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HEALTH INSURANCE AND HEALTH ECONOMIC ASPECTS OF DIABETES MELLITUS AND DIETARY HABITS

Ph.D. Thesis

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1. Introduction

The four main chronic non-communicable disease groups (cancer, respiratory diseases, cardiovascular diseases and diabetes) account for 74% of all deaths worldwide. Although in recent years, some chronic diseases have been reported to have declining mortality and incidence rates, the prevalence remains high. This may be explained by the increasing life expectancy at birth or the development of more advanced healthcare technologies (diagnostic procedures, new technologies resulting in decreased mortality).

According to the Global Burden of Disease (GBD), worldwide annual mortality attributed to diabetes mellitus (1.5 million) ranks fourth, following cardiovascular diseases (17.9 million deaths per year), cancer (9.3 million), and respiratory diseases (4.1 million).

The Sustainable Development Goals (SDGs) is an action plan aimed at increasing well-being globally. Within this program, goals to be achieved by 2030 have been set, the fulfillment of which is crucial for the health of the population and for proper economic development. Regarding chronic non-communicable diseases, one of the goals is to reduce premature mortality by one-third by 2030 through prevention and treatment, which aligns with the theme of this dissertation. A study published in The Lancet illustrating the current status of the aforementioned goal highlighted that while there is indeed a decreasing trend in mortality related to the four most significant chronic diseases, the risk of mortality from diabetes is decreasing at the slowest rate.

As for the above indicators, Hungary is in an unfavourable position on an international level. According to the Hungarian Central Statistical Office (KSH), in 2021, life expectancy in Hungary was 71.1 years for males, 78.0 years for females, and 74.5 years overall, which was the second worst among member states of the Organisation for Economic Co-operation and Development (OECD) in the same year. The KSH also reports that the average healthy life expectancy at birth has increased over the past 20 years. In 2000, it was 54.7 years for males, 57.5 years for females, while in 2021, it was 61.7 years for males and 63.5 years for females. Similarly, the average healthy life expectancy at age 65 has also increased. In 2000, it was 5.0 years for males, 5.6 years for females, whereas in 2021, it was 7.1 years for males and 7.7 years for females. Among various chronic diseases, at least one was suffered by 38.4% of the population in 2021, with this proportion rising to over 50% among those aged 55 and over.

To conclude, we can say that the fight against preventable chronic diseases is crucial in both developing and developed countries, including Hungary.

This dissertation aims to provide a more detailed analysis of type 2 diabetes mellitus (T2DM) among chronic non-communicable diseases, as well as its primary risk factor, dietary habits. Among the primary and most significant risk factors for T2DM are sedentary lifestyle and an unhealthy diet. Among specific food types and nutrients, processed red meat (OR: 1.51; 95% CI: 1.25–1.83) and sugary soft drinks (OR: 1.26; 95% CI: 1.12–1.41) carry the highest risks, indicating increased risk, while adherence to the Mediterranean diet (OR: 0.60; 95% CI: 0.43–0.85), consumption of leafy vegetables (OR: 0.84; 95% CI: 0.74–0.94), and whole grains (OR: 0.68; 95% CI: 0.58–0.81) has been shown to be protective. Additionally, cholesterol intake (RR: 1.24; 95% CI: 1.10–1.40) and artificially sweetened beverages (RR: 1.07; 95% CI: 1.03–1.10) alongside sugary drinks can also be predisposing factors. Overall, obesity represents the greatest risk (RR: 6.88; 95% CI: 5.39–8.78), which is also clearly associated with improper dietary habits.

The International Diabetes Federation's (IDF) Diabetes Atlas, of 2021 contains a global estimate of 537 million people living with diabetes aged 20-79, with 11.36% (n=61 million) from Europe. These alarming numbers are further nuanced by the estimation that by 2045, a 46.63% increase is projected based on current prevalence and trends. Although the growth rate in Europe is expected to be lower at (13.11%), it is worth noting that the Diabetes Atlas has consistently reported higher figures in reality compared to earlier estimations in previous editions. Moreover, if the World Health Organization's goal is to halt the rise of diabetes (and obesity) by 2025, these projections emphasize the importance of health policy action plans and interventions aimed at combating this condition.

A 2011 WHO study on sustainable healthcare financing structures and universal coverage, highlighted and recommended to member countries, among other things, to ensure that overall resource allocation strikes an appropriate balance between health promotion, disease prevention, rehabilitation and health-care provision,' as well as to share experiences and important lessons learnt at the international level for encouraging country efforts, supporting decision-makers, and boosting reform processes'.

Several countries implement health policy measures to promote a healthy lifestyle worldwide. The WHO provides detailed data on the number of these measures for 194 countries. In 2021, health policy measures against excessive alcohol consumption were present in the smallest proportion (70.16%; n=134), while those that combat unhealthy eating were in the largest (84.38%; n=162), and the latter showed the highest rate of growth between 2013 and 2021 (+23.24%, +55 countries). These measures may involve restrictions on the availability or advertising, sanctioning or even taxing of the unhealthy products.

On achieving more sustainable healthcare financing, McIntyre and Kutzin highlights the revenue-raising technique known as 'earmarking,' wherein a portion or all of a specific revenue source (such as taxes) is allocated to a particular sector. In Hungary, examples of such earmarked taxes include the accident tax until 2019, or the currently effective and later to be detailed public health product tax (PHPT), the entire revenue of which goes to the Hungarian Health Insurance Fund.

Earmarking taxes can be advantageous, in such a way that they target products associated with public health risks (smoking, alcohol consumption etc.), thereby providing a double benefit to the healthcare system. This involves implementing what are known as Pigouvian taxes, which not only aim to positively influence consumer behaviour but also generate revenue for the healthcare system. However, it's worth emphasizing that achieving both of these dual objectives requires a moderate, gradual introduction.

Considering that poor diet is a proven risk factor for diabetes mellitus, taxing unhealthy foods can contribute, among other factors, reducing its prevalence and incidence.

2. Objectives

This dissertation aims to assess the health insurance and health-economic aspects of diet-related diseases, focusing on type 2 diabetes mellitus (T2DM). It also examines a health policy intervention aimed at reducing burden of T2DM, the public health product tax. Given that the intervention we examined has a dual purpose - revenue generation and health promotion - we formulated several specific objectives to study these aspects.

Our first research question aimed to investigate how the dietary habits have changed over the past two decades. To achieve this, we examined the temporal changes in factors known to influence food consumption, such as the availability of nutrients (fat, protein) and the amount of calories, as well as their relative proportions among OECD member countries. We justify our research goal by noting that improper quantity and quality of food consumption and accessibility are risk factors for chronic diseases, including T2DM. Therefore, understanding these indicators can assist in the formulation of health policy interventions aimed at reducing its epidemiological and health insurance burden.

Secondly, we aimed to investigate the revenues and expenditures of the Hungarian Health Insurance Fund between 1993 and 2020. To do this, we analysed the structure of the Fund, the

distribution of its revenue and expenditure sides, as well as their changes over the past decades in Hungary.

Furthermore, we analysed the public health product tax (PHPT). Our research question was as follows: how has the PHPT affected the purchasing trends of the taxed products? Our goal was to determine whether the public health product tax has a positive effect on lifestyle improvement, thereby reducing lifestyle-related diseases, particularly focusing on reducing the prevalence of T2DM.

Finally, we assessed the health insurance and epidemiological burden of T2DM in Hungary. We paid particular attention to presenting both its acute and chronic complications. In Chapter 6, we also provided a separate analysis on the most common complication (neurological).

The objectives of the dissertation are the following:

1. Time-series analysis of per capita nutrient and calorie supplies among OECD countries, focusing on Hungary;
2. Retrospective analysis of the revenue and expenditure sides of the Health Insurance Fund of Hungary;
3. Analysis of the quantity of taxable products and changes in PHPT revenues;
4. Impact analysis of PHPT using interrupted time series analysis, including examination of trends in households' purchases of certain unhealthy food and beverage groups pre- and post-intervention;
5. Assessment of the epidemiology of T2DM and diabetic polyneuropathy based on annual real-world, routinely collected data from the National Health Insurance Fund Administration;
6. Assessment of the health insurance burden of T2DM and diabetic polyneuropathy based on annual real-world, routinely collected data from the National Health Insurance Fund Administration.

3. Results

3.1. Assessing the per capita food supply trends of 38 OECD countries

The food supply can impact the prevalence of chronic non-communicable diseases associated with dietary habits. Our goal is to examine the trend of available nutrient quantities between 2000 and 2019 for 38 OECD member states, with a particular focus on Hungary.

Data on the daily per capita protein (g/capita/day), fat (g/capita/day) and calorie (kcal/capita/day) intake were derived from the OECD Health Statistics database, with the original source being calculations made by the Food and Agriculture Organization of the United Nations (FAO)'s Food Balance Sheets. For each indicator examined, we also calculated the average trend for the OECD member countries, with the latter being defined as the average of the countries providing the data (n=38). Joinpoint regression analysis was used to identify the number and location (years) of breakpoints within the time series. In the case of trends between individual joinpoints, we analysed the annual percentage change (APC) using JoinPoint 4.9.0.0 software ($p<0.05$).

The average per capita protein, fat and calorie supplies increased significantly between 2000 and 2019. The average available quantity of fat increased at the fastest rate (0.6%/year), followed by protein (0.3%/year) and kcal (0.2%/year). The more significant rises seen in the early 2000s are shown, creating breakpoints in the time series around 2006 and 2007, where the per capita levels of nutrients and calories started to stagnate (fat, calories) or slightly decrease (protein). Afterwards, an even steeper and significant upward trend for all three indicators is seen, starting approximately around 2012–2014. **(Table 1)**

	AAPC (95%CI)	**Trends**					
		Trend 1		Trend 2		Trend 3	
		APC (95%CI)	**Period**	**APC (95%CI)**	**Period**	**APC (95%CI)**	**Period**
Protein	0.3* (0.2 – 0.4)	0.4*** (0.2 – 0.5)	2000–2007	-0.2 (-0.5 – 0.1)	2007–2012	0.5*** (0.3 – 0.6)	2012–2019
Fat	0.6* (0.5 – 0.7)	0.7*** (0.5 – 0.9)	2000–2006	0.1 (0.0 – 0.3)	2006–2013	1.0*** (0.8 – 1.1)	2013–2019
Kcal	0.2* (0.1 – 0.2)	0.2*** (0.1 – 0.3)	2000–2006	0.0 (-0.1 – 0.1)	2006–2014	0.4*** (0.3 – 0.5)	2014–2019

*: p<0.05; **: p<0.01; ***: p<0.001.

Table 1: *The annual average percent changes (AAPC) and average percent changes (APC) of protein, fat and calories supplies between 2000 and 2019: Results of joinpoint regression models based on OECD averages.*

The fat supply level in Hungary in 2019 was 152.8 g/capita/day, which was 16.61 g higher than the OECD average. This indicator was higher in every examined year, on average by 9.91±4.28

grams. A significant increasing trend was observed between 2012 and 2018, with the fat supply level increasing annually by an average of 2.53% compared to the previous year ($p<0.05$). Meanwhile, the OECD also showed a positive trend between 2014 and 2019. **(Figure 1)**

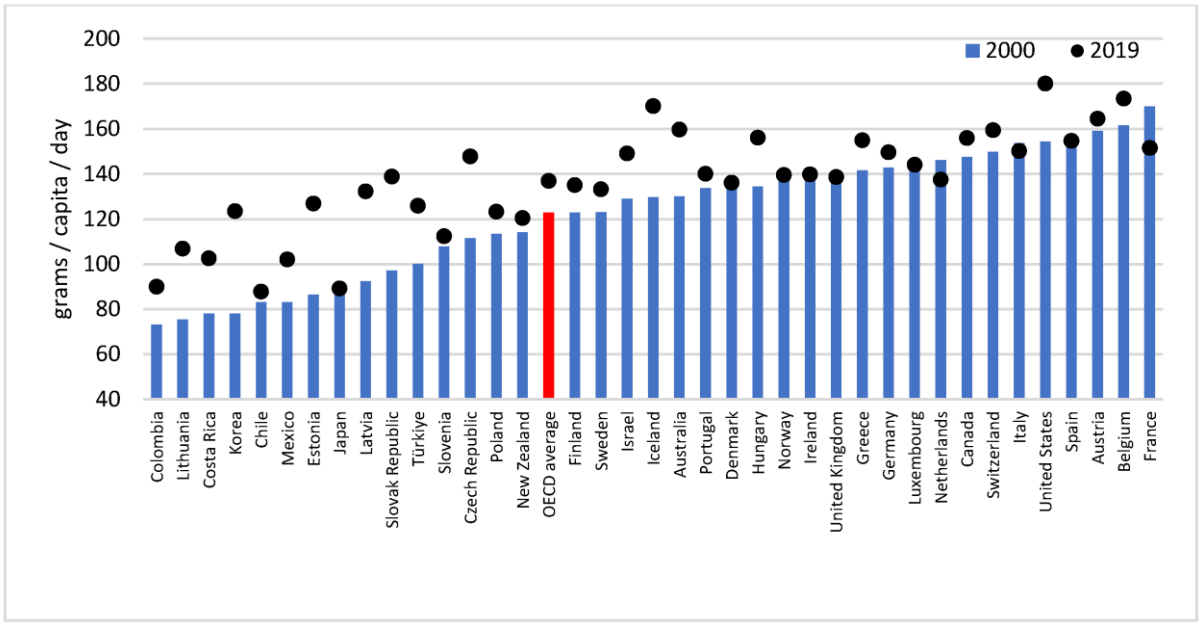


Figure 1. *Fat supply of the 38 OECD countries in 2000 and 2019.*

Mean protein supply of OECD countries started to increase slowly but significantly after 2012 ($p<0.05$). However, a decreasing trend was observed in two out of four periods identified by the model in Hungary (2000-2002; 2005-2012), and since then, there has also been a significant increasing trend (2.12% per year; $p<0.05$). In 2019, domestic consumption (89.6 g/capita/day) still showed a value below the international average (104.2 g/capita/day). **(Figure 2)**

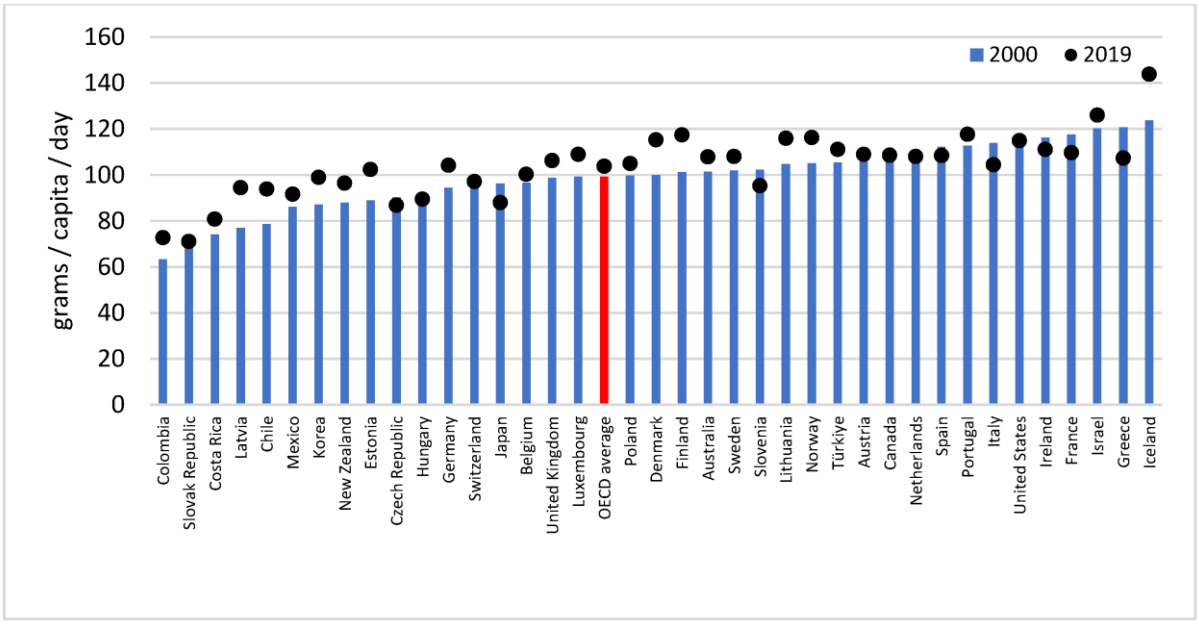


Figure 2. *Protein supply of the 38 OECD countries in 2000 and 2019.*

The daily calorie supply of Hungary was equivalent to the OECD average in all years examined, or only slightly lower by a few percentage points. However, its trend showed steeper changes. In contrast to the international almost constant growth, following a decline between 2005 and 2012 (-1.19% per year), a rise matching the OECD average began from 2012 (1.81% per year), resulting in an increase in Hungary from 3,172 kcal/capita/day to 3,316 kcal/capita/day over the examined period. **(Figure 3)**

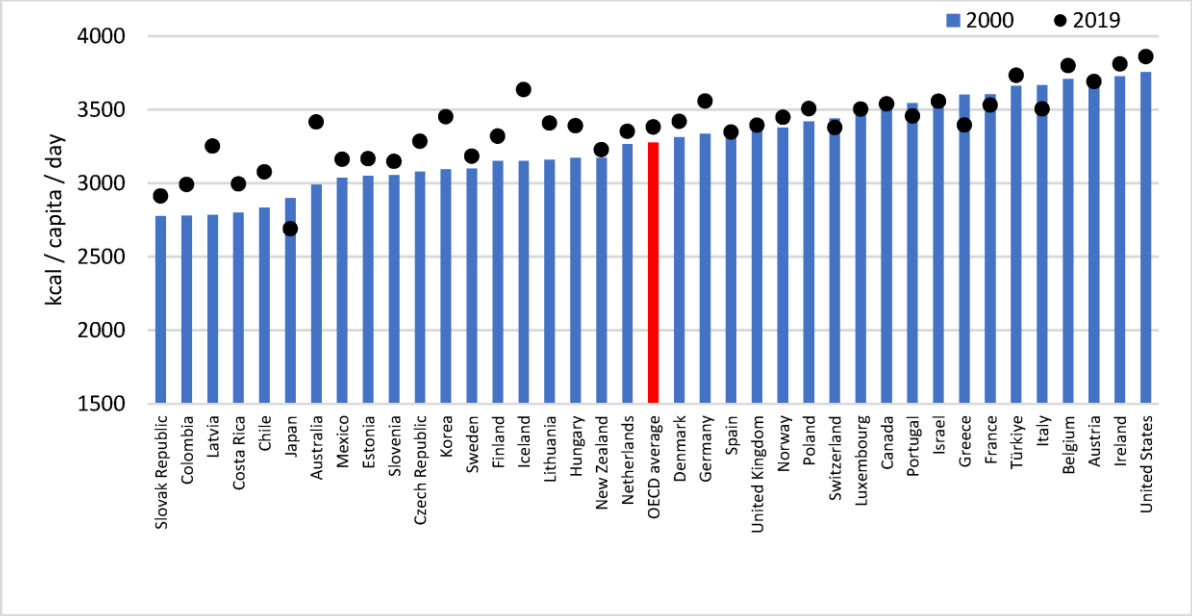


Figure 3. *Calorie supply of the 38 OECD countries in 2000 and 2019.*

The distribution of the daily calorie intake has also changed between 2000 and 2019, as shown in Table 2. In 2019, the level of fat intake ranged from 27.7% (Japan) to 48.6% (Iceland), the distribution of protein from 10.2% (Slovakia) to 18.3% (Iceland), and carbohydrate from 33.2% (Iceland) to 60.4% (Colombia). When comparing the results with the recommended distribution, we found that the distribution of fat was still higher than the recommended 35% in 27 member states in 2019 (71.05%). Protein levels were within the acceptable range in all countries, and carbohydrate levels were below the recommended (<45%) levels in 6 countries. Hungary is also included among the highlighted samples mentioned above. **(Table 2)**

Nutrient		2000	2019	Change	p value
Fat	% of daily kcal supply (95%CI)	32.7% (30.7%–34.7%)	37.6% (36.0%–39.3%)	4.9%	<0.001
Protein	% of daily kcal supply (95%CI)	11.7% (11.3%–12.2%)	12.7% (12.2%–13.1%)	1.0%	<0.001
Carbohydrates (+fiber)	% of daily kcal supply (95%CI)	55.6% (53.4%–57.8%)	49.7% (47.9%–51.5%)	-5.9%	<0.001

Table 2. *Proportion of macronutrients in the daily calorie supply in the OECD countries (average).*

In terms of the composition of daily calorie supply per capita, we found that the proportion of fat and protein has increased overall. The increasing proportion of protein in the total available calories over the past two decades, and the optimal ratio in every country assessed, are commendable. However, 71% of countries have access to an amount of fat exceeding the optimal ratio in 2019. This deserves particular attention from health policy makers in the fight against obesity and nutrition-related diseases. This fact reinforces the necessity and justification of efforts aimed at (further) improving the lifestyle of the Hungarian population.

3.2. Retrospective analysis of the revenues and expenditures of the Hungarian Health Insurance Fund

The appropriate allocation and distribution of resources are key for ensuring efficient healthcare provision. The aim of our research is to examine the revenues and expenditures, as well as the balance of the Hungarian Health Insurance Fund.

We conducted a quantitative, retrospective analysis using data provided by the National Health Insurance Fund Administration (NHIFA) for the period between 1993 and 2020. We examined the amount and proportion of the Fund‘s subheadings, as well as the its balance in nominal and real values (at 2020 prices).

In 1993, health insurance contributions accounted for 91.99% of the revenue side. Their proportion reached its peak in 1998 (97.88%) and hit its lowest point in 2014 (47.02%). Over the years, there has been an increasing proportion of tax-type resources within the Fund. **(Figure 4)**

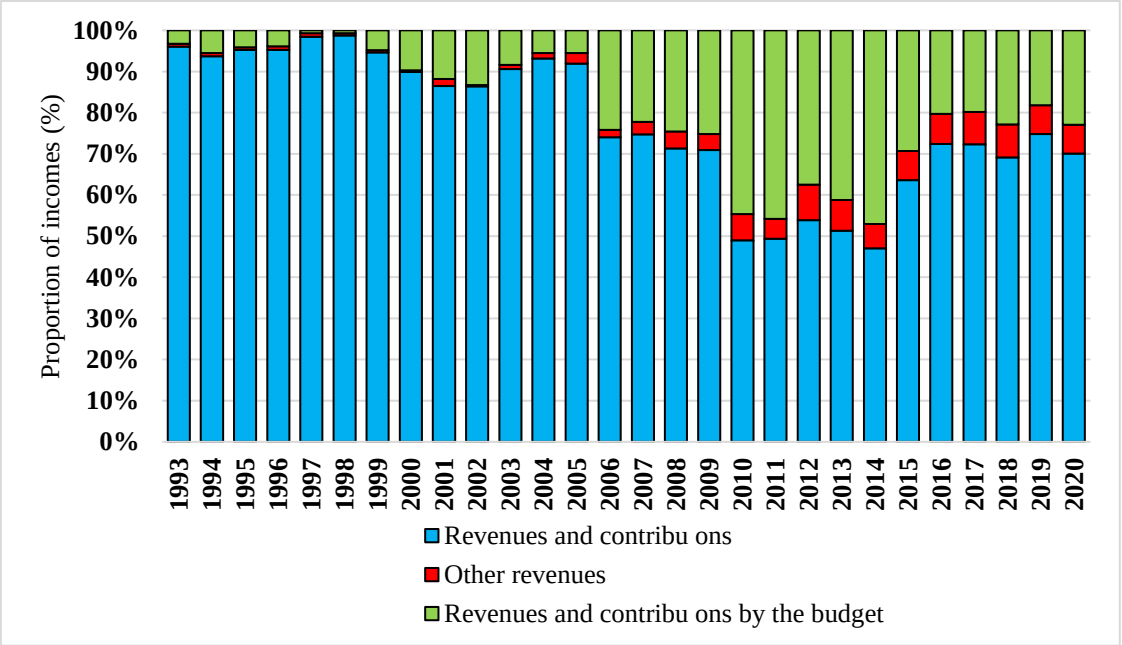


Figure 4: *The proportions of the revenues* of the Health Insurance Fund*

** Revenues from asset management, operational income, and settlements between funds are not visible on the diagram due to their negligible amounts.*

The expenditure side of the Fund consists of in-kind, monetary, and other benefits. The distribution of major subheadings and legal categories between 1993 and 2020 is found in **Figure 5**.

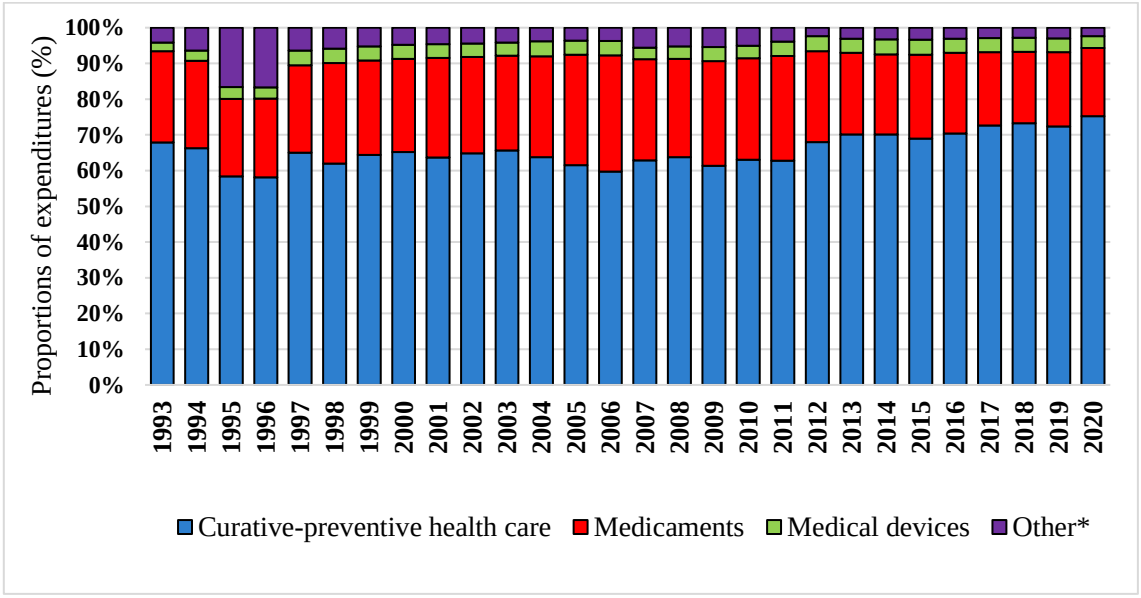
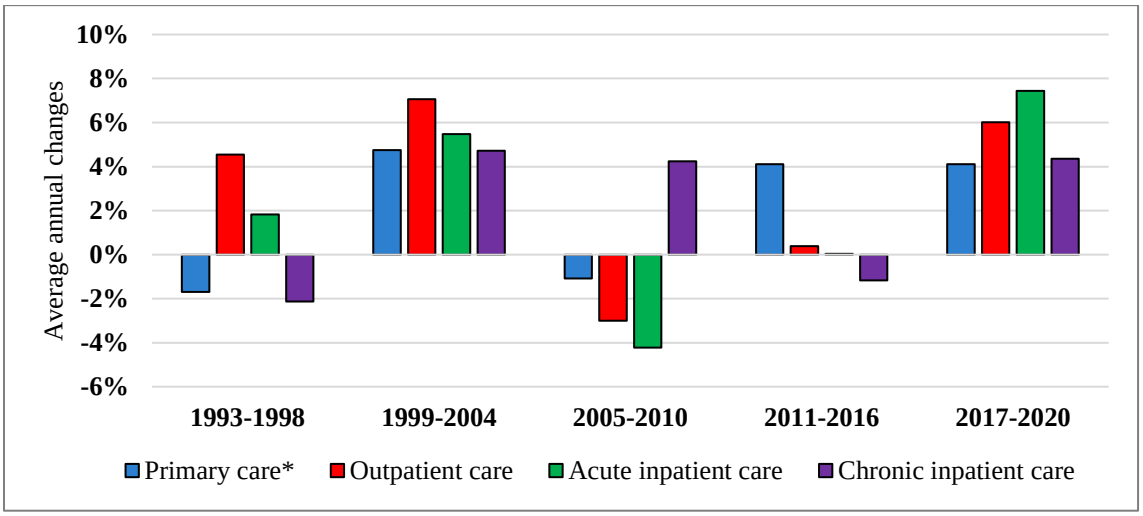


Figure 5: *The proportions of the expenditures* of the Health Insurance Fund*

** Other: Spa services, Mother's milk supply, refunding of travel expenses, expenses resul ng from interna onal agreements and treatments provided abroad.*

When looking at the expenditures of therapeutic and preventive services, we did not observe significant changes from the inpatient care expenditure (61.37%±1.97%) towards outpatient (12.76%±0.95%) or primary care (18.46%±1.79%).

Figure 6 shows the average annual growth rates of expenditures for the four main therapeutic and preventive care forms over five time periods. In the first cycle (1993-1998), we highlight the average annual growth of outpatient specialized care at 4.75%. However, in the subsequent years, the growth rate of expenditures shows a decreasing trend for all forms of care. Between 2003 and 2012, chronic inpatient care gained strength due to the restructuring of hospital bed numbers, allowing its share to increase even in the years following the crisis, unlike other types of care – uniquely during the years of crisis.



** Primary care: general practitioner care, on-duty general practitioner care, health visitor service, mother, child and youth care. Outpatient care: outpatient care, laboratory diagnostics, CT, MRI, care in care centres.*

Figure 6: *Annual growth rates of expenditures for the four main therapeutic and preventive care forms between 1993-2020 (at 2020 prices)*

Figure 7 shows the balance of the Health Insurance Fund over the examined period. Looking at the values calculated in real terms, it can be stated that both the revenue and expenditure sides of the last examined year are roughly similar to those of the 2006s. In the past five years, the deficit of the fund ranged from 0% to 6%, meaning that expenditures exceeded revenues by this margin – apart from the year 2020, where a deficit of 11.5% occurred.

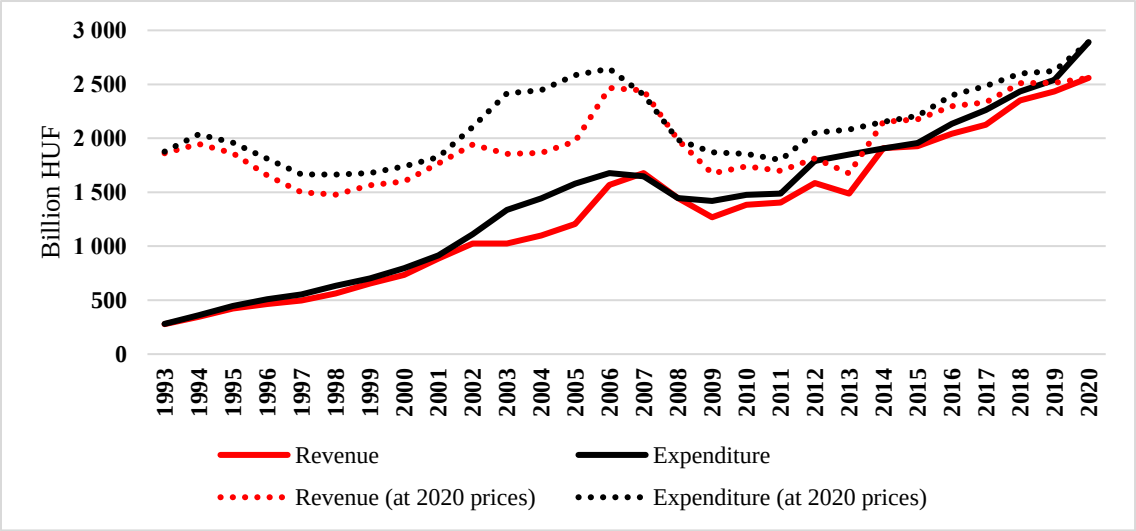


Figure 7: *Balance of the Health Insurance Fund (nominal values and at 2020 prices)*

Since 2012, the Fund has been operating without building up a significant deficit compared to previous years, although the last six examined years also exhibit a deficit. By 2020, we have determined that - looking at the real values of revenues and expenditures - we allocated and spent roughly the same amount at the state level on healthcare as in the years directly preceding the crisis. Overall, it can be said that establishing an optimal, stable revenue source composition and creating a financing system, capacity, and patient pathways that align with needs are essential for operating a sustainable healthcare system.

3.3. The introduction and impact analysis of the public health product tax using interrupted time series analysis

Imposing taxes on unhealthy goods can generate income, raise people's health awareness, and eventually decrease the prevalence of chronic diseases. Our aim was to assess the impact of Hungary's public health product tax (PHPT) since its implementation in September 2011. Differences in purchasing habits between households with different income statuses were also compared.

A retrospective, descriptive analysis of tax bases and income was carried out, and an interrupted time-series analysis using the generalised least squares method was performed to examine the changes in trends regarding the purchase of taxable products before and after the implementation of the tax. The amount of tax base (in kilograms or litres), income (in HUF and EUR), and annual purchased quantity of food and beverage groups per household were assessed. Data were derived from the National Tax and Customs Administration of Hungary and the Hungarian Household Budget and Living Conditions Surveys. The study sample was

composed of households who participated in the surveys (n_{mean}=8,359; SD: 1,146) between 2006 and 2018.

The total tax revenue of the PHPT was 19.49 billion HUF in 2012 and increased to 81.13 billion HUF by 2022. The relative proportions of individual products did not show significant differences between the years, however, the tax base (i.e., the quantity of taxable products) and consequently the tax income have been continuously increasing since 2013. **(Figure 8)**

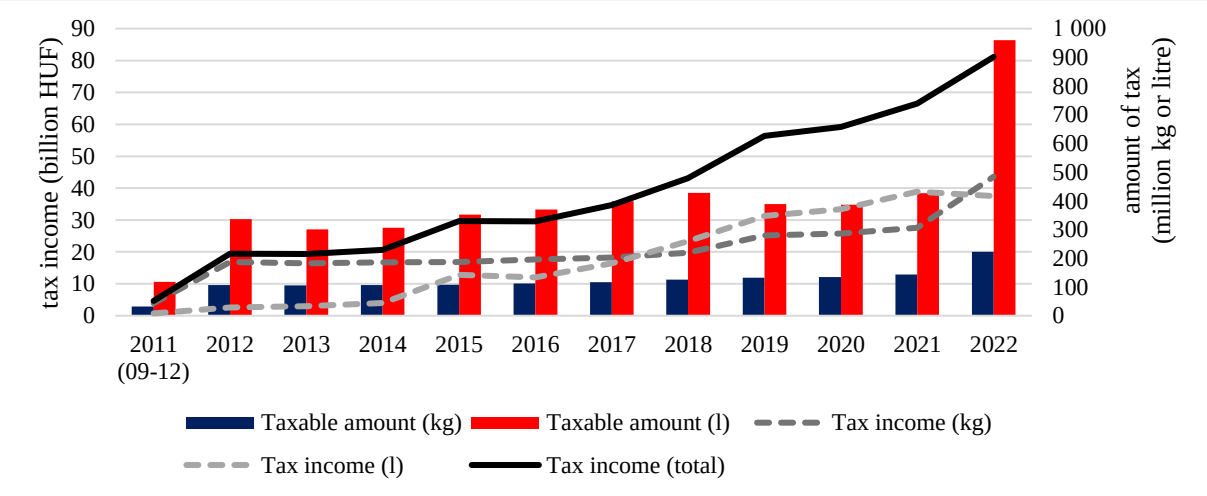


Figure 8: *Taxable amount (in kg or in litre) and the amount of tax income between 2011-2022.*

Despite the continuous growth in tax revenue, household purchasing habits did not change as expected. A short-term (between 2012 and 2013), significant decrease in purchasing unhealthy products was observed for three product groups: soft drinks (p=0.009), jams (p=0.047), and fruit juices (p=0.038). Only soft drinks showed a significant long-term decreasing trend even after the intervention period, between 2012 and 2018 (p<0.001). **(Table 3)**

		Quantity per household (kg, l)								
		2006	**2010**		**2012**		**2015**		**2018**	
		kg / l	kg / l	change (2006 =100%)	kg / l	change (2010 =100%)	kg / l	change (2012 =100%)	kg / l	change (2015 =100%)
Processed potato		**2.32**	**2.18**	**-5.73%**	**1.93**	**-11.63%**	**3.46**	**79.22%**	**2.42**	**-30.02%**
First quintile		*2.25*	*2.18*	*-3.11%*	*1.97*	*-9.63%*	*4.26*	*116.24%*	*2.47*	*-42.02%*
Fifth quintile		*2.58*	*2.50*	*-3.10%*	*2.00*	*-20.00%*	*3.39*	*69.50%*	*2.74*	*-19.17%*
Cocoa powder		**1.15**	**1.11**	**-3.48%**	**0.93**	**-16.22%**	**1.11**	**19.35%**	**0.80**	**-27.93%**
First quintile	**kg**	*1.35*	*1.29*	*-4.44%*	*1.06*	*-17.83%*	*1.58*	*49.06%*	*0.91*	*-42.41%*
Fifth quintile		*0.88*	*0.93*	*5.68%*	*0.80*	*-13.98%*	*0.83*	*3.75%*	*0.59*	*-28.92%*
Jam		**3.17**	**2.33**	**-26.50%**	**1.55**	**-33.48%**	**0.91**	**-41.29%**	**1.29**	**41.76%**
First quintile		*2.71*	*2.53*	*-6.64%*	*1.44*	*-43.08%*	*0.86*	*-40.28%*	*1.18*	*37.21%*
Fifth quintile		*3.40*	*2.54*	*-25.29%*	*1.70*	*-33.07%*	*1.16*	*-31.76%*	*1.05*	*-9.48%*
Carbonated soft drinks	**l**	**88.98**	**70.27**	**-21.03%**	**57.04**	**-18.83%**	**66.20**	**16.06%**	**52.04**	**-21.39%**

	First quintile	*126.33*	*88.91*	*-29.62%*	*75.96*	*-14.57%*	*84.58*	*11.35%*	*56.93*	*-32.69%*
	Fifth quintile	*67.33*	*59.69*	*-11.35%*	*45.26*	*-24.17%*	*52.05*	*15.00%*	*49.70*	*-4.51%*
Syrup		**3.87**	**3.86**	**-0.26%**	**4.06**	**5.18%**	**4.74**	**16.75%**	**3.89**	**-17.93%**
	First quintile	*5.66*	*5.65*	*-0.18%*	*6.78*	*20.00%*	*8.49*	*25.22%*	*3.46*	*-59.25%*
	Fifth quintile	*2.49*	*3.08*	*23.69%*	*2.81*	*-8.77%*	*3.33*	*18.51%*	*3.57*	*7.21%*
Fruit juice		**41.71**	**32.77**	**-21.43%**	**23.68**	**-27.74%**	**27.64**	**16.72%**	**23.24**	**-15.92%**
	First quintile	*32.58*	*23.35*	*-28.33%*	*16.50*	*-29.34%*	*24.60*	*49.09%*	*18.95*	*-22.97%*
	Fifth quintile	*49.90*	*42.25*	*-15.33%*	*27.95*	*-33.85%*	*32.83*	*17.46%*	*29.21*	*-11.03%*
Spirits		**1.76**	**1.71**	**-2.84%**	**1.19**	**-30.41%**	**1.43**	**20.17%**	**1.55**	**8.39%**
	First quintile	*1.29*	*0.76*	*-41.09%*	*0.72*	*-5.26%*	*0.93*	*29.17%*	*0.77*	*-17.20%*
	Fifth quintile	*2.31*	*2.66*	*15.15%*	*1.74*	*-34.59%*	*1.84*	*5.75%*	*2.07*	*12.50%*

First quintile = 20% of the sample with the lowest income; fifth quintile = 20% of the sample with the highest income

Table 3. *Changes in the amount of products purchased per household between 2006-2018*

We concluded that the PHPT did not significantly reduce households' purchasing habits related to unhealthy foods. Its positive impact primarily stems from its revenue-generating nature for health promotion programs.

3.4. Epidemiology and annual health insurance burden of type 2 diabetes mellitus in Hungary

Our aim was to assess the epidemiology and health insurance disease burden of type 2 diabetes mellitus and its different complications.

We carried out a comprehensive data analysis based on data from the Hungarian Health Insurance Fund Administration for the year of 2018. Annual patient numbers and prevalence according to age groups and sex were determined. Patients were identified with the International Classification of Diseases (ICD) 10th revision codes: E11.0-E11.9 and G63.2.

The Health Insurance Fund Administration spent 49.86 billion HUF for treating type 2 diabetes mellitus linked to the assessed ICD codes.

Subsidization of medications (73.41%), general practice care (9.31%) and outpatient care (8.13%) were the main cost drivers.

Figure 9 shows the distribution of the patient population according to various complication types. It can be observed that 43% of patients suffer from some type of complication, predominantly chronic ones. The highest number of patients is associated with unspecified (n=139,409), and multiple complications (n=47,315), but noteworthy is also the

number of those who take prescribed medications associated with neurological complications (n=35,057).

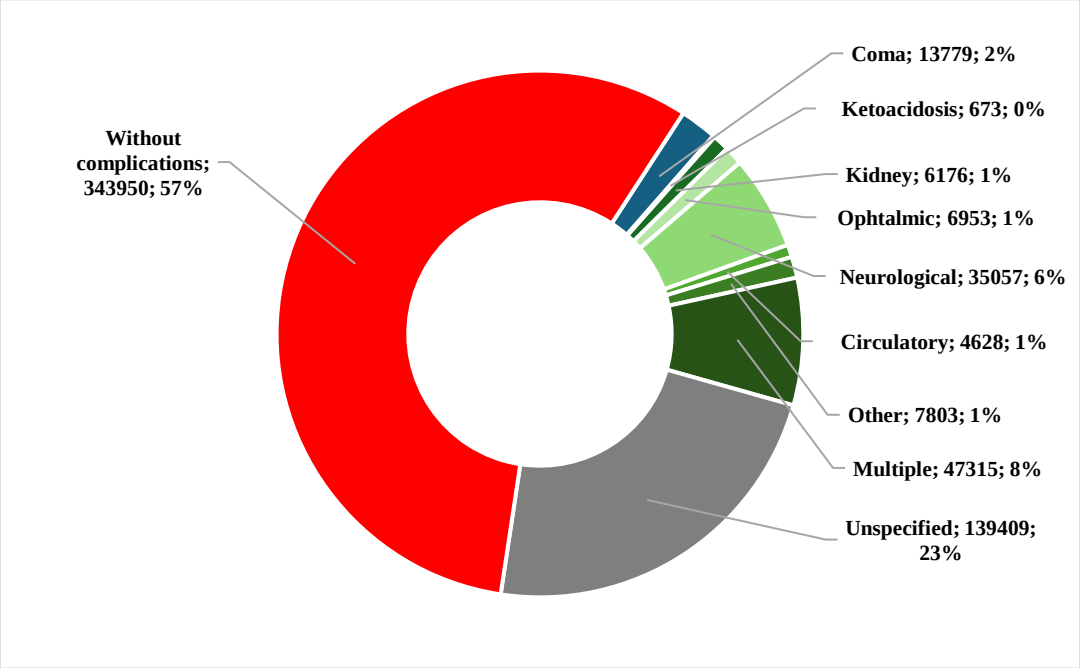


Figure 9: *Proportion of complications among the patient population in Hungary, 2018*

The highest expenditures are associated with patients without complications (21.44 billion HUF), followed by those with unspecified (10.79 billion HUF), multiple (4.81 billion HUF), and neurological (3.30 billion HUF) conditions.

The prevalence of T2DM without complications is 3.52%, with complications is 2.68%, and together is 6.19%. The prevalence of diabetic polyneuropathy (DPN), also based on outpatient care utilization, was 0.92%**. (Figure 10)**

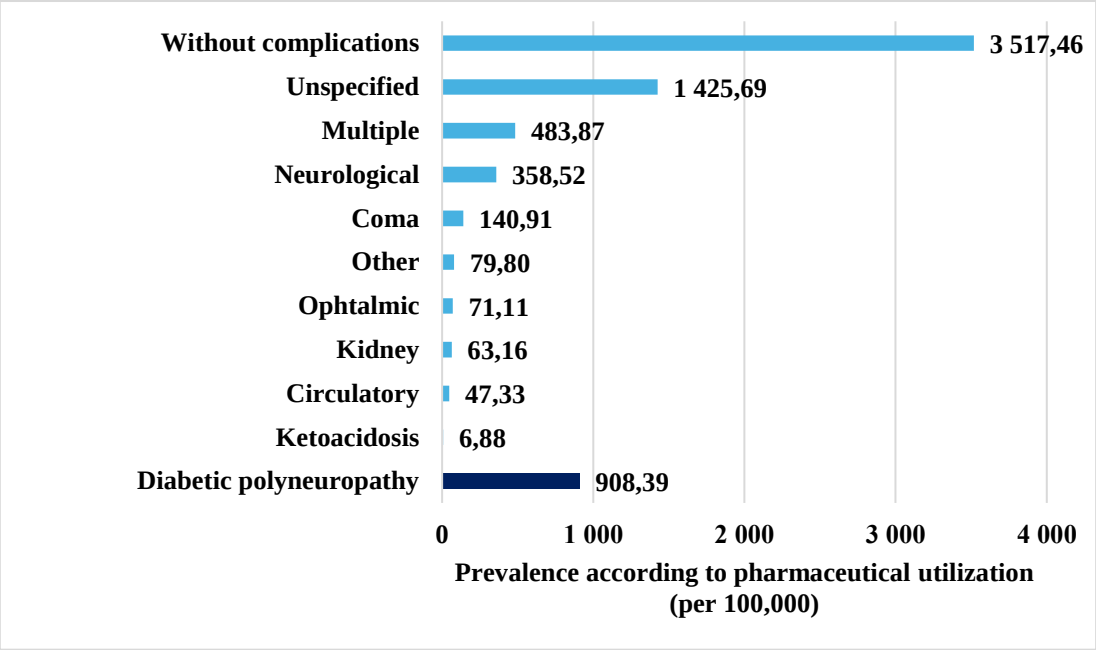


Figure 10: *Prevalence of T2DM by complications and DPN in Hungary, 2018*

4. Discussion

Our main objective was to assess the impact of the PHPT, as well as to examine the Hungarian Health Insurance Fund and the burden of T2DM.

Understanding these trends are essential for food policies that support sustainable and healthy lifestyles: how they have developed, and how they might change in the future.

Overall, we have concluded that raising awareness of the public health issues caused by overconsumption and inadequate nutrient intake is key. Useful information and results can be found in the annexes of the dissertation, where we list the trends of each country. Our aim is to contribute to the fight against the high prevalence and frequency of nutrition-related diseases through the international analysis of available macronutrient supply. Considering that, as the data presented in section 3.1 also show, the available calorie and fat supply has significantly increased in recent years. It is worth paying special attention to possible risks, emphasizing the importance of consuming healthy foods in adequate quantity and quality, and the role of proper nutrition in disease prevention.

One promising health policy measure in the fight against nutrition-related diseases, including T2DM, is the taxation of unhealthy victuals. To better understand the role and place of this tax in the Hungarian health insurance system, we analysed the past and current structure of the Health Insurance Fund. We have found that alongside contributions, tax revenues are becoming increasingly prominent in financing the healthcare system. The so-called 'other

revenues', which include the special tax on pharmaceutical companies alongside the PHPT, are also appearing on the revenue side with a growing proportion. This aligns with the recommendation made by the WHO in 2010, advocating for innovative methods in healthcare financing, such as the introduction of taxes similar to PHPT, to be adopted by member countries.

By assessing the revenue and expenditure indicators of the Health Insurance Fund, we also demonstrated that the amount of curative-preventive expenditure was 1,306.33 billion HUF in 2017, of which 3.82% was accounted for by T2DM and DPN. This further illustrates that despite the decreasing incidence observed by others, T2DM still qualifies as a public health issue in Hungary. Therefore, efforts need to be made: firstly, to ensure more efficient utilization of the available resources in Hungary - for which drastic reduction in the prevalence and incidence of preventable diseases could be an adequate measure. Secondly, combating T2DM is an integral part of international health policy, so reducing the number of diabetic patients and improving their quality of life and lifespan can be seen as a sort of expectation.

An action plan by the WHO aims to halt the rise of diabetes by 2025. It is promising that in some developed countries, decreasing incidence was found by 2019. However, if we wish to see a similar trend in mortality, attention need to be paid preventing acute and chronic complications and proper patient educations, a crucial component of which should be the development of conscious dietary habits.

We have found that several health policy measures can be applied to achieve public health goals, whether it involves sanctioning unhealthy foods or other products, restricting or discontinuing advertising, promoting screening, or establishing participation in screenings as a condition for subsidized healthcare, etc. In addition to these, during our research, we analysed the effectiveness of excise taxes on unhealthy products. A solid basis for this was provided by the PHPT, which taxes a wide range of products even on an international scale. Based on the available data, we were able to identify pre- and post-tax purchasing trends of certain food groups. We observed that the impact of the PHPT on these product groups mainly resulted in a one-time, short-term decrease; however, we did not observe any significant decreasing trend in any of the examined groups except for one. This suggests that the positive effect of the PHPT is more evident in increasing the revenue side of the Health Insurance Fund rather than reforming public health awareness.

When introducing the PHPT, the government outlined several goals, one of which was indeed the proven increase in revenue. In the light of the available literature, we can say that the success of changing consumption habits depends on two factors. Firstly, a well-selected tax

base and tax rate accepted by consumers, which is higher than the current one but not to the extent that it triggers resentment among the population – as this could lead to the repeal of the law or its circumvention (e.g., through cross-border purchases), examples of which we have seen in international practice. Denmark, for example, was a pioneer with its tax on high trans and saturated fat content foods introduced in 2011, which, however, was withdrawn a year later. Danes began to purchase taxed products abroad, in Germany or Sweden. Furthermore, the legislation specified the saturated fat content, leading to the taxation of some otherwise healthy goods.

Finland imposed taxes on chocolate, ice cream, and sugary drinks. Due to the inadequate definition of tax bases (other high-sugar foods were not included, leading to dissatisfaction among manufacturers with the unfair market situation), their taxation was discontinued.

In Belgium, taxes were placed upon sugary drinks in 2016, followed by plans to tax cereals, yogurts, and other sweets a year later. However, this extension was withdrawn to avoid further burdens on the population. Additionally, a working group published a study on the tax disadvantages: the lack of evidence regarding the correlation between weight gain and taxable products, its regressive nature, and its negative impact on the labour market.

However, the effectiveness of the Hungarian PHPT can be measured not only by improvements in public health consciousness and the financing of healthcare but also by its impact on manufacturers. After its introduction, manufacturers sought to avoid taxation by altering the recipes of their products. For example, between 2011 and 2013, 40% of manufacturers subject to the law changed their production processes, 30% removed the taxable ingredient, and 70% reduced its amount.

To further investigate the prevalence and burden of T2DM related to unhealthy lifestyle and dietary habits, we examined routinely collected health insurance data for the year 2018. We found that the prevalence of T2DM in Hungary was 6.19%, with 3.52% representing cases without complications, while some form of acute or chronic complication was documented in 2.68% of the population.

Our study is not without limitations, but they also indicate our future research, which we summarize below. Firstly, expanding the time series for all examined datasets from the National Health Insurance Fund, the Central Statistical Office, and the National Tax and Customs Administration, wherever possible, can enhance the reliability of our findings. Secondly, to further refine the delineation of the patient population affected by diabetes mellitus, we plan to broaden our analysis by examining other ICD codes in detail, such as the E10, E12, E13, and E14 code groups.

Knowledge obtained from larger, representative cohort samples, patient registries, or even real-world health insurance data analysed according to carefully defined selection criteria (prescribed medications, ICD codes) can provide the most reliable information. With this knowledge and consideration, the long-term economic and societal burden of the disease can be reduced.

Another limiting factor is that we analysed the epidemiological and health insurance burden of diabetes of just one year. In the future, it would be worthwhile to examine the changes in disease prevalence over time using a longitudinal approach.

We characterized the impact of the PHPT on purchasing habits during the period between 2006 and 2018. However, it's important to highlight that since then, there have been several significant changes in both the taxable products and the tax rates imposed. For instance, in 2019, the tax rates per kilogram or litre were generally increased by 20%. Additionally, in July 2022, as part of a comprehensive reform, new food groups were included (such as sweet and savoury pastries, products with sweeteners), while alcoholic beverages were exempted from taxation. We plan to analyse the effectiveness of these reforms in a similar manner in the future to understand how the increase in taxes affects the purchasing and consumption habits of the population.

Overall, we conclude that analysing the effects of public health interventions – such as the taxation of unhealthy foods and beverages – is extremely important. Optimizing such taxes and improving public health conditions are essential tasks and key objectives for decision-makers.

5. New results

1. We were first to conduct a time-series analysis of available nutrients and calories in 38 OECD countries for assessing the past 20 years. We found that there were differences in macronutrient availability between countries and that calorie, protein and fat supplies showed an upward trend.
2. Detailed analysis of the revenue and expenditure side of the Hungarian Health Insurance Fund, based on the longest time series currently available. It has been shown that the so-called "other revenue" is an increasingly important segment of the revenue side (HUF 179 billion in 2020, covering approximately the expenditure of the outpatient care).
3. We have presented the change in the PHPT tax bases and revenues from the introduction of the tax (September 2011) to 2022, which is the longest time series available at the time of the thesis' submission. We found that the tax income has shown a positive trend since its introduction and is an effective instrument for generating health resources.
4. As to our knowledge, we are the first to assess the effect of the PHPT by carrying out an interrupted time-series analysis using households' purchasing data. We concluded that the PHPT did not change the purchasing habits of Hungarian households regarding unhealthy foods.
5. We conducted a nationwide study of the epidemiological disease burden of T2DM and its complications, as well as DPN, by taking all curative-preventive care types into account, based on real-world data. We found that in 2018, 6.19% of the population required medication for T2DM, while the prevalence of DPN was 0.92%. Additionally, nearly half of all T2DM patients struggled with one or more complications.
6. We conducted a nationwide analysis of the health insurance disease burden of T2DM and its complications, as well as DPN, by taking all curative-preventive care types into account, based on real-world data. We described that the NHIFA spent nearly 50 billion HUF on these patients in 2018, indicating a significant burden on the health insurance system.

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6. Publication list

Publications related to the dissertation

Csákvári, T.; Elmer, D.; Németh, N.; Komáromy, M.; Kajos, L.F.; Kovács, B.; Boncz, I. Assessing the per Capita Food Supply Trends of 38 OECD Countries between 2000 and 2019—A Joinpoint Regression Analysis. Life 2023, 13, 1091.

(Impact Factor: 3,2)

Csákvári, T., Elmer, D., Németh, N., Komáromy, M., Mihály-Vajda R, Boncz, I. (2023). Assessing the impact of Hungary's public health product tax: an interrupted time series analysis. Central European Journal of Public Health, 2023; 31(1): 43-49.

(Impact Factor: 1,2)

Csákvári, T., Elmer, D., Németh, N., Kívés Z., Horváth, L., Wittmann I., Boncz, I. (2023). A 2-es típusú diabetes mellitus és szövődményeinek epidemiológiai és betegségteher vizsgálata rutinszerűen gyűjtött egészségbiztosítási adatok alapján. Diabetologia Hungarica, 31(1): 17-25.

Csákvári, T; Elmer, D ; Németh, N ; Kívés, Zs ; Wittmann, I ; Janszky, J ; Boncz, I. A diabeteses polyneuropathia okozta epidemiológiai és egészségbiztosítási betegségteher elemzése egészségbiztosítási adatok alapján. Orvosi Hetilap 2021; 162(Suppl 1): 38-45.

(Impact Factor: 0,707)

Csákvári, T; Elmer, D; Horváth, L; Boncz, I. Status of Diabetic Neuropathy in Korea: A National Health Insurance Service-National Sample Cohort Analysis (2006 to 2015) (Diabetes Metab J 2021;45:115-9). Diabetes And Metabolism Journal 45: 454-456.

Csákvári, T; Sebestyén, A ; Elmer, D ; Németh, N ; Pónusz, R ; Komáromy, M ; Zemplényi, A; Endrei, D ; Boncz, I. Az Egészségbiztosítási Alap bevételi és kiadási oldalának elemzése 1993-2019 között. Egészség-Akadémia 2020; 11: 5-18.

Impact factor of the publications used for the dissertation: 5,107.

Citable conference abstracts published on the topic of the dissertation

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kives, Z ; Kajos, L ; Endrei, D ; Molics, B ; Boncz, I. Epidemiological Disease Burden Of Non-Insulin-Dependent Diabetes With Ophthalmic Complications Based On Routinely Collected Health Insurance Claims Data. Value In Health 2022; 25: S128-S128.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kives, Z ; Kajos, L ; Molics, B ; Boncz, I. Epidemiological Disease Burden Of Non-Insulin-Dependent Diabetes With Peripheral Circulatory Complications Based On Routinely Collected Health Insurance Claims Data. Value In Health 2022; 25: S123-S124.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kives, Z ; Ponusz, R ; Kovacs, D ; Sebestyen, A ; Molics, B ; Boncz, I. Annual Health Insurance Treatment Cost Of Non-Insulin-Dependent Diabetes With Renal Complications Based On Routinely Collected Financing Data. Value In Health 2022; 25: S76-S77.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kives, Z ; Kajos, L ; Molics, B ; Boncz, I. Annual Health Insurance Treatment Cost Of Non-Insulin-Dependent Diabetes With Peripheral Circulatory Complications Based On Routinely Collected Financing Data. Value In Health 2022; 25: S50-S51.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kives, Z ; Molics, B ; Boncz, I. Annual Health Insurance Treatment Cost Of Non-Insulin-Dependent Diabetes With Coma Based On Routinely Collected Financing Data. Value In Health 2022; 25: S50-S50.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kajos, L ; Molics, B ; Boncz, I. Epidemiological Disease Burden Of Non-Insulin-Dependent Diabetes Mellitus With Other Specified Complications Based On Routinely Collected Health Insurance Claims Data. Value In Health 2022; 25: S129-S130.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kives, Z ; Molics, B ; Boncz, I. Epidemiological Disease Burden Of Non-Insulin-Dependent Diabetes Mellitus With Coma Based On Routinely Collected Health Insurance Claims Data. Value In Health 2022; 25: S123-S123.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kives, Z ; Ponusz, R ; Kovacs, D ; Sebestyen, A ; Molics, B ; Boncz, I. Epidemiological Disease Burden Of Non-Insulin-Dependent Diabetes With Renal Complications Based On Routinely Collected Health Insurance Claims Data. Value In Health 2022; 25: S128-S128.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kajos, L ; Molics, B ; Boncz, I. Annual Health Insurance Treatment Cost Of Non-Insulin-Dependent Diabetes With Other Specified Complications Based On Routinely Collected Financing Data. Value In Health 2022; 25: S51-S51.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kives, Z ; Kajos, L ; Endrei, D ; Molics, B ; Boncz, I. Annual Health Insurance Treatment Cost Of Non-Insulin-Dependent Diabetes With Ophthalmic Complications Based On Routinely Collected Financing Data. Value In Health 2022; 25: S76-S76.

Csakvari, T; Elmer, D ; Nemeth, N ; Horvath, L ; Kajos, L ; Danku, N ; Sebestyen, A ; Molics, B ; Boncz, I. Annual Health Insurance Treatment Cost Of Non-Insulin-Dependent Diabetes Mellitus Without Complications Based On Routinely Collected Financing Data. Value In Health 2022; 25: S103-S104.

Boncz, I ; Elmer, D ; Németh, N ; Kívés, Zs ; Wittmann, I ; Horváth, L ; **Csákvári, T.** A 2-es típusú diabetes mellitus és szövődményeinek epidemiológiai és betegségteher vizsgálata rutinszerűen gyűjtött egészségbiztosítási adatok alapján. Diabetologia Hungarica 2021; 29(Suppl 1): 13-15.

Csákvári, T ; Elmer, D ; Németh, N ; Komáromy, M ; Mihály-Vajda, R ; Boncz, I. A népegészségügyi termékadó hatása a vásárlási szokásokra. Népegészségügy 2021; 98: 257.

Csákvári, T; Horváth, L; Elmer, D; Németh, N; Kívés, Zs; Wittmann, I; Janszky, J; Boncz, I. A diabeteses polyneuropathia epidemiológiai és egészségbiztosítási betegségteher elemzése egészségbiztosítási adatok alapján. Diabetologia Hungarica 2021; 29(Suppl 1): 15-16.

Boncz, I. ; Pónusz, R. ; Elmer, D. ; Németh, N. ; Horváth, L. ; Sebestyén, A. ; Endrei, D.; **Csákvári, T.** Epidemiological Disease Burden Of Diabetic Polyneuropathy Based On Routinely Collected Health Insurance Claims Data. Value In Health 2020; 23(Suppl 1): S121-S122.

Boncz, I. ; Pónusz, R. ; Elmer, D. ; Németh, N. ; Horváth, L. ; Sebestyén, A. ; Endrei, D.; **Csákvári, T.** Annual Health Insurance Treatment Cost Of Diabetic Polyneuropathy Based On Routinely Collected Financing Data. Value In Health 2020; 23(Suppl 1): S117.

Csakvari, T ; Nemeth, N ; Elmer, D ; Komaromy, M ; Ponusz, R ; Boncz, I. The Importance Of Innovative Financing And Earmarked Taxes In Health Care - The Case Of Hungary. Value In Health 2020; 23(Suppl 2): S659-S659.

Csákvári, T. ; Elmer, D. ; Németh, N. ; Komáromy, M. ; Zoltán, V. ; Pónusz, R. ; Boncz, I. Changes In The Expenditure On Sweets After The Introduction Of The Hungarian Public Health Product Tax: An Interrupted Time Series Analysis. Value In Health 2020; 23(Suppl 1): S298-S299.

Csákvári, T. ; Pónusz, R. ; Elmer, D. ; Németh, N. ; Horváth, L. ; Sebestyén, A. ; Endrei, D. ; Boncz, I. Epidemiological Disease Burden Of Non-Insulin-Dependent Diabetes With Neurological Complications Based On Routinely Collected Health Insurance Claims Data. Value In Health 2020; 23(Suppl 1): S122.

Csákvári, T. ; Endrei, D. ; Elmer, D. ; Németh, N. ; Horváth, L. ; Sebestyén, A. ; Pónusz, R. ; Boncz, I. Epidemiological Disease Burden Of Non-Insulin-Dependent Diabetes With Multiple Complications Based On Routinely Collected Health Insurance Claims Data. Value In Health 2020; 23(Suppl 1): S122.

Csákvári, T. ; Sebestyén, A. ; Elmer, D. ; Németh, N. ; Horváth, L. ; Pónusz, R. ; Endrei, D. ; Boncz, I. Epidemiological Disease Burden Of Non-Insulin-Dependent Diabetes With Complications Based On Routinely Collected Health Insurance Claims Data. Value In Health 2020; 23(Suppl 1): S12.

Csákvári, T. ; Endrei, D. ; Elmer, D. ; Németh, N. ; Horváth, L. ; Sebestyén, A. ; Pónusz, R. ; Boncz, I. Annual Health Insurance Treatment Cost Of Non-Insulin-Dependent Diabetes With Multiple Complications Based On Routinely Collected Financing Data. Value In Health 23(Suppl 1): S118.

Csákvári, T. ; Sebestyén, A. ; Elmer, D. ; Németh, N. ; Horváth, L. ; Pónusz, R. ; Endrei, D. ; Boncz, I. Annual Health Insurance Treatment Cost Of Non-Insulin-Dependent Diabetes With Complications Based On Routinely Collected Financing Data. Value In Health 2020; 23(Suppl 1): S116-S117.

Csákvári, T. ; Pónusz, R. ; Elmer, D. ; Németh, N. ; Horváth, L. ; Sebestyén, A. ; Endrei, D. ; Boncz, I. Annual Health Insurance Treatment Cost Of Non-Insulin-Dependent Diabetes Mellitus With Neurological Complications Based On Routinely Collected Financing Data. Value In Health 2020; 23(Suppl 1): S112.

Csákvári, T ; Németh, N ; Kerner, Á ; Sebestyén, A ; Endrei, D ; Boncz, I. Assessing the effect of the public health product tax in Hungary between 2011-2017. VALUE IN HEALTH 2018; 21(Suppl 2): S52.

Csákvári, T ; Vajda, R ; Kerner, Á ; Molics, B ; Endrei, D ; Sebestyén, A ; Boncz, I. Alternative sources for health care funding: Public health taxes in Hungary between 2011-2016. Value In Health 2017; 20: A517-A517.

Csákvári, T ; Endrei, D ; Boncz, I. Development of the public health product tax in Hungary between 2011-2015. Value In Health 2017; 20: A34.

Csákvári, T ; Turcsányi, K ; Endrei, D ; Sebestyén, A ; Boncz, I. Analyzing the revenues and expenditures of the Hungarian Health Insurance Fund between 1993-2015. Value In Health 2016; 19: A462.

University textbook on the topic of the dissertation (Hungarian)

Csákvári, T.; Ágoston, I.; Endrei, D.; Boncz, I. Makrogazdasági környezet és egészségügyi finanszírozás. In: Boncz, I.; Ágoston, I.; Kovács, G.; Endrei, D. (szerk.) Gazdálkodás és menedzsment az egészségügyi intézményekben. Budapest, Magyarország: Medicina Könyvkiadó 2019; 15-26.