867299X0000516X.
85. Shangquan, S., et al., *A Meta-Analysis of Food Labeling Effects on Consumer Diet Behaviors and Industry Practices*. American journal of preventive medicine, 2019. **56**(2): p. 300-314. DOI: 10.1016/j.amepre.2018.09.024.
86. Kerr, M.A., M.T. McCann, and M.B.E. Livingstone, *Food and the consumer: could labelling be the answer?* Proceedings of the Nutrition Society, 2015. **74**(2): p. 158-163. DOI: 10.1017/S0029665115001676.
87. WHO technical staff. *Increasing fruit and vegetable consumption to reduce the risk of noncommunicable diseases*. 2014 [cited 2021 27-09]; Available from: <https://www.who.int/tools/elena/bbc/fruit-vegetables-ncds>.
88. Klepac Pogrmilovic, B., et al., *National physical activity and sedentary behaviour policies in 76 countries: availability, comprehensiveness, implementation, and effectiveness*. International Journal of Behavioral Nutrition and Physical Activity, 2020. **17**(1): p. 116. DOI: 10.1186/s12966-020-01022-6.
89. Osypuk, T.L., et al., *Do Social and Economic Policies Influence Health? A Review*. Current epidemiology reports, 2014. **1**(3): p. 149-164. DOI: 10.1007/s40471-014-0013-5.
90. White Paper on a Strategy for Europe on Nutrition, Overweight and Obesity related health issues, (2007). Office of the European Union,: 52007DC0279. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52008IP0461>.
91. Robertson, A., *Obesity and socio-economic groups in Europe: Evidence review and implications for action*. 2007.
92. European Commission. *Questions and Answers: EU4Health Programme 2021-2027*. 2021 [cited 2021 10-08]; Available from: https://ec.europa.eu/commission/presscorner/detail/en/QANDA_20_956.
93. European Commission. *Exchange of electronic health records across the EU*. 2021 [cited 2021 11-08]; Available from: <https://digital-strategy.ec.europa.eu/en/policies/electronic-health-records>.
94. Commission, E. *European Health Union*. 2022 [cited 2022 28.10.]; Available from: https://ec.europa.eu/info/strategy/priorities-2019-2024/promoting-our-european-way-of-life/european-health-union_en#documents.
95. Conference on the Future of Europe, *Conference on the Future of Europe. Report on the Final Outcome*. 2022. Available from: <https://www.europeansources.info/record/conference-on-the-future-of-europe-report-on-the-final-outcome/>.
96. Burris, S., et al., *A Transdisciplinary Approach to Public Health Law: The Emerging Practice of Legal Epidemiology*. Annual Review of Public Health, 2016. **37**(1): p. 135-148. DOI: 10.1146/annurev-publhealth-032315-021841.
97. Somasundaram, N.P. and N.S. Kalupahana, *Population-based dietary approaches for the prevention of noncommunicable diseases*. WHO South East Asia J Public Health, 2016. **5**(1): p. 22-26. DOI: 10.4103/2224-3151.206548.
98. Dietz, W.H., D.E. Benken, and A.S. Hunter, *Public health law and the prevention and control of obesity*. The Milbank quarterly, 2009. **87**(1): p. 215-227. DOI: 10.1111/j.1468-0009.2009.00553.x.
99. Haire-Joshu, D., et al., *Surveillance of obesity-related policies in multiple environments: the Missouri Obesity, Nutrition, and Activity Policy Database, 2007-2009*. Preventing chronic disease, 2010. **7**(4): p. A80-A80.

100. Penn-Newman, D., et al., *How well do national and local policies in England relevant to maternal and child health meet the international standard for non-communicable disease prevention? A policy analysis*. *BMJ Open*, 2018. **8**(11): p. e022062. DOI: 10.1136/bmjopen-2018-022062.
101. Kaselitz, E., G.K. Rana, and M. Heisler, *Public Policies and Interventions for Diabetes in Latin America: a Scoping Review*. *Curr Diab Rep*, 2017. **17**(8): p. 65. DOI: 10.1007/s11892-017-0888-x.
102. Egnell, M., et al., *Impact of Front-of-Pack Nutrition Labels on Portion Size Selection: An Experimental Study in a French Cohort*. *Nutrients*, 2018. **10**(9). DOI: 10.3390/nu10091268.
103. Grummon, A.H., et al., *How should sugar-sweetened beverage health warnings be designed? A randomized experiment*. *Prev Med*, 2019. **121**: p. 158-166. DOI: 10.1016/j.ypmed.2019.02.010.
104. Hyseni, L., et al., *The effects of policy actions to improve population dietary patterns and prevent diet-related non-communicable diseases: scoping review*. *Eur J Clin Nutr*, 2017. **71**(6): p. 694-711. DOI: 10.1038/ejcn.2016.234.
105. Bollard, T., et al., *Effects of plain packaging, warning labels, and taxes on young people's predicted sugar-sweetened beverage preferences: an experimental study*. *International Journal of Behavioral Nutrition and Physical Activity*, 2016. **13**(1): p. 95. DOI: 10.1186/s12966-016-0421-7.
106. Gelius, P., et al., *What are effective policies for promoting physical activity? A systematic review of reviews*. *Preventive Medicine Reports*, 2020. **18**: p. 101095. DOI: <https://doi.org/10.1016/j.pmedr.2020.101095>.
107. Wolfenden, L., et al., *Strategies to improve the implementation of workplace-based policies or practices targeting tobacco, alcohol, diet, physical activity and obesity*. *The Cochrane database of systematic reviews*, 2018. **11**(11): p. CD012439-CD012439. DOI: 10.1002/14651858.CD012439.pub2.
108. Long, M.W., et al., *Cost-Effectiveness Analysis and Stakeholder Evaluation of 2 Obesity Prevention Policies in Maine, US*. *J Nutr Educ Behav*, 2019. **51**(10): p. 1177-1187. DOI: 10.1016/j.jneb.2019.07.005.
109. Goiana-da-Silva, F., et al., *Projected impact of the Portuguese sugar-sweetened beverage tax on obesity incidence across different age groups: A modelling study*. *PLoS Med*, 2020. **17**(3): p. e1003036. DOI: 10.1371/journal.pmed.1003036.
110. Palmieri, L., et al., *Cardiovascular diseases monitoring: lessons from population-based registries to address future opportunities and challenges in Europe*. *Archives of Public Health*, 2018. **76**(1): p. 31. DOI: 10.1186/s13690-018-0283-3.
111. Piepoli, M.F., et al., *2016 European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts): Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR)*. *Eur J Prev Cardiol*, 2016. **23**(11): p. Np1-np96. DOI: 10.1177/2047487316653709.
112. van der Heijden, A.A., et al., *Policy evaluation in diabetes prevention and treatment using a population-based macro simulation model: the MICADO model*. *Diabet Med*, 2015. **32**(12): p. 1580-7. DOI: 10.1111/dme.12811.
113. Awad, S.F., et al., *Preventing type 2 diabetes mellitus in Qatar by reducing obesity, smoking, and physical inactivity: mathematical modeling analyses*. *Popul Health Metr*, 2019. **17**(1): p. 20. DOI: 10.1186/s12963-019-0200-1.

114. Nianogo, R.A. and O.A. Arah, *Impact of Public Health Interventions on Obesity and Type 2 Diabetes Prevention: A Simulation Study*. Am J Prev Med, 2018. **55**(6): p. 795-802. DOI: 10.1016/j.amepre.2018.07.014.
115. Sisnowski, J., J.M. Street, and T. Merlin, *Improving food environments and tackling obesity: A realist systematic review of the policy success of regulatory interventions targeting population nutrition*. PLoS One, 2017. **12**(8): p. e0182581. DOI: 10.1371/journal.pone.0182581.
116. Roberts, S., et al., *Efficacy of population-wide diabetes and obesity prevention programs: An overview of systematic reviews on proximal, intermediate, and distal outcomes and a meta-analysis of impact on BMI*. Obes Rev, 2019. **20**(7): p. 947-963. DOI: 10.1111/obr.12821.
117. Hu, F.B., A. Satija, and J.E. Manson, *Curbing the Diabetes Pandemic: The Need for Global Policy Solutions*. Jama, 2015. **313**(23): p. 2319-20. DOI: 10.1001/jama.2015.5287.
118. Magnusson, R.S., et al., *Legal capacities required for prevention and control of noncommunicable diseases*. Bull World Health Organ, 2019. **97**(2): p. 108-117. DOI: 10.2471/blt.18.213777.
119. Al Busaidi, N., P. Shanmugam, and D. Manoharan, *Diabetes in the Middle East: Government Health Care Policies and Strategies that Address the Growing Diabetes Prevalence in the Middle East*. Curr Diab Rep, 2019. **19**(2): p. 8. DOI: 10.1007/s11892-019-1125-6.
120. Den Braver, N.R., et al., *Built environmental characteristics and diabetes: a systematic review and meta-analysis*. BMC Medicine, 2018. **16**(1). DOI: 10.1186/s12916-017-0997-z.
121. Kumari, M., J. Head, and M. Marmot, *Prospective Study of Social and Other Risk Factors for Incidence of Type 2 Diabetes in the Whitehall II Study*. Archives of Internal Medicine, 2004. **164**(17): p. 1873-1880. DOI: 10.1001/archinte.164.17.1873.
122. Stringhini, S., et al., *Lifecourse socioeconomic status and type 2 diabetes: the role of chronic inflammation in the English Longitudinal Study of Ageing*. Sci Rep, 2016. **6**: p. 24780. DOI: 10.1038/srep24780.
123. Rumball-Smith, J., et al., *Diabetes associated with early labor-force exit: a comparison of sixteen high-income countries*. Health Aff (Millwood), 2014. **33**(1): p. 110-5. DOI: 10.1377/hlthaff.2013.0518.
124. Magadzire, B.P., T. Mathole, and K. Ward, *Reasons for missed appointments linked to a public-sector intervention targeting patients with stable chronic conditions in South Africa: results from in-depth interviews and a retrospective review of medical records*. BMC Family Practice, 2017. **18**(1). DOI: 10.1186/s12875-017-0655-8.
125. Pazmino, L., et al., *Impact of Work and Recreational Physical Activity on Prediabetes Condition among U.S. Adults: NHANES 2015–2016*. International Journal of Environmental Research and Public Health, 2021. **18**(4): p. 1378. DOI: 10.3390/ijerph18041378.
126. Kang, E., *Differences in Clinical Indicators of Diabetes, Hypertension, and Dyslipidemia Among Workers Who Worked Long Hours and Shift Work*. Workplace Health & Safety, 2021. **69**(6): p. 268-276. DOI: 10.1177/2165079920986160.
127. Vareiro, D., et al., *Availability of Mediterranean and non-Mediterranean foods during the last four decades: comparison of several geographical areas*. Public Health Nutrition, 2009. **12**(9A): p. 1667-1675. DOI: 10.1017/s136898000999053x.
128. Riccardi, G., M. Vitale, and O. Vaccaro, *Are Europeans moving towards dietary habits more suitable for reducing cardiovascular disease risk?* Nutrition, Metabolism and

- Cardiovascular Diseases, 2020. **30**(11): p. 1857-1860. DOI: <https://doi.org/10.1016/j.numecd.2020.07.018>.
129. Jiang, Z., et al., *Dietary fruit and vegetable intake, gut microbiota, and type 2 diabetes: results from two large human cohort studies*. BMC Medicine, 2020. **18**(1). DOI: 10.1186/s12916-020-01842-0.
 130. Cooper, A.J., et al., *A Prospective Study of the Association Between Quantity and Variety of Fruit and Vegetable Intake and Incident Type 2 Diabetes*. Diabetes Care, 2012. **35**(6): p. 1293-1300. DOI: 10.2337/dc11-2388.
 131. World Health Organization, *Action plan for the prevention and control of noncommunicable diseases in the WHO European Region*. 2016, World Health Organization. Regional Office for Europe. Available from: <https://iris.who.int/bitstream/handle/10665/341522/WHO-EURO-2016-2582-42338-58618-eng.pdf?sequence=1>.
 132. European Commission. *Non-communicable diseases overview*. [cited 2021 27-03]; Available from: https://ec.europa.eu/health/non-communicable-diseases/overview_en.
 133. Neuenschwander, M., et al., *Role of diet in type 2 diabetes incidence: umbrella review of meta-analyses of prospective observational studies*. BMJ (Clinical research ed.), 2019. **366**: p. 12368-12368. DOI: 10.1136/bmj.12368.
 134. López-Valenciano, A., et al., *Changes in sedentary behaviour in European Union adults between 2002 and 2017*. BMC Public Health, 2020. **20**(1). DOI: 10.1186/s12889-020-09293-1.
 135. Aune, D., et al., *Physical activity and the risk of type 2 diabetes: a systematic review and dose–response meta-analysis*. European Journal of Epidemiology, 2015. **30**(7): p. 529-542. DOI: 10.1007/s10654-015-0056-z.
 136. Ross, L.M., et al., *Effects of Amount, Intensity, and Mode of Exercise Training on Insulin Resistance and Type 2 Diabetes Risk in the STRRIDE Randomized Trials*. Frontiers in Physiology, 2021. **12**. DOI: 10.3389/fphys.2021.626142.
 137. Taheri, S., et al., *Effect of intensive lifestyle intervention on bodyweight and glycaemia in early type 2 diabetes (DIADEM-I): an open-label, parallel-group, randomised controlled trial*. Lancet Diabetes Endocrinol, 2020. **8**(6): p. 477-489. DOI: 10.1016/s2213-8587(20)30117-0.
 138. Erica Richardson, J.Z., Ellen Nolte, *National Diabetes Plans: in Europe What lessons are there for the prevention and control of chronic diseases in Europe?* 2016, Ljubljana National Institute of Public Health Available from: https://www.euro.who.int/data/assets/pdf_file/0009/307494/National-diabetes-plans-Europe.pdf.
 139. World Health Organization. *Diabetes country profiles: Slovakia*. 2016 [cited 2021 15-05]; Available from: https://www.who.int/diabetes/country-profiles/svk_en.pdf.
 140. World Obesity Federation. *Global Obesity Observatory*. [cited 2021 15-05]; Available from: <https://data.worldobesity.org/>.
 141. Mazzù, M.F., et al., *A cross-country experimental study on consumers' subjective understanding and liking on front-of-pack nutrition labels*. International Journal of Food Sciences and Nutrition, 2021. **72**(6): p. 833-847. DOI: 10.1080/09637486.2021.1873918.
 142. Curtain, F. and S. Grafenauer, *Health Star Rating in Grain Foods-Does It Adequately Differentiate Refined and Whole Grain Foods?* Nutrients, 2019. **11**(2). DOI: 10.3390/nu11020415.

143. Gillon-Keren, M., et al., *Development of Criteria for a Positive Front-of-Package Food Labeling: The Israeli Case*. *Nutrients*, 2020. **12**(6): p. 1875. DOI: 10.3390/nu12061875.
144. Olive Oil Times. *Nutri-Score Remains the Front Runner for Europe's Food Label Program*. 2021 [cited 2021 12-12]; Available from: <https://www.oliveoiltimes.com/business/nutri-score-front-runner-europe-food-labels/89919>.
145. European Commission. *Food labelling - revision of rules on information provided to consumers*. 2021 [cited 2021 12-12]; Available from: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12749-Food-labelling-revision-of-rules-on-information-provided-to-consumers/public-consultation_en.
146. Kumari, S. and G. Muralidhara, *Nestlé Under Fire Over Unhealthy Product Portfolio: Will the Company Emerge Unscathed?*, in *IUP Journal of Business Strategy*. 2021. p. 38-61.
147. Vasiljevic, M., R. Pechey, and T.M. Marteau, *Making food labels social: The impact of colour of nutritional labels and injunctive norms on perceptions and choice of snack foods*. *Appetite*, 2015. **91**: p. 56-63. DOI: 10.1016/j.appet.2015.03.034.
148. Mialon, M., et al., *Food industry political practices in Chile: "the economy has always been the main concern"*. *Globalization and Health*, 2020. **16**(1): p. 107. DOI: 10.1186/s12992-020-00638-4.
149. Mialon, M., et al., *'I had never seen so many lobbyists': food industry political practices during the development of a new nutrition front-of-pack labelling system in Colombia*. *Public Health Nutrition*, 2021. **24**(9): p. 2737-2745. DOI: 10.1017/S1368980020002268.
150. Hunt, D., *How food companies use social media to influence policy debates: a framework of Australian ultra-processed food industry Twitter data*. *Public Health Nutrition*, 2021. **24**(10): p. 3124-3135. DOI: 10.1017/S1368980020003353.
151. Sabat, I., et al., *United but divided: Policy responses and people's perceptions in the EU during the COVID-19 outbreak*. *Health Policy*, 2020. **124**(9): p. 909-918. DOI: 10.1016/j.healthpol.2020.06.009.
152. UK Department of Health and Social Care. *Building on the success of front-of-pack nutrition labelling in the UK: a public consultation 2020* [cited 2021 12.12.]; Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/905096/front-of-pack-labelling-consultation-document-english.pdf.
153. Kozinets, R.V., et al., *Networked Narratives: Understanding Word-of-Mouth Marketing in Online Communities*. *Journal of Marketing*, 2010. **74**(2): p. 71-89. DOI: 10.1509/jm.74.2.71.
154. Berger, J. and K.L. Milkman, *What Makes Online Content Viral?* *Journal of Marketing Research*, 2012. **49**(2): p. 192-205. DOI: 10.1509/jmr.10.0353.
155. Hamilton, R., *Shared Consumption Experiences*. Impact at JMR, 2021(May).
156. Rutsaert, P., et al., *The use of social media in food risk and benefit communication*. *Trends in Food Science & Technology*, 2013. **30**(1): p. 84-91. DOI: <https://doi.org/10.1016/j.tifs.2012.10.006>.
157. Muzzioli, L., et al., *Are Front-of-Pack Labels a Health Policy Tool?* *Nutrients*, 2022. **14**(4). DOI: 10.3390/nu14040771.
158. de Boer, A., *Fifteen Years of Regulating Nutrition and Health Claims in Europe: The Past, the Present and the Future*. *Nutrients*, 2021. **13**(5): p. 1725.

159. Federalimentare. *Etichetta a batteria, Federalimentare: Battaglia unanime contro il Nutriscore*. 2020 [cited 2021 12-12]; Available from: http://www.federalimentare.it/new2016/ms_comunicati_det.asp?ID=976.
160. LLP, K.a.H. *EU wants harmonised front of pack nutrition labelling before end 2022*. 2020 [cited 2021 12-12]; Available from: <https://www.lexology.com/library/detail.aspx?g=6aafd588-7ecc-436f-b82a-19c20d54637d#:~:text=EU%20wants%20harmonised%20front%20of%20pack%20nutrition%20labelling%20before%20end%202022,-Blog%20Tomorrow's%20Food&text=As%20a%20minimum%2C%20the%20nutrition,format%20with%20the%20numbers%20aligned>.
161. Hung, Y., et al., *Setting Policy Priorities for Front-of-Pack Health Claims and Symbols in the European Union: Expert Consensus Built by Using a Delphi Method*. *Nutrients*, 2019. **11**(2). DOI: 10.3390/nu11020403.
162. Moore, S.G., et al., *Effect of Educational Interventions on Understanding and Use of Nutrition Labels: A Systematic Review*. *Nutrients*, 2018. **10**(10): p. 1432. DOI: 10.3390/nu10101432.
163. Egnell, M., et al., *Objective understanding of the Nutri-score front-of-pack label by European consumers and its effect on food choices: an online experimental study*. *International Journal of Behavioral Nutrition and Physical Activity*, 2020. **17**(1): p. 146. DOI: 10.1186/s12966-020-01053-z.
164. Song, J., et al., *Impact of color-coded and warning nutrition labelling schemes: A systematic review and network meta-analysis*. *PLOS Medicine*, 2021. **18**(10): p. e1003765. DOI: 10.1371/journal.pmed.1003765.
165. Champagne, B., et al., *World Heart Federation Policy Brief: Front-Of-Pack Labelling: Unhealthy Changes in the Global Food System*. *Global heart*, 2020. **15**(1): p. 70-70. DOI: 10.5334/gh.935.
166. Brosius, A., E.J. van Elsas, and C.H. de Vreese, *Trust in context: National heuristics and survey context effects on political trust in the European Union*. *European Union Politics*, 2020. **21**(2): p. 294-311. DOI: 10.1177/1465116519896010.

7.2 References by the library



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Subject: PhD Publication List

Candidate: Nour Mahrouseh
Doctoral School: Doctoral School of Health Sciences

List of publications related to the dissertation

1. Septia Irawan, A., Shahin, B., Wangeshi Njuguna, D., Nellamkuzhi, N. J., Thiên, B. Q., **Mahrouseh, N.**, Varga, O.: Analysis of Content, Social Networks, and Sentiment of Front-of-Pack Nutrition Labeling in the European Union on Twitter.
Front. Nutr. 9, 1-14, 2022.
DOI: <http://dx.doi.org/10.3389/fnut.2022.846730>
IF: 6.59 (2021)
2. **Mahrouseh, N.**, Lovas, S., Njuguna, D. W., Nellamkuzhi, N. J., Soares, A. C. A., Sackey, W. E., Irawan, A. S., Varga, O.: How the European Union legislations are tackling the burden of diabetes mellitus: a legal surveillance study.
Front. Public Health. 10, 1-12, 2022.
DOI: <http://dx.doi.org/10.3389/fpubh.2022.1002265>
IF: 6.461 (2021)
3. **Mahrouseh, N.**, Soares, A. C. A., Kovács, N., Njuguna, D. W., Varga, O.: Diabetes Mellitus and Associated Factors in Slovakia: results from the European Health Interview Survey 2009, 2014, and 2019.
Nutrients. 13 (7), 1-11, 2021.
DOI: <http://dx.doi.org/10.3390/nu13072156>
IF: 6.706
4. Lovas, S., **Mahrouseh, N.**, Bolaji, O. S., Nellamkuzhi, N. J., Soares, A. C. A., Njuguna, D. W., Varga, O.: Impact of Policies in Nutrition and Physical Activity on Diabetes and Its Risk Factors in the 28 Member States of the European Union.
Nutrients. 13 (10), 1-17, 2021.
DOI: <http://dx.doi.org/10.3390/nu13103439>
IF: 6.706





List of other publications

5. Soares, A. C. A., Paz, J. L. C., de Melo, G. S., **Mahrouseh, N.**, Januário, A. L., Capeletti, L. R.:
Survival rate and peri-implant evaluation of immediately loaded dental implants in individuals with type 2 diabetes mellitus: a systematic review and meta-analysis.
Clin. Oral Investig. 26 (2), 1797-1810, 2022.
DOI: <http://dx.doi.org/10.1007/s00784-021-04154-6>
IF: 3.606 (2021)
6. Bencze, Z., Kovalecz, G., Márton, S., Gáll, T., **Mahrouseh, N.**, Varga, O.: Childhood caries management in the European Union: a cross-sectional study.
Heliyon. 7 (2), 1-10, 2021.
DOI: <http://dx.doi.org/10.1016/j.heliyon.2021.e06198>
IF: 3.776
7. Njuguna, D. W., **Mahrouseh, N.**, Isowamwen, O. V., Varga, O.: Knowledge, Attitude and Practice of Main Stakeholders towards Human Papilloma Virus Infection and Vaccination in Mombasa and Tana-River Counties in Kenya: a Qualitative Study.
Vaccines. 9 (10), 1-16, 2021.
DOI: <http://dx.doi.org/10.3390/vaccines9101099>
IF: 4.961
8. Bencze, Z., **Mahrouseh, N.**, Soares, A. C. A., Kovács, N., Varga, O.: The Burden of Early Childhood Caries in Children under 5 Years Old in the European Union and Associated Risk Factors: an Ecological Study.
Nutrients. 13 (2), 1-12, 2021.
DOI: <http://dx.doi.org/10.3390/nu13020455>
IF: 6.706
9. Onisoyonivosekume, D., **Mahrouseh, N.**, Varga, O.: Introduction to Health Law.
In: Health Information Management: Empowering Public Health. Ed.: John Mantas, Ramo Sendelj, Ivana Ognjanovic, Petra Knaup, Elske Ammenwerth, Orsolya Varga, Ios Press, Amsterdam, 10-18, 2020.





10. Njuguna, D. W., **Mahrouseh, N.**, Onisoyonivosekume, D., Varga, O.: National Policies to Prevent and Manage Cervical Cancer in East African Countries: a Policy Mapping Analysis. *Cancers (Basel)*. 12 (6), 1-16, 2020.
DOI: <https://doi.org/10.3390/cancers12061520>
IF: 6.639

Total IF of journals (all publications): 52,151

Total IF of journals (publications related to the dissertation): 26,463

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

14 June, 2023



8. Keywords

Diabetes mellitus, Disease burden, European Union, Policies, non-communicable diseases, Front-of-pack nutrition labeling, Public discourse, European Commission (EC), obesity

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With profound gratitude,

Nour Mahrouseh

10. Appendix

Appendix 1: Type of legislations included and their definitions:

The search was limited to the following types of documents and their definitions:

1. EU treaties are binding agreements between member countries of the European Union.
2. The current active treaty is the Treaty on the Functioning of the EU (TFEU).
3. The main legal acts derived from the Treaties include regulations, directives, decisions, recommendations, and opinions.
4. Consolidation texts are comprehensive documents that include the original act and all subsequent amendments.
5. International agreements are agreements between member states, the EU, and/or the European Atomic Energy Community with other countries or international organizations.
6. Preparatory documents are generated during the process of developing EU legislation and are created at different stages of the legislative and budgetary process.
7. EFTA documents are produced by the EFTA institutions to promote free and economic trade among their member states, both within Europe and globally.

Appendix 2: Overview of the themes target population and functional categories used:

Themes covered in the WHO Global report on diabetes and EU strategic framework for the prevention of NCDs guidelines:

- Life-course approach to preventing diabetes: Legislative measures to prevent diabetes by addressing early childhood as a critical period for intervention, considering the establishment of food and exercise habits and long-term energy balance management. This approach recognizes the increasing risk associated with diabetes throughout one's life.

- Improving early childhood nutrition: Strategies to enhance early childhood nutrition, including improving maternal health, promoting healthy nutrition during pregnancy and early childhood, and encouraging physical activity while discouraging the consumption of calorie-dense, fatty, sugary, and salty foods.
- Supportive environments for physical activity: Actions aimed at reducing overweight and obesity, such as urban planning and active transport regulations to promote walking, cycling, and non-motorized transportation. Additionally, creating physical environments that offer recreational and sporting opportunities while ensuring safe places for physical activity for both children and adults.
- Settings-based interventions: Interventions focusing on the environment to prevent and manage diabetes. These interventions aim to implement population-wide and targeted interventions within families and communities, considering the places where people live, learn, work, and engage in recreational activities.
- Fiscal, legislative, and regulatory measures for healthy diet: Legislative actions that involve increasing the prices of high-fat, high-sugar, and high-salt foods to discourage their consumption, as well as reducing the prices of healthier food options to promote healthier choices.
- Trade and agricultural policies that promote healthy diets: Legislative measures aimed at boosting the production, transportation, and marketing of fruits, vegetables, and healthier food options to improve dietary patterns.
- Regulation of marketing of foods high in sugars, fats, and salt: Legislative actions to control the marketing of unhealthy foods, particularly to minors, and promote better food choices through nutrition labeling, calorie information, and other measures.

- Education, social marketing, and mobilization: Legislative initiatives involving ongoing media campaigns and educational programs to promote healthy eating habits, discourage the consumption of unhealthy foods, and encourage physical exercise.
- Preventing diabetes in high-risk individuals: Legislative interventions targeted at individuals with impaired glucose tolerance, impaired fasting glucose, or other high-risk factors, focusing on dietary changes, increased physical activity, and weight loss.
- Implementation of WHO 'Best buys': Legislation supporting the implementation of the WHO's "Best Buys" and other recommended interventions, which are evidence-based policy measures addressing the major risk factors and disease categories associated with non-communicable diseases (NCDs).
- Tackling health inequalities and adopting a rights-based approach: Legislative measures addressing health inequalities, socioeconomic factors, and targeting the poorest and most disadvantaged population groups.
- Establishing a pan-European system for data collection, policy evaluation, and accountability: Legislative actions aimed at creating an EU-wide health data system, including registries for NCD incidence, prevalence, health outcomes, costs, and key risk factors. These measures aim to address data gaps, improve data collection methods, and provide funding for data collection.
- Ensuring inter-institutional coordination on health and well-being and a policy home for health within the European Commission structure: Legislative efforts to promote coordination and collaboration across institutions, particularly in the fields of public health and other relevant areas.
- Launching a 'Health in All Policies' online policy portal: Legislative measures to establish an online platform that promotes a comprehensive approach to health, particularly for

NCDs, through tracking tools and serving as a repository for impact assessments of policy initiatives.

- Pursuing 'EU flagship initiatives' with co-benefits for NCD prevention and other SDGs (Sustainable Development Goals): Legislative actions that focus on collaboration with organizations, professionals, and legislators to address potential conflicts of interest and ensure effective use of policy resources.

List of target population based on population aimed to be addressed by legislations identified by Timpel et al.:

- Pregnant women and young families
- Children and adolescents
- Working-age population
- The elderly
- General population
- Governments
- Communities or non-governmental organizations (NGOs)
- Not defined or not applicable

List of functional categories used by legislations to address determinants of DM, NCDs, and obesity:

- Energy intake: Legislations focused on promoting a healthy diet through measures such as nutrition laws, food labeling regulations, calorie intake guidelines, food taxation policies, and other initiatives aimed at regulating dietary habits.
- Energy expenditure: Legislations aimed at increasing physical activity levels by implementing measures such as promoting sports and recreational activities, creating infrastructure to support physical activity (e.g., parks, walking trails),

improving transportation systems to encourage active commuting, and other initiatives that facilitate regular exercise.

- Information: Legislations aimed at collecting relevant data on health, implementing health education programs to raise awareness about healthy eating habits and exercise routines, providing accessible and accurate information on maintaining a healthy weight, and other initiatives that promote informed decision-making regarding lifestyle choices.
- Screening and treatment: Legislations focused on population-wide screening efforts to identify individuals at high risk for DM, NCDs, and obesity, monitoring and managing high-risk patients through healthcare systems, and implementing regulations related to the production, distribution, and use of medications for managing these conditions.

Appendix 3: List of policy categories, policy areas and sub-policy areas from the NOURISHING and MOVING policy databases by the the World Cancer Research Fund International (WCRF International)

Number of implemented government policy actions promoting healthy diets and targeting physical activity, national diabetes plans in effect and national diabetes register in operation in the EU member states and their diabetes prevalence, 2014.

P o l i c y c a t e g o r i e s	C a t e g o r i e s	P o l i c y A r e a s	S u b - p o l i c y A r e a s	A	B	B	C	D	G	E	I	G	S	F	C	L	L	H	M	N	P	R	S	S	F	S	U	
				u	e	u	z	e	e	s	r	r	r	r	p	r	r	a	i	x	a	e	e	o	l	l	i	w
N	F	Nutrition label standards and regulations on	Mandatory nutrient lists on packaged food*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

populated areas in 2014 and self-reported answers indicating towns and suburbs in 2019; and Rural areas, which were derived from self-reported answers indicating thinly-populated areas.

- Educational level was derived from the question "What is the highest education leaving certificate, diploma, or education degree you have obtained?" The self-reported answers were divided into three categories: Primary or less than primary education, which was derived from self-reported answers indicating no formal education or below, primary education, and lower secondary education in 2014; Secondary education, which was derived from self-reported answers indicating upper secondary education, post-secondary but non-tertiary education, and tertiary education short-cycle; and Higher education, which was derived from self-reported answers indicating bachelor level or equivalent, master level or equivalent, and doctoral level or equivalent.
- Labour status was derived from the question "How would you define your current labour status?" The self-reported answers were divided into three categories: Employed, which was derived from self-reported answers indicating carrying out a job or profession, including unpaid work for a family business or holding an apprenticeship or paid traineeship, etc.; Unemployed, which was derived from the self-reported answer indicating unemployed; and Others, which included self-reported answers indicating pupil, student, further training, unpaid work experience, in retirement or early retirement or having given up business, permanently disabled, in compulsory military or community service, fulfilling domestic tasks, and other inactive person.
- Net monthly equivalised income of the household the respondent belongs to was derived from the question "Net monthly equivalised income of the household the respondent belongs to." The self-reported answers were divided into three categories: Between 1st quintile and 2nd quintile, which was derived from self-reported answers

indicating below 1st quintile and between 1st quintile and 2nd quintile; Between 2nd quintile and 4th quintile, which was derived from self-reported answers indicating between 2nd quintile and 3rd quintile and between 3rd quintile and 4th quintile; and Between 4th quintile and 5th quintile, which was derived from self-report answers indicating between 4th quintile and 5th quintile.

- BMI was calculated based on two questions: "How tall are you without shoes?" and "How much do you weigh without clothes and shoes?" The self-reported answers were available in centimeters (cm) and kilograms (kg) respectively. BMI was calculated using the formula " kg/m^2 " and divided into three categories: <25 , 25-29.9, and ≥ 30 .
- Frequency of eating fruits was based on the question "How often do you eat fruits (excluding juice)?" The self-reported answers were divided into three categories: One or more times per day, derived from self-reported answers indicating once or more a day; 1 to 6 times a week, derived from self-reported answers.
- Frequency of eating vegetables was based on the question "How often do you eat vegetables or salad, excluding juice and potatoes?" The self-reported answers were divided into three categories: One or more times per day, derived from self-reported answers indicating once or more a day; 1 to 6 times a week, derived from self-reported answers.

Appendix 5: Definitions of the variables based on the European Health Interview Survey 2009, 2014 and 2019 (EHIS wave 1, wave 2 and wave 3)

List variables and their definitions:

- Sex was based on the question "Sex." The self-reported answers were divided into two categories: male and female.

- Age was based on the question "Age of the person interviewed at the moment of interview" in 2009, the question "Age of respondent in completed years at the time of the interview" in 2014, and the question "Year of birth" in 2019. The self-reported answers were divided into three categories: 15-44, 45-64, and 65 and older.
- Region was based on the question "Region of residence." The self-reported answers were categorized according to NUTS (Nomenclature of Territorial Units for Statistics) at the 2-digit level.
- Degree of urbanization was based on the question "Degree of urbanisation." The self-reported answers were divided into three categories. Cities: based on self-reported answers indicating densely-populated areas in 2009, 2014, and cities in 2019. Towns and suburbs: based on self-reported answers indicating intermediate-populated areas in 2009, 2014, and towns and suburbs in 2019. Rural areas: based on self-reported answers indicating thinly-populated areas in 2009, 2014, and rural areas in 2019.
- Educational level was based on the question "What is the highest education leaving certificate, diploma, or education degree you have obtained?" The self-reported answers were divided into three categories. Primary or less than primary education: based on self-reported answers indicating no formal education or below, primary education, and lower secondary education in 2009, 2014, and 2019. Secondary education: based on self-reported answers indicating upper secondary education, post-secondary but non-tertiary education, and tertiary education short-cycle in 2009, 2014, and 2019. Higher education: based on self-reported answers indicating the first stage of tertiary education, second stage of tertiary education in 2009, and bachelor level or equivalent, master level or equivalent, doctoral level or equivalent in 2014 and 2019.
- Labour status was based on the question "How would you define your current labour status?" The self-reported answers were divided into three categories. Employed: based

on the self-reported answer indicating working for pay or profit (including unpaid work for a family business or holding, including an apprenticeship or paid traineeship, including currently not at work due to maternity, parental, sick leave, or holidays) in 2009, the self-reported answer indicating carrying out a job or profession, including unpaid work for a family business or holding, an apprenticeship or paid traineeship, etc. in 2014, and the self-reported answer indicating employed in 2019. Unemployed: based on the self-reported answer indicating unemployed in 2009, 2014, and 2019. Others: based on the self-reported answers indicating pupil, student, further training, unpaid work experience, in retirement or early retirement or has given up business, permanently disabled, in compulsory military or community service, fulfilling domestic tasks, other in 2009, the self-reported answers indicating pupil, student, further training, unpaid work experience, in retirement or early retirement or has given up business, permanently disabled, in compulsory military or community service, fulfilling domestic tasks, and other inactive person in 2014, and the self-reported answers indicating retired, unable to work due to longstanding health problems, student, pupil, fulfilling domestic tasks, compulsory military or civilian service, and other in 2019.

- BMI was calculated based on two questions: "How tall are you without shoes?" and "How much do you weigh without clothes and shoes?" The self-reported answers were available in centimeters (cm) and kilograms (kg), respectively. BMI was calculated using the formula " kg/m^2 " and divided into three categories: <25 , 25-29.9, and ≥ 30 .
- Frequency of walking for at least 10 minutes continuously for transportation purposes (to get to and from places) per week was based on the question "In a typical week, on how many days do you walk for at least 10 minutes continuously in order to get to and from places?" The self-reported answers indicating the number of days were divided into three categories. Everyday: self-reported number of days equal to or larger than 7

days per week. 1 to 6 times a week: self-reported number of days between 1 to 6 days per week. Less than once a week and never: self-reported number of days equal to 0 days per week.

- Physical activity was based on merging two questions: "During the past 7 days, on how many days did you do vigorous physical activities?" and "During the past 7 days, on how many days did you do moderate physical activities?" The self-reported answers were divided into three categories. 2 days and more: self-reported number of days equal to or larger than 2 days per week. Never: self-reported number of days equal to 0 days per week. One day per week: self-reported number of days equal to 1 day per week.
- Frequency of eating fruits was based on the question "How often do you eat fruits (excluding juice)?" The self-reported answers were divided into three categories. One and more per day: based on self-reported answers indicating twice or more a day and once a day in 2009, and self-reported answers indicating once or more a day in 2014 and 2019. 1 to 6 times a week: based on self-reported answers indicating less than once a day but at least 4 times a week, and less than 4 times a week but at least once a week. Less than once a week and never: based on the self-reported answers indicating less than once a week and never.
- Frequency of eating vegetables or salad was based on the question "How often do you eat vegetables or salad (excluding juice and potatoes)?" The self-reported answers were divided into three categories. One and more per day: based on self-reported answers indicating twice or more a day and once a day in 2009, and self-reported answers indicating once or more a day in 2014 and 2019. 1 to 6 times a week: based on self-reported answers indicating less than once a day but at least 4 times a week, and less than 4 times a week but at least once a week. Less than once a week and never: based on the self-reported answers indicating less than once a week and never.

Appendix 6: Search terms used for Tweets extraction

The search terms used to gather Tweets form Twitter on nutrition labelling and related concepts are available in the below search string:

“Nutriscore OR Keyhole Nutrition labeling OR Nutrition labeling OR front-of-package labeling OR Fop labeling OR Food labeling OR heart symbol Nutrition labeling OR Nutrition labeling traffic light OR Nutrition labeling healthy choices tick OR Healthy living guarantee mark OR Zivjeti zdravo OR Nutrition Labeling Battery”

Appendix 7: Categories and definitions manual coding guidance

List of categories that serve as guidance for explaining the criteria and definitions utilized during manual coding. The primary category is Relevance, which is then followed by four additional categories: Opinion, Announcement, Science, and EU Regulations.

Category	Definition
Relevance	If the content of the tweets is in any way connected to food labeling, such as Nutri-score, color-coded nutrient schemes, or other relevant topics, it is coded as 1. If the tweet is unrelated to food labeling, it is coded as 0. A relevant tweet may fall into one or more sub-categories.
Subcategory	
Opinion	If an individual expresses their viewpoint, sentiment, or judgment, not based on knowledge or scientific facts, on any topic related to food labelling systems in the EU, it is coded as 1. If the tweet is not expressing an opinion, it is coded as 0.
Announcement	If the tweet solely consists of factual statements or declarations regarding the food labelling system, it is coded as 1. If the tweet is irrelevant to making an announcement, it is coded as 0.

Science	If the tweet shares information related to evidence-based science on food labelling, it is coded as 1. If the tweet is unrelated to scientific evidence, it is coded as 0.
EU regulations	If the tweet is connected to EU food labelling policies and includes any commentary on EU food labelling regulations or legal acts, it is coded as 1. If the tweet is irrelevant to EU regulations, it is coded as 0.

Appendix 8: List of legislations and their details

List of legislations and their details including their CELEX numbers, dates of documents, dates of publication, dates of end of validity and authors.

Title	CELEX number	Date of document	Date of publication	Author	Date of end of validity
Addressing the EU diabetes epidemic European Parliament resolution of 14 March 2012 on addressing the EU diabetes epidemic (2011/2911(RSP))	52012IP0082	3/14/2012	8/31/2013	European Parliament	No end date
Commission staff working document - Summary of dietary recommendations for people with diabetes	52008SC2295	7/10/2008		European Commission	No end date
Commission staff working document - Summary of main points of scientific basis of the dietary recommendation for diabetics	52008SC2294	7/10/2008		European Commission	No end date

Council conclusions on promotion of healthy lifestyles and prevention of Type 2 diabetes	52006XG0623(01)	6/23/2006	6/23/2006	Council of the European Union	
Report from the Commission to the European Parliament and the Council on foods for persons suffering from carbohydrate metabolism disorders (diabetes)	52008DC0392	6/26/2008		European Commission	No end date
98/251/EC: Commission Decision of 21 May 1997 on the proposal of Austria to award aid to the Hoffmann-La Roche company for the development of the drug 'Orlistat', designed for the treatment of pathological obesity (Only the German text is authentic) (Text with EEA relevance)	31998D0251	5/21/1997	4/3/1998	European Commission	No end date
Commission Decision of 17 July 2018 setting up a Commission expert group 'Steering Group on Health Promotion, Disease Prevention and Management of Non-Communicable Diseases' and repealing the Decision setting up a Commission expert group	32018D0718(02)	7/17/2018	7/18/2018	Directorate-General for Health and Food Safety, European Commission	12/31/2023

on rare diseases and the Decision establishing a Commission expert group on Cancer Control (Text with EEA relevance.)					
Commission Delegated Regulation (EU) 2017/1522 of 2 June 2017 supplementing Regulation (EU) No 609/2013 of the European Parliament and of the Council as regards the specific compositional and information requirements for total diet replacement for weight control (Text with EEA relevance)	32017R1522	6/2/2017	9/6/2017	European Commission, Directorate-General for Health and Food Safety	9/6/2017
Commission Delegated Regulation (EU) 2017/1798 of 2 June 2017 supplementing Regulation (EU) No 609/2013 of the European Parliament and of the Council as regards the specific compositional and information requirements for total diet replacement for weight control (Text with EEA relevance)	32017R1798	6/2/2017	10/7/2017	Directorate-General for Health and Food Safety, European Commission	No end date
Commission staff working document - accompanying the White paper on a Strategy for	52007SC0707	5/31/2007		European Commission	No end date

Europe on Nutrition, Overweight and Obesity related health issues - Summary of the Impact Assessment {COM(2007) 279 final}11124 {SEC(2007) 706}					
Commission staff working document accompanying the White Paper on a Strategy for Europe on Nutrition, Overweight and Obesity related health issues Impact assessment {COM(2007) 279 final} {SEC(2007) 707}	52007SC0706	5/31/2007		European Commission	No end date
Council Conclusions of 2 December 2002 on obesity	52003XG0117(01)	12/2/2002	1/17/2003	Council of the European Union	No end date
Council conclusions to contribute towards halting the rise in Childhood Overweight and Obesity	52017XG0629(01)	6/29/2017	6/29/2017	Council of the European Union	
EU position and commitment in advance of the UN high-level meeting on the prevention and control of non-communicable diseases European Parliament resolution of 15 September 2011 on European Union position and commitment in advance to the UN high-level	52011IP0390	9/15/2011	2/22/2013	European Parliament	

meeting on the prevention and control of non-communicable diseases					
European Parliament resolution on 'Promoting healthy diets and physical activity: a European dimension for the prevention of overweight, obesity and chronic diseases' (2006/2231(INI))	52007IP0019	2/1/2007	10/25/2007	Committee on the Environment, Public Health and Food Safety, European Parliament	
Green Paper - \Promoting healthy diets and physical activity : a European dimension for the prevention of overweight	/* COM/2005/0637 final */	12/8/2005	12/8/2005	European Commission	No end date
Opinion of the Commission for Sustainable Development on A strategy for Europe on nutrition, overweight and obesity related health issues	52007AR0312	2/7/2008	4/25/2008	European Committee of the Regions	No end date
Opinion of the European Economic and Social Committee on Obesity in Europe — role and responsibilities of civil society partners	52005IE1070	9/28/2005	1/31/2006	European Economic and Social Committee	No end date
Position (EU) No 3/2013 of the Council at first reading with a view to the adoption of a	52013AG0003	4/22/2013	6/15/2013	Council of the European Union	

<p>Regulation of the European Parliament and of the Council on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control and repealing Council Directive 92/52/EEC, Commission Directives 96/8/EC, 1999/21/EC, 2006/125/EC and 2006/141/EC, Directive 2009/39/EC of the European Parliament and of the Council and Commission Regulations (EC) No 41/2009 and (EC) No 953/2009 Adopted by the Council on 22 April 2013#Statement by the Federal Republic of Germany#Statement by the United Kingdom</p>					
<p>Regulation (EU) No 609/2013 of the European Parliament and of the Council of 12 June 2013 on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control and repealing</p>	<p>32013R0609</p>	<p>6/12/2013</p>	<p>2014-05-29, 2013-06-29</p>	<p>Council of the European Union, European Parliament</p>	<p>No end date</p>

<p>Council Directive 92/52/EEC, Commission Directives 96/8/EC, 1999/21/EC, 2006/125/EC and 2006/141/EC, Directive 2009/39/EC of the European Parliament and of the Council and Commission Regulations (EC) No 41/2009 and (EC) No 953/2009 Text with EEA relevance</p>					
<p>White Paper on a Strategy for Europe on Nutrition, Overweight and Obesity related health issues</p>	52007DC0279	5/30/2007		European Commission	No end date
<p>White Paper on Nutrition, Overweight and Obesity-related health issues European Parliament resolution of 25 September 2008 on the White Paper on nutrition, overweight and obesity-related health issues (2007/2285(INI))</p>	52008IP0461	9/25/2008	1/14/2010	Committee on the Internal Market and Consumer Protection, European Parliament, Committee on the Environment, Public Health and Food Safety, Committee on Women's Rights and Gender Equality, Committee on Agriculture and Rural Development	

Appendix 9: Top 10 most influential users

The ranking of the top 10 most influential users is determined by considering the total number of followers acquired through Re-tweets, Reply to Tweet, and quoted Tweet. The list of influential users in the EU is primarily dominated by individuals from four countries: Spain, France, the United Kingdom, and Germany.

Rank	User ID	User Name	Category	Country	User Description	User Background	Tweet Preference	Tweet Example
1	273084024	@NanBabio	person	Spain	Degree in nutrition from the University of Buenos Aires and PhD from the Rovira i Virgili University.	Scientist	Support traffic light system, nutriscore as a better label system for Spanish food regulation	@DrTinahones: «The nutritional traffic light #Nutriscore is better than the current system, but it must be adapted to Spain» https://t.co/YhkAcEF4Vm via @diariosur
2	22653020	@Teolemon	person	France	Co-founder openfoodfacts.org and openbeautyfacts.org	Activist	Support nutriscore on all french products	@agnesbuzyrn @StRAVERT @BGriveaux The #nutriscore is available on all French products from today thanks to @OpenFoodFactsFr https://t.co/FOBdkVYbJR
3	927742304	@FoodAllergyAW	organization	United Kingdom	Enterprise/business sector with a focus on reviewing human allergen policies and processes	Company	Support food allergy labelling	@CEDAUK pls RT serve food? Be aware of compulsory food allergy labelling decl14 start planning now checkout wkshop http://t.co/k5zAyMJjVv
4	8.55E+17	@Resourceful1942	person	Germany	Retired linguist Passions, activist on the environment, health, and the rights of all living creatures	Activist	Support nutriscore labelling	How can anyone still be agreeing that labelling is unnecessary. It is essential for true choice. More people realise the harm that #BigAg and #BigFood is causing. They have a right to know food is safe. Too many have already paid the price...
5	2333109386	@Hercberg5	person	France	Professor of Nutrition, Faculty of Medicine, University Sorbonne Paris North	Scientist	Support implementation nutriscore in Europe	Thank you to the Federation of Diabetics for their long-standing support for #NutriScore and their commitment to make it mandatory in Europe by calling to sign the petition https://t.co/RfHMORSQ8c https://t.co/XzOP0yk4O1
6	538574076	@SolanoLuisa	person	Spain	Nutritionist	Scientist	Against nutriscore in term define the nutrition level	@ArisChristod I gree with you, NutriScore damage the healthy image od EVOO by having the same classification as refined ones. They are absolutely different in terms of nutritional quality.
7	42330442	@Facundoetche	person	France	Global Public Affairs in Danone	Employee	Support nutriscore, FOP to guide food choices	#NutriScore #FOP in order to better choose the foods we consume https://t.co/QhHDZHWluN via @YouTube
8	1448362592	@QualivoresOc	organization	France	Hobby organisation	Non profit organisation	Against implementation nutriscore on local product	#StopNutriscore The #nutriscore on local products is an aberration. Heirs to ancestral recipes, quality products from #Occitanie supported by #IRQUALUM are continuing to mobilize. #food https://t.co/3Hfj8mwsEK
9	380898514	@21stringer	person	United Kingdom	Person live in United Kingdom	No data	Neutral statement	@globaljukeboxer @panamadip @SteveLawrence_ @Morrisons Non-EU is a technical labelling term used in the single market when it's a blend from multiple countries. \n\nit's a requirement of ... the EU ?? \n\n https://t.co/3AOcUlbqVou
10	2676348891	@gord1brad	person	United Kingdom	Person live in United Kingdom	No data	Support to reimplement food labelling in UK	rule out " ? ? Haaaaaaaaaaaaaaaaaaaaaw ! Accepting Yankee crap and scrapping EU food labelling regs so we can't know WHAT we're eating is the first demand in the surrender and occupation document Trump has dictated for us to sign !

Appendix 10: Sentiment analysis Tweets by organizations and persons

The presented table showcases the sentiment analysis of tweets from two distinct categories, namely "organization" and "person," based on four different types of sentiments. The results

of the sentiment analysis indicated that individuals exhibited a greater frequency of both negative and positive sentiments compared to organizations.

	Very negative	Moderately negative	Moderately positive	Very positive
Organization	23,22%	37,57%	24,52%	14,69%
Person	30,32%	28,35%	23,97%	17,35%