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The Calculation of Social Benefits of Influenza Vaccination based on Statistical Data

Az influenza elleni védőoltás társadalmi hasznosságának számítása statisztikai adatok alapján

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Abstract

The goal we set in our study has had no precedent either in the Hungarian or in the international literature: our intention was to quantify the effectiveness of influenza vaccination based on facts, and to define the number of non-occurred diseases as a result of vaccination.
We evaluated data from the influenza season of 2018/2019 in our study. We analyzed the available data on population, vaccination and the number of diseases, and drew objective conclusions therefrom. It was a problem that the basic data appeared in different data sets for different age groups, so we had to find a consensus between them, and establish comparable age groups. Ultimately, we defined three distinct age groups: the age group of minors (0-18 years), the economically active (19-59 years) and the age group of over 60 years. These three age groups became well distinguishable by population, vaccination, and morbidity.
We described the influenza disease in general, the characteristics and variability of the influenza virus. We defined the typically affected age group, the number of patients to be treated, the trends for the past 5-10 years.
The presented facts, numbers, the results of the calculations, and the conclusions drawn clearly show – excluding subjectivity – the preventive effect and effectiveness of vaccination, which was quantified for the first time in Hungarian literature.

Keywords: Qualitative Methods, Finance, Health
JEL Codes: C4, G0, I1

Absztrakt

Tanulmányunkban olyan célt tűztünk magunk elé, melyre vonatkozóan sem a magyar, sem a nemzetközi szakirodalomban nem találtunk precedenst: tényadatokból kiindulva számszerűsíteni az influenza elleni védőoltás hatékonyságát, s a valós adatok alapján számított hatékonysági értékből kiindulva megállapítani a védőoltások révén be nem következett megbetegedések számát.
Tanulmányunkban a 2018/2019-es influenza szezon adatait elemeztük. Munkánk során a népesség számra, a beoltottságra és a megbetegedések számára vonatkozóan rendelkezésre álló adatokat elemeztük, vontunk le belőlük objektív következtetéseket. Problémát jelentett, hogy az eltérő adatállományokban eltérő korcsoportokra vonatkoztatva jelentek meg az alapadatok, így azok között a konszenzust meg kellett teremteni, összehasonlítható korcsoportokat kellett képezni. Végső soron három jól elkülöníthető korosztály keletkezett. A kiskorúak csoportja (0 - 18 év), a gazdaságilag

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aktívak (19 - 59 év) és a 60 év felettiek korcsoportja. Ez a három korosztály népességileg, beoltottság és megbetegedés szerint jól elkülöníthetővé vált.
Bemutattuk az influenza betegséget általánosságban, az influenza vírus jellemzőit, változékonyságát. Ismertettük a jellemzően érintett korosztályt, a kezelendő betegek számát, az elmúlt 5 - 10 évre vonatkozó trendeket.
A bemutatott tényadatokból, számsorokból, az abból végzett számítások eredményéből és a levont következtetésekből a szubjektivitást teljes mértékben kizárva látszik a védőoltások betegséget megelőző hatása, hatékonysága, melyet - elsőként a hazai szakirodalomban - számszerűsíteni is sikerült.

Kulcsszavak: Kvalitatív Módszerek, Finanszírozás, Egészség
JEL Kódok: C4, G0, I1

Introduction

Influenza is a worldwide epidemic viral disease caused by the different influenza virus strains that poses a serious threat to health.
Influenza is a seasonal disease lasting from October to March on the Northern Hemisphere. Since it is spread by droplet infection and direct contact, the virulence of the virus is extremely high.
Due to its extremely effective infection strategy and its subsequently rapid spread, the influenza virus strains annually infect several ten million people.
There are no widely applied anti-viral drugs against influenza. Accordingly, the only way to fight influenza is by means of annual vaccination.

Hypothesis

Our hypothesis is that greater emphasis should be placed on vaccinating the active (18-60 years of age), as well as the children and adolescent (3-18 years of age) population groups, while maintaining the supply of free of charge vaccines to the age group of over 60 that current regulations define as one of the most vulnerable groups.
While evaluating the vaccination coverage against seasonal influenza and its consequences from healthcare point of view it should be taken into account that the World Health Organization (WHO) constantly warns the international community regarding the outmost threat caused by seasonal influenza, as well by pandemic situations.
The WHO regularly publishes documents, papers and scientific advises regarding the influenza issues, runs different programs to address influenza-caused problems worldwide.
From the perspective of the present study the valuable background information has been used from a relevant WHO publication. (*WHO, 2016*)

1. MATERIAL AND METHOD

Description of the demographic and socio-economic situation of the patient group exposed to infection with influenza viruses
Typical risk age-groups: The high risk groups in order to reduce the severity of illnesses caused by the influenza virus and the number of deaths are as follows:
A) People over 60 regardless of their health status
B) People over six months of age who are at risk of serious illness
C) Persons posing risk to the above risk groups through transmission
D) Due to the risk of mixing zoonotic and human influenza viruses and the possibility of gene exchange, those working in livestock farms (pigs, poultry and horses).
Incidence: In epidemiology, an incidence is a measure of the frequency of new cases that occur in a given population over a given period of time.
Number of patients to be treated: Several hundreds of thousands of people visit their doctor with influenza-like illness per year. Given that the majority of patients do not consult their physician when

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affected by an influenza-like illness, the number of patients actually to be treated is much higher than the number of known cases.
Apart from foreign literature, mortality data published by the Central Statistics Office (CSO/KSH) are worth considering since they justify the fact that mortality increases depending on the severity of the influenza epidemic.
Vaccination is still inevitably the most effective way currently known to prevent influenza, although no single vaccine can guarantee 100% protection against the given disease. According to data from recent years, influenza vaccines have provided approximately 40-60% protection against laboratory-confirmed influenza disease cases. (*Egészségkalauz, 2019*)
Thus, the average effectiveness of vaccination is 50 percent based on professional literature. This means that if one person out of those vaccinated falls ill, in lack of vaccination 2 people would become ill. We personally feel and believe that this is an underestimated value.
In case future research results or ever sophisticated methodological effectiveness measurement further refine the value of non-occurring diseases, our calculations could become more specific, as well. Even though our study is not a guideline, we hope it is definitely a gap-filling analysis.

2. STUDY RESULTS AND THEIR ASSESSMENT

Number of non-occurred diseases based on facts
Before quantifying non-occurred diseases, let us first review the influencing data over a five-year period. (*KSH/Central Statistics Office, Hungary, 2017*)
A) Basic data
a) Population

Table 1: Population of Hungary between 2013 and 2017
1. táblázat: Magyarország lakossága 2013-2017 között

Year	2013	2014	2015	2016	2017
Population	9 908 798	9 877 365	9 855 571	9 830 485	9 797 561

Source: Health Statistics Yearbook, (2017)

It can be clearly seen that the population is constantly and practically steadily declining (Table 1). The decline was 1.12 percent in four years.
b) Vaccination (Table 2, Figure 1)

Table 2: Number of vaccines administered between 2013 and 2017
2. táblázat: Felhasznált oltóanyagmennyiség 2013-2017 között

Number of vaccines administered					
Year	2013	2014	2015	2016	2017
Vaccine (number of people)	**898 086**	**765 524**	**752 282**	**694 155**	**782 497**

Source: Health Statistics Yearbook, (2017)

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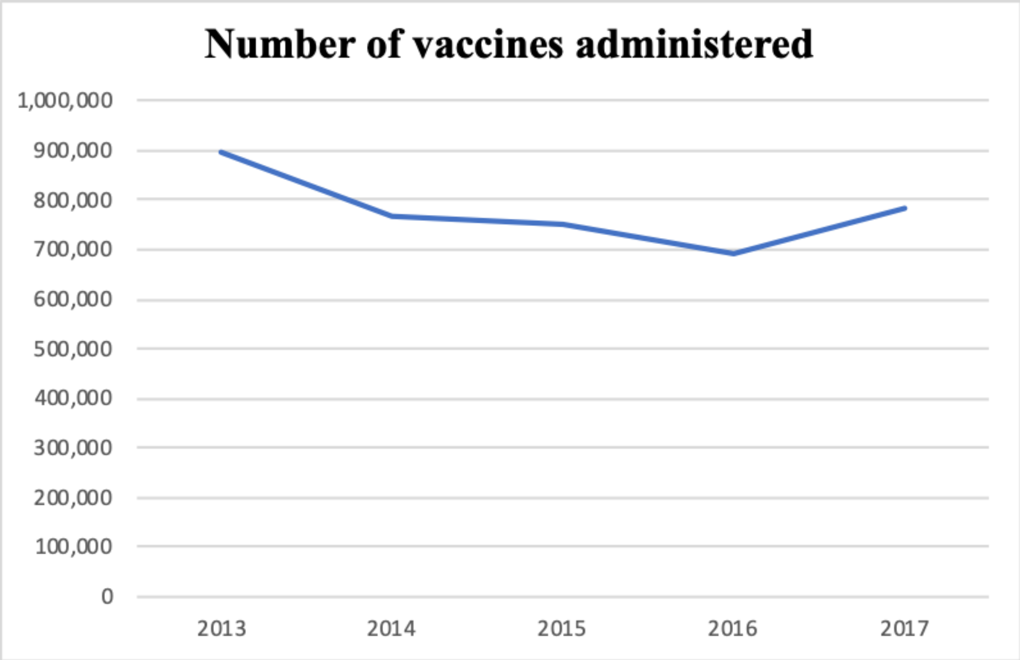

Figure 1: Number of vaccines administered
1. ábra: Felhasznált oltóanyag mennyiség
Source: Own edit Vajo, (2020)

The average number of people who received vaccination during the period was 778,509 with a standard deviation of approx. 10%. From the quotient of the previous figures the vaccination rate can be established (Table 3, Figure 2), which was as follows during the reference period:

Table 3: Vaccination (%)/year
3. táblázat: Beoltottság (%)/év

Year	2013	2014	2015	2016	2017
Vaccination (%)	9.064	7.750	7.633	7.061	7.987

Source: Health Statistics Yearbook, (2017)
Own edit Vajo, (2020)

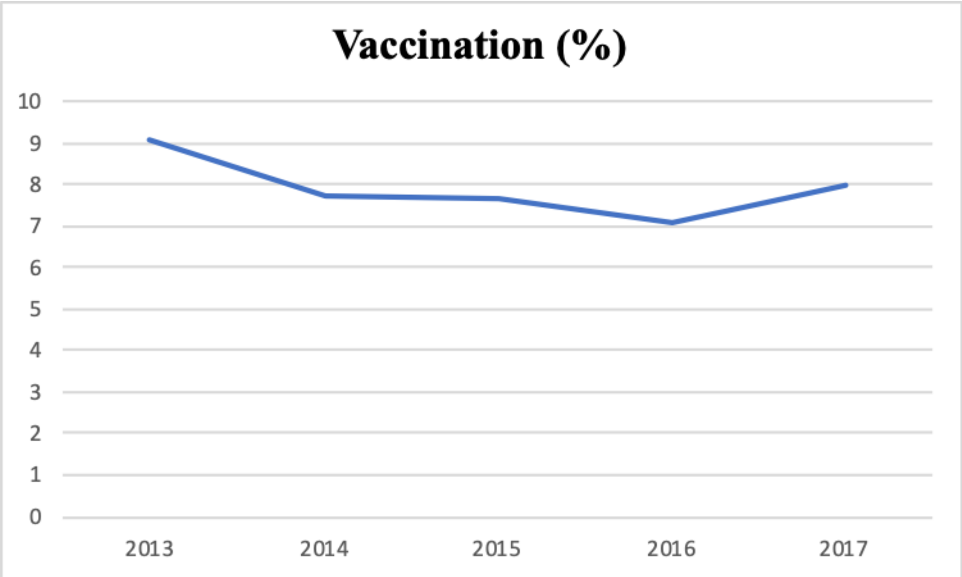

Figure 2: Vaccination (%)
2. ábra: Beoltottság (%)
Source: Own edit Vajo, (2020)

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c) Morbidity numbers (Table 4, Figure 3)

Table 4: Morbidity data for the influenza seasons between 2013 and 2017
4. táblázat: A 2013-2017 közötti influenza szezonok megbetegedési adatai

Year	2013	2014	2015	2016	2017
Morbidity (k)	198	141	504	261	466

Source: Health Statistics Yearbook, (2017)

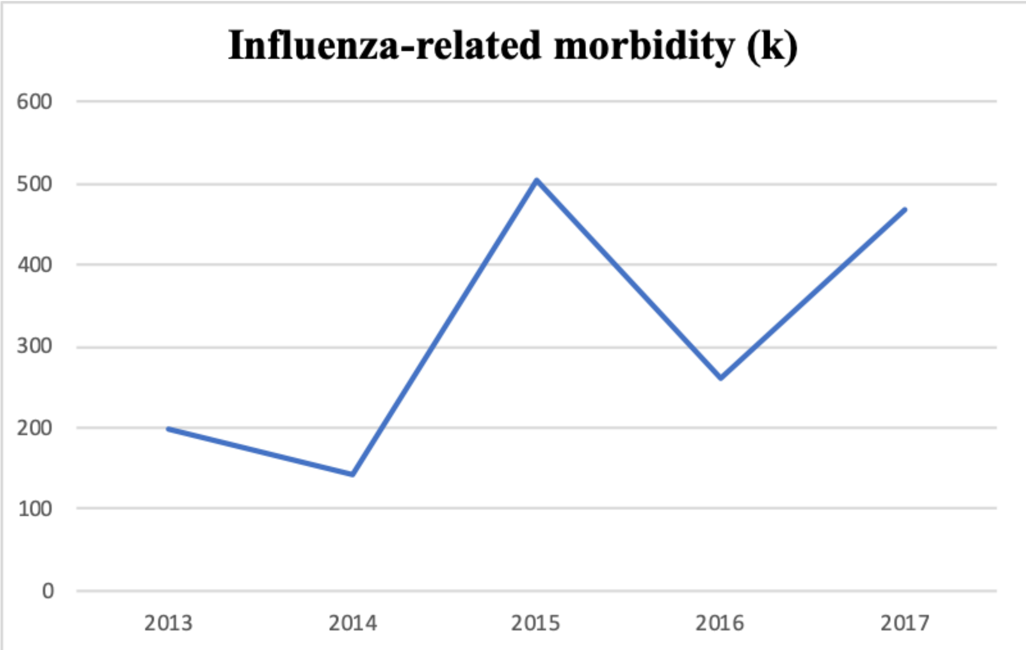

Figure 3: Influenza-related morbidity
3. ábra: Influenzával összefüggő megbetegedések
Source: Own edit Vajo, (2020)

d) Mortality numbers (Table 5, Figure 4)

Table 5. Mortality data for the influenza seasons between 2013 and 2017
5. táblázat: A 2013-2017 közötti influenza szezonok halálozási adatai

Year	2013	2014	2015	2016	2017
Mortality (number of people)	126 778	126 308	131 697	127 053	131 674

Source: Health Statistics Yearbook, (2017)

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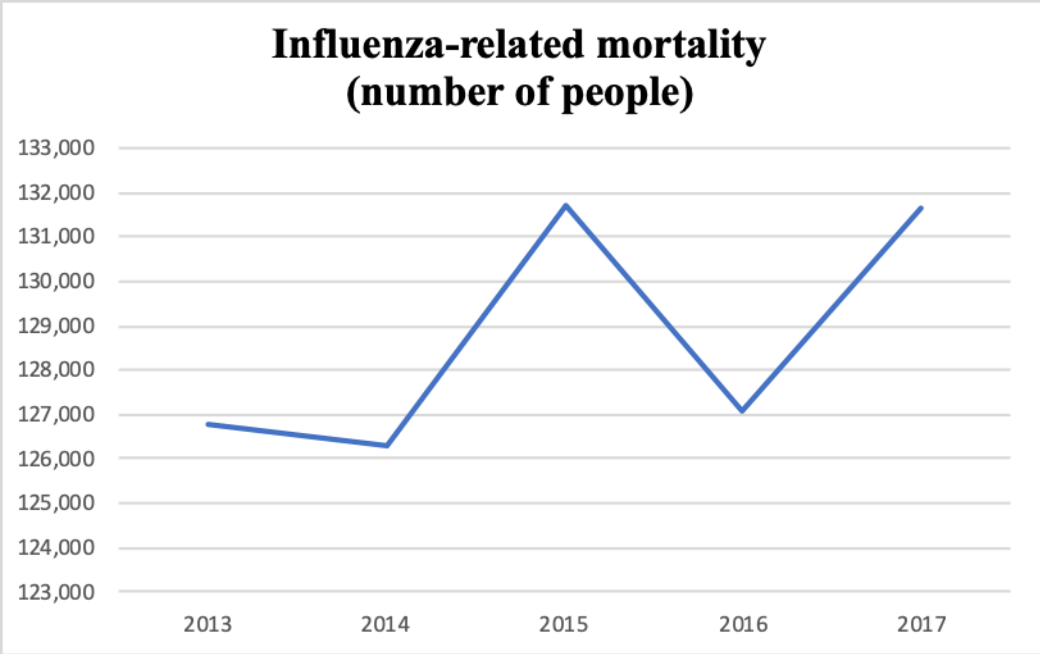


Figure 4: Influenza-related mortality (number of people)
4. ábra: Influenzával összefüggő halálozások (esetszám)
Source: Own edit Vajo, (2020)

It is remarkable that the graphs representing morbidity and mortality are almost identical (Figure 3, Figure 4).

It is worth having a look at the ratio of morbidity and total population (Table 6, Figure 5):

Table 6: Morbidity rate (%)/year
6. táblázat:Megbetegedések aránya (%)/év

Year	2013	2014	2015	2016	2017
Morbidity rate (%)	2.00	1.43	5.11	2.66	4.76

Source: Own edit Vajo, (2020)

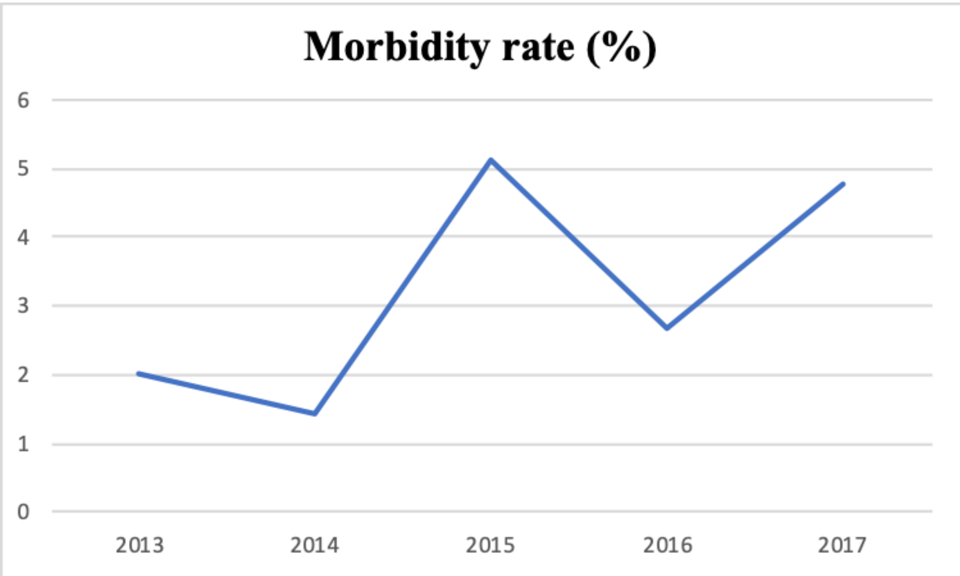
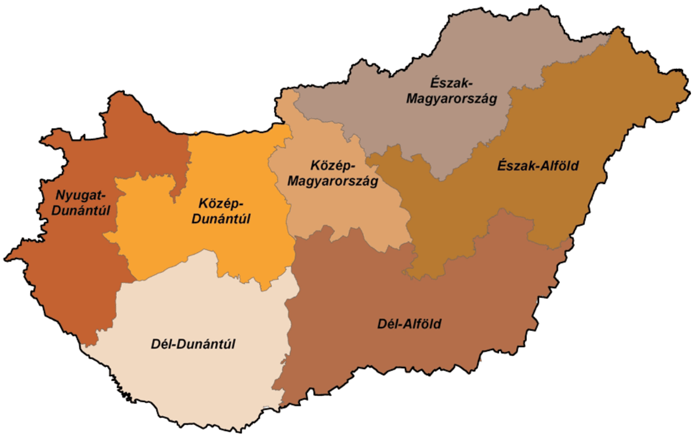


Figure 5: Morbidity rate (%)
5. ábra: Megbetegedések aránya (%)
Source: Own edit Vajo, (2020)

e) Regional overview
Before determining the number of influenza cases successfully avoided, it is worth making a regional comparison within the territory of Hungary to see if there are any significant differences in vaccination rates and morbidity rates in different parts of the country.
In principle, county and regional data allow for territorial comparison. There are 19 counties plus the Capital as well as seven regions in Hungary. We excluded the county-level comparison in our study: on the one hand it is difficult for the reader to review twenty data sets, and on the other the county-level data (due to their relatively small number) no longer provide a reliable basis for conclusions. Consequently, we opted for the regional level comparison.
Regions in Hungary
There are seven regions in Hungary that are illustrated in the following picture. (*Regions of Hungary map, 2019*)



The regions are, as follows:
- Western Transdanubian (WT)
- Central Transdanubian (CT)
- South Transdanubian (ST)
- Central Hungarian (CH)
- Northern Hungarian (NH)
- Southern Great Plain (SGP)
- Northern Great Plain (NGP)

We excluded Budapest from the CH Region as it plays a concentrated role from a healthcare and epidemiological point of view. Thus, the CH Region covers Pest county only whereas Budapest is a separate territorial unit.
There is no detailed presentation of each region as this is not relevant for our study purpose. We only make a territorial comparison based on the number of influenza vaccination and the number of flu-like illnesses.
Source of data
The task was relatively simple in terms of population and county-level data on vaccinations. The distribution of the population corresponding to the situation on 1 January 2018 broken down by counties is based on data presented in the Health Statistics Yearbook of 2017, published by the CSO, while the number of influenza vaccinations broken down by counties is indicated in the 2018 edition of the same yearbook. (*KSH/Central Statistics Office, Hungary, 2018*)
Defining the number of cases at the county level was a much more difficult task as no specific data were available. However, the Department of Epidemiology and Infection Control of the National Public Health Center data on the Influenza Surveillance Service showed the incidence data per 100,000 inhabitants broken down by counties as well as the number of total morbidities. The number of patients broken down by weeks and counties can be calculated on this basis. (*National Public Health Center, 2019*)
Methodology

The incidence data relevant for week 40, 2018 to week 20, 2019 as well as the total weekly morbidity numbers were summarized. The number of cases in a given county broken down by weeks was defined on the basis of these data. By aggregating the weekly data, we get the morbidity numbers for the influenza season of 2018/2019 at the county level.

The distribution of the population broken down by counties, the number of vaccinations, the number of cases at the county-level defined by the above described method, as well as the aggregation of county data at the regional level (highlighting the data concerning the capital city) are shown below (Table 7).

Table 7: Regional distribution of the population, the influenza vaccination, and the number of influenza-like diseases in the influenza season of 2018/2019

7. táblázat: A lakosság, az influenza elleni oltások, valamint az influenza-szerű megbetegedések regionális eloszlása a 2018/2019 influenza szezonban

Regional unit	Population	Vaccination number	Total cases
Budapest	1,749,734	151,834	88,575
Pest	1,261,864	78,054	69,048
Central Hungary total	**3,011,598**	**229,888**	**157,623**
Central Transdanubia*	1,055,570	91,544	57,897
Western Transdanubia*	985,457	68,678	62,665
Southern Transdanubia*	886,840	75,547	36,924
Transdanubia total	**2,927,867**	**235,769**	**157,486**
Northern Hungary*	1,134,945	77,075	46,523
Northern Great Plain*	1,460,096	82,097	81,111
Southern Great Plain*	1,243,865	93,567	51,581
Great Plain and the North total	**3,838,906**	**252,739**	**179,215**
Grand Total	**9,778,371**	**718,396**	**494,324**

Source: Health Statistics Yearbook, (2017)
Own edit Vajo, (2020)

**Note: regional data represent the aggregated data of counties*

Analysis of regional data

Table 8: The rate of vaccination and morbidity in relation to the total population broken down by regions, expressed in percentage, and sorted by increasing vaccination rate

8. táblázat: A beoltottság és a megbetegedések aránya a teljes lakossághoz viszonyítva, regionális bontásban, százalékosan kifejezve, a növekvő beoltottság sorrendjében

Region (Capital)	Vaccination (%)	Morbidity (%)
Northern Great Plain	5.62	5.56
Pest	6.19	5.47
Northern-Hungary	6.79	4.10
Western-Transdanubia	6.97	6.36
Southern Great Plain	7.52	4.15
Southern-Transdanubia	8.52	4.16
Central-Transdanubia	8.67	5.48
Budapest	8.68	5.06

Source: Health Statistics Yearbook, (2017)
Own edit Vajo, (2020)

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The percentage rate of vaccinations and morbidity in relation to the population can be generated broken down by region (and separately by the Capital).
The data we thus get can be more easily reviewed after having sorted the data in the table based on vaccination (Table 8).
It can be concluded that the vaccination rate was the lowest (5.62%) as for the population of the NGP Region, whereas it came second in the territorial ranking in terms of morbidity. The higher incidence rate was observed in the WT Region followed by the NGP Region even though vaccination there reached almost 7% (however, it is only the fourth least vaccinated region).
Vaccination rate was over 7.5 percent in each of the regions listed in the second half of the table, while morbidity remained below 5.5 percent everywhere.
The highest vaccination rate is observed in the Capital; however, morbidity is considered average.
The morbidity rate in relation to the population was the lowest in the NH Region, despite the fact that this region represents the third least vaccinated area.
Showing the data from the table in a line chart, it can be seen that morbidity is decreasing with increasing vaccination (Figure 6.).

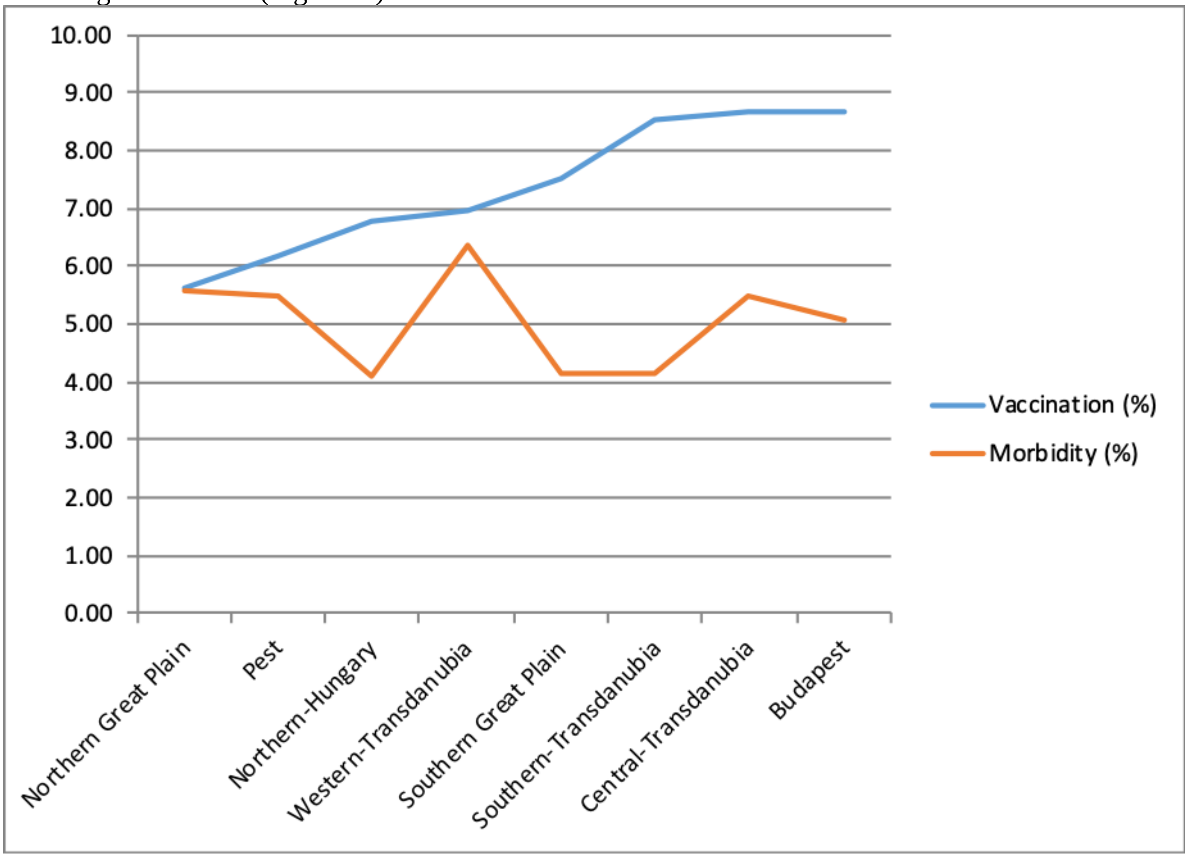

Figure 6: Vaccination and morbidity
6. ábra: Beoltottság és megbetegedések
Source: Own edit Vajo, (2020)

The inverse relationship is evident; in order to quantify such relationship, correlation coefficient calculation for the data series was done. The correlation coefficient is used to numerically measure a relationship, and shows the strength between the two variables of a linear relationship as well as the direction of the relationship. Its value can be between −1 and +1, where ± 1 indicates the strongest possible match and 0 indicates the largest possible difference.
The result of the calculation was minus 0.28, which does not show an intensive relationship between vaccination and morbidity, yet it also quantifies the trend that the morbidity significantly decreases with increasing vaccination. In view of this trend, it would be worth putting more emphasis on the promotion of influenza vaccination in the NGP Region, which ranks last (but is second in terms of morbidity), given that the region can boast of renowned institutions such as the University of Debrecen, which "… with its four hundred and fifty uninterrupted years of history is now the oldest

higher educational institution in the country, which operates continuously in the same city. Being one of the largest educational campuses in Hungary, it is now of outstanding significance in the higher education system in Hungary. It offers outstanding education, research and innovation capacities as well as scientific results even in international terms; all these provide a solid basis to play a significant role in the implementation of national strategic goals. Also, it ranks among the 500 best universities in the world". (*University of Debrecen, 2019*)

B) Data from the influenza season of 2018/2019

We intend to quantify the number of illnesses that could be avoided based on the influenza season data of 2018/2019. The required data were collected from several sources.

a) Facts

The population was 9,778,371 on January 1, 2018; 718,396 people were vaccinated in the influenza season of 2018/2019, which is 7.35 percent of the total population. (*Health Statistics Yearbook, 2017)*

This resource categorized those that received influenza vaccine broken down in four age groups.

Morbidity in the influenza season of 2018/2019 was 494,520, which is 5.06 percent of the total population. In other words, it can be stated that in the influenza season of 2018/2019, 7.35 percent of the Hungarian population received influenza vaccination, and 5.06 percent fell ill. (*Health Statistics Yearbook, 2017)*

This value refers to the average of the total population. However, in terms of age distribution, vaccination is unlikely to be evenly distributed. It is necessary to analyze the available data in order to find out the distribution.

The distribution of vaccine recipients by age group (Table 9, Figure 7) is as follows:

Table 9: People/age group

9. táblázat: Lakosságszám korcsoportonként

Age group	3-18	19-59	60-64	over 65	Total
People	20 125	187 566	64 013	446 692	718 396
%	2.80	26.11	8.91	62.18	100.00

Source: Zsuzsanna Molnár MD, National Center for Public Health, (2019)

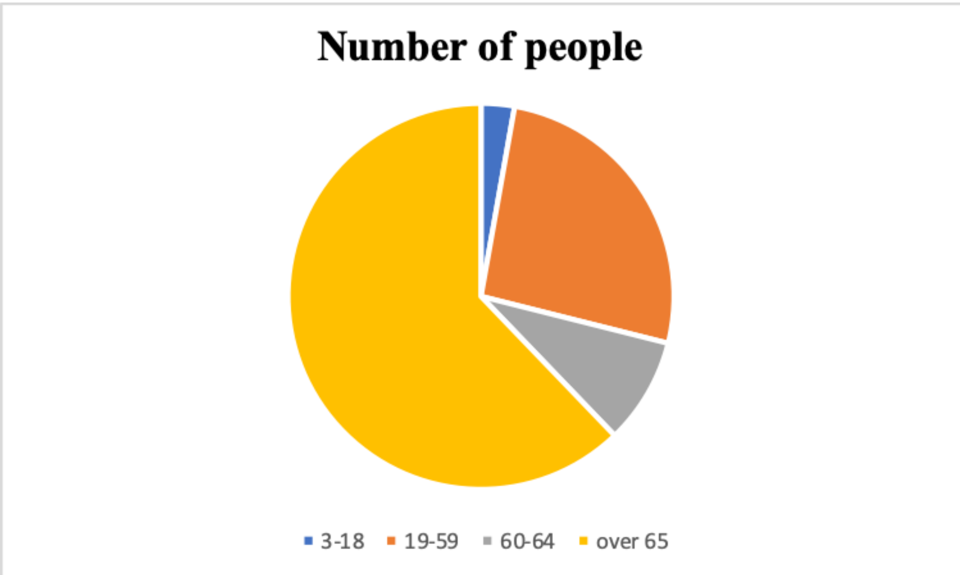

Figure 7: Number of people/age group

7. ábra: Lakosságszám korcsoportonként

Source: Own edit Vajo, (2020)

These data and the illustration clearly show that people under 18 years of age received 2.8 percent of all vaccinations, and those over sixty received 62.18 percent of the vaccines. The distribution of these age groups in the total population needs to be known in order to decide whether these values are too high or too low.

The CSO categorizes the population by age group in the following breakdown: 0 - 14 years, 15-19 years, then ten-year groups (decades) afterwards (Table 10, Figure 8).

Table 10: People/age group

10. táblázat: Lakosságszám korcsoportonként

Age group	0–14	15–19	20–29	30–39	40–49	50–59	60–69	70–79	over 80	Total
People	1 421 916	489 340	1 204 219	1 323 506	1 558 261	1 207 262	1 324 480	821 456	427 931	9 778 371
%	14.54	5.00	12.32	13.54	15.94	12.35	13.54	8.40	4.38	100.00

Source: Health Statistics Yearbook, (2017)

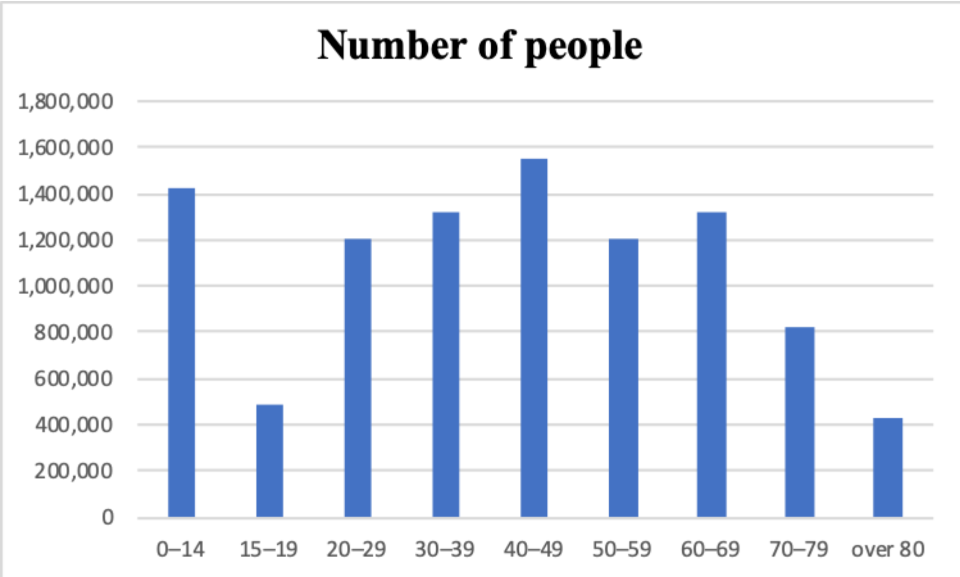

Figure 8: Number of people/age group

8. ábra: Lakosságszám korcsoportonként

Source: Own edit Vajo, (2020)

Unfortunately, this age group distribution does not match the distribution of those age groups that received vaccination. Moreover, we have yet another data set: the number of people who visit their doctor with influenza-like illnesses.

The prevalence of influenza-like illnesses broken down by area and age group was monitored on the basis of morbidity data of 1,349 general- and pediatric practitioners during the influenza season of 2018/2019. District offices asked 100 physicians that participated in the surveillance system to regularly send respiratory samples for virological testing from patients with influenza complaints in order to identify the pathogen of the disease. Based on the results of the received samples, the occurrence and spread of influenza viruses could be monitored weekly. During the influenza season of 2018/2019, the number of influenza-like illnesses was as below (Table 11).

Table 11: Number of influenza-like illnesses

11. táblázat: Influenza-szerű megbetegedések száma

Period	Total number of people visiting a doctor with influenza-like symptoms	Percentage				People			
		age 0-14	age 15-34	age 35-59	age over 60	age 0-14	age 15-34	age 35-59	age over 60
Week 40, 2018	3 500	16.9	40	29.1	14	592	1 400	1 019	490
Week 41, 2018	3 500	11.3	42.6	33.8	12.3	396	1 491	1 183	431
Week 42, 2018	4 300	16.3	40.8	26.3	16.6	701	1 754	1 131	714
Week 43,	2 700	16.9	41.3	27.1	14.7	456	1 115	732	397

2018									
Week 44, 2018	2 500	9.4	49.1	28.7	12.8	235	1 228	718	320
Week 45, 2018	4 500	15.1	43.4	28.3	13.2	680	1 953	1 274	594
Week 46, 2018	4 800	16	44.6	24.5	14.9	768	2 141	1 176	715
Week 47, 2018	6 000	18.4	44.3	25.7	11.6	1 104	2 658	1 542	696
Week 48, 2018	7 000	21.2	40.6	25.9	12.3	1 484	2 842	1 813	861
Week 49, 2018	8 000	18.4	42.3	27.4	11.9	1 472	3 384	2 192	952
Week 50, 2018	10 000	21.9	37.6	26.4	14.1	2 190	3 760	2 640	1 410
Week 51, 2018	11 000	22.9	38.4	26	12.7	2 519	4 224	2 860	1 397
Week 52, 2018	no data collected *								
Week 01, 2019	11 000	16.8	40.6	29.8	12.8	1 848	4 466	3 278	1 408
Week 02, 2019	19300	19.7	42.6	26.7	11	3 802	8 222	5 153	2 123
Week 03, 2019	38 200	32.5	34.9	24.3	8.3	12 415	13 332	9 283	3 171
Week 04, 2019	65 000	37.7	32.6	22.8	6.9	24 505	21 190	14 820	4 485
Week 05, 2019	77 500	35.5	34.5	23	7	27 513	26 738	17 825	5 425
Week 06, 2019	67 900	34.7	33.1	24.3	7.9	23 561	22 475	16 500	5 364
Week 07, 2019	52 200	31.6	34.1	25.8	8.5	16 495	17 800	13 468	4 437
Week 08, 2019	33 900	31.5	34.3	26.2	8	10 679	11 628	8 882	2 712
Week 09, 2019	21 300	29.1	34.9	27.6	8.4	6 198	7 434	5 879	1 789
Week 10, 2019	13 900	25.3	37.2	26.6	10.9	3 517	5 171	3 697	1 515
Week 11, 2019	7 300	22.3	37.9	27.9	11.9	1 628	2 767	2 037	869
Week 12, 2019	5 600	20	39.2	28.8	12	1 120	2 195	1 613	672
Week 13, 2019	3 800	18.1	41.8	27.2	12.9	688	1 588	1 034	490
Week 14, 2019.	2 700	20.1	42.8	24.8	12.3	543	1 156	670	332
Week 15, 2019	1 970	10	47.4	33.1	9.5	197	934	652	187
Week 16, 2019	1 000	9.3	44.9	33.2	12.6	93	449	332	126
Week 17, 2019	1 200	8.3	54.4	25	12.3	100	653	300	148

Week 18, 2019	800	9.4	38.6	33.3	18.7	75	309	266	150
Week 19, 2019	1 200	6	55.9	23.9	14.2	72	671	287	170
Week 20, 2019	950	7.5	59.2	20.9	12.4	71	562	199	118
Total	**494 520**	**N/A**	**N/A**	**N/A**	**N/A**	**147 715**	**177 688**	**124 451**	**44 667**
Percentage	**100.00**	**N/A**	**N/A**	**N/A**	**N/A**	**29.87**	**35.93**	**25.17**	**9.03**

Source: National Center for Public Health, (2019)

* *Note*: due to the year-end period (public holidays) there were no data collected by the physicians during the week of 52.

According to the assessment based on reports from the surveillance system, 494,520 doctor visits occurred with influenza-like symptoms between October 1, 2018 and May 19, 2019. The age group distribution of those visits is indicated in (Table 11) above.

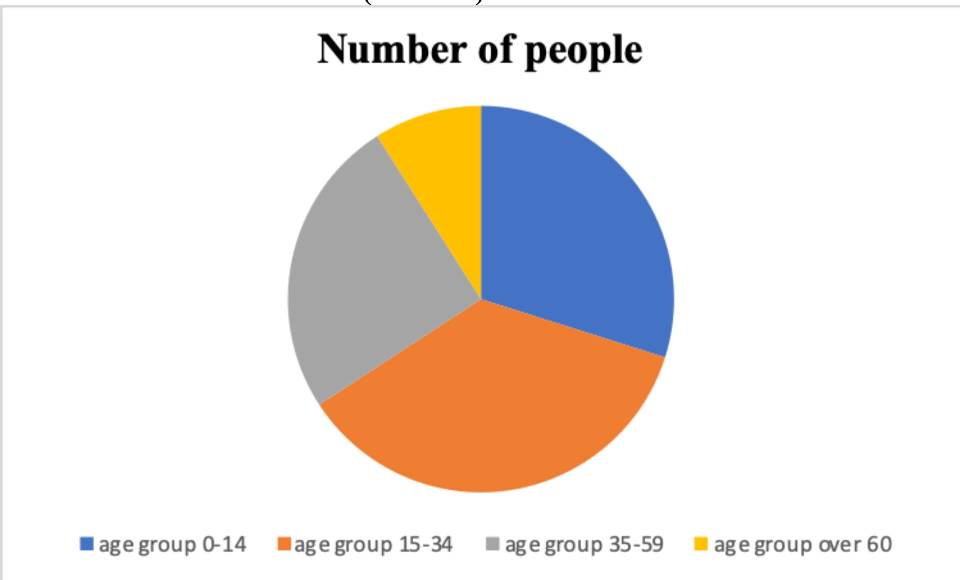

Figure 9: Number of people/age group
9. ábra: Lakosságszám korcsoportonként
Source: Own edit Vajo, (2020)

The figure above (Figure 9) clearly shows how large an extent the age group under 14, and how small an extent the age group over 60 became ill. This is in sharp contrast with the figure showing distribution of vaccine recipients by age group.

b) Establishing comparative age groups

A serious disadvantage to the data presented in the previous figures is that although they can be interpreted on their own, they do not contain the values in identical age group distributions; therefore they cannot be compared with each other. In order to ensure comparability, identical age groups should be established on the basis of available data, which inevitably requires that data derived and calculated from the established age groups have to be shown.

Age groups established by the CSO: age groups 0-14; 15-19, then ten-years groups afterwards.

Distribution of vaccination as per age groups: 3-18; 19-59; 60-64, and over 65.

Morbidity data are available for age groups 0-14; 15-34; 35-59, and age group over 60.

Comparable age groups from the above base data sources were selected (corresponding to all three data sources) so that the data for the given age group could be calculated as accurately as possible.

The exact data for the age group over 60 can be determined from each data source without calculation, thus it was chosen to be one of the age groups.

The age group available for vaccination is between 19 and 59 years, the breakdown of which by calculations (establishing a new group) would have provided a great deal of uncertainty as to the end result. Consequently, this was selected as the second age group.

Hence, it follows that the next and smallest age group is the 0-18. The vaccination data were factually available for all three age groups as established above, so no calculation or adjustment had to be performed in this respect.
However, it was required in terms of population and morbidity per age group, in both cases by means of regrouping between the minors and the active. No adjustment was required for the age group over 60.
We resolved the age group adjustment with regard to the distribution of the population by considering the composition of the age group 15-19 (489,340 people) as equal then deducting the portion for the age group 19 (one-fifth) from this value, and taking it into account for the data of the age group 19-59. The value of this adjustment is 97,868 people.
In terms of morbidity, the age group to be broken down is the age group 15-34 (20 years). It means 177,688 cases. Assuming an evenly distributed morbidity, adjustment was required for four years (15-18 years). It makes up twenty percent of the total age group in this case as well, that is, 35,538 cases had to be withdrawn from the data of the age group 15-34, and adjusted the data of the age group 0-14 with this number.
As a result, three distinctive age groups were established: the group of minors (0-18 years), the economically active (19-59 years), and those over 60 (economically no longer active, inactive, or passive). These three age groups are clearly distinguishable by population, vaccination, and morbidity. At the same time, only a small amount of calculated data was generated, the error size of which can only be minimal.
c) Value data belonging to the established age groups and their correlations
Let us consider the adjusted values as for the established age groups (Table 12).

Table 12: Value data/age groups
12. táblázat: Értékadatok korcsoportonként

Age group	0-18	19-59	over 60	Total
Population	1 813 388	5 391 116	2 573 867	9 778 371
Vaccinated	20 125	187 566	510 705	718 396
Morbidity number	183 253	266 601	44 666	494 520
Distribution of population (%)	18.54	55.13	26.32	100.00
Distribution of vaccination (%)	2.80	26.11	71.09	100.00
Distribution of morbidity (%)	37.06	53.91	9.03	100.00

Source: Own edit Vajo, (2020)

The age group of the minors makes up 18.54 percent of the population, those economically active mean 55.13 percent, and those over 60 years of age give 26.32 percent.
These ratios are far from being matched by either the distribution of vaccination or the distribution of morbidity. 2.8 percent of all vaccination is made up by the minors, 26.11 percent are the economically active, and 71.09 percent are the retired.
37.06 percent of the total morbidity occurred in the age group of minors, 53.91 percent in the economically active group, and 9.03 percent in the age group of over 60.
The pie charts (Figure 10, 11 and 12) of the above ratios shows strikingly different picture.

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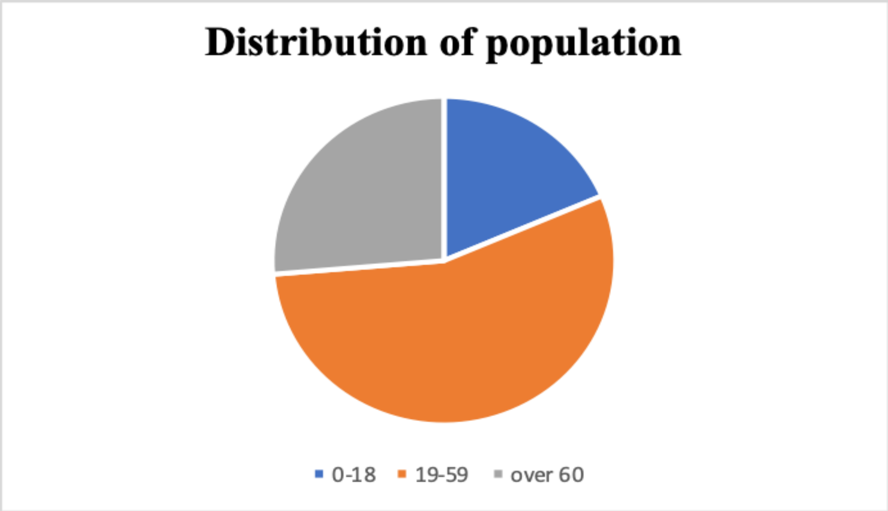

Figure 10: Distribution of population
10. ábra: A lakosság megoszlása
Source: Own edit Vajo, (2020)

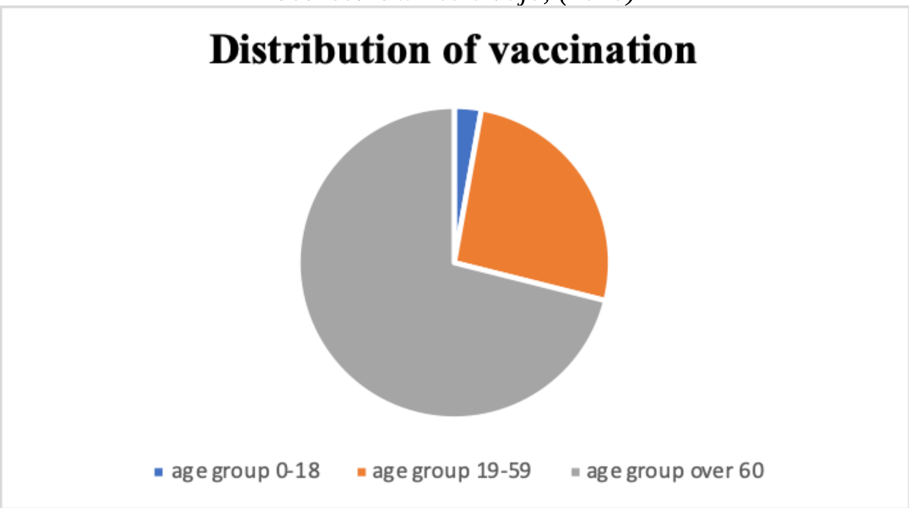

Figure 11: Distribution of vaccination
11. ábra: A beoltottság megoszlása
Source: Own edit Vajo, (2020)

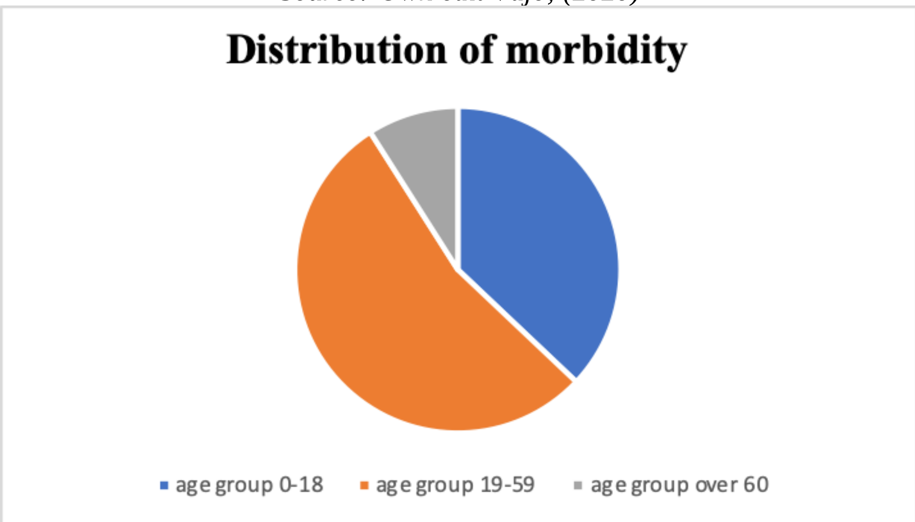

Figure 12: Distribution of morbidity
12. ábra: A megbetegedések megoszlása
Source: Own edit Vajo, (2020)

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Let us examine the ratios of vaccination and morbidity in the given age groups (Table 13).

Table 13: Vaccination and morbidity ratios/age groups

13. táblázat: A beoltottság és a megbetegedések arányai korcsoportonként

Age group	0-18	19-59	over 60	Total
Vaccination (%)	1.11	3.48	19.84	7.35
Morbidity (%)	10.11	4.95	1.74	5.06

Source: Own edit Vajo, (2020)

When interpreting these data, the following conclusions can be drawn:

1,11% of the age group of minors, 3.48% of those economically active, and almost 20% of those over 60 years of age (19.84 percent) received vaccination.

Morbidity: 10.11 percent of the minors, 4.95 percent of the economically active, and only 1.74 percent of those over 60 years of age fell ill.

It can be clearly seen that the direction of the vaccination rate and the morbidity data is significantly opposite.

A line chart (Figure 13) of the data plainly shows the reverse direction.

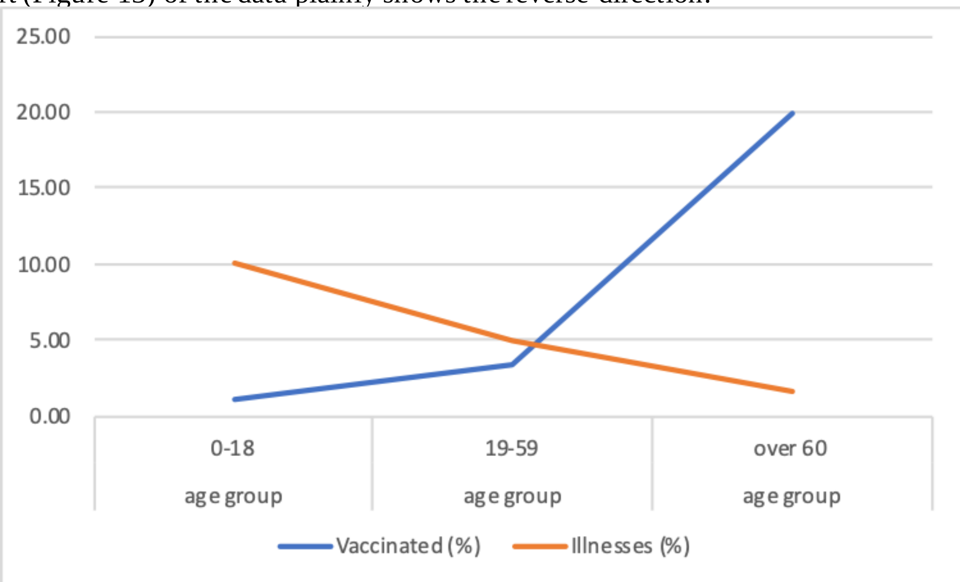

Figure 13: Vaccinated (%) and illnesses (%)/age group

13. ábra: Beoltottak (%) és megbetegedések (%) korcsoportonként

Source: Own edit Vajo, (2020)

When evaluating the numbers, we can say that 1.11 per cent of the minors were vaccinated, while more than 10 per cent (every tenth minor) became ill. Practically only one in ninety minors was vaccinated, yet one in ten fell ill.

As for the economically active, the vaccination rate is still below the proportion of the sick (3.48 percent and 4.95 percent, respectively). In this age group, every 29th person was vaccinated, but every twentieth became ill.

The most striking difference can be seen in the case of those over 60 years of age. Their vaccination rate is 19.84 percent, while morbidity is only 1.74 percent. It means that one in five people was vaccinated, resulting in only one in 58 people becoming ill.

The preventive effect and effectiveness of vaccines can be plainly seen even if we remove subjectivity from the former numbers. Solely based on published professional views, we assumed that the effectiveness of vaccination is 50%. Now, however, based on the differences by age group, we can review the effectiveness on the basis of the facts or at least their magnitude.

d) Calculating effectiveness based on facts

Vaccination was very low in the minors group with only 20,125 out of 1,813,388 people.

At 100 % effectiveness, all vaccinated persons – 20,125 – managed to avoid influenza, meaning they did not increase the morbidity data. The total morbidity in this age group is 183,253. Assuming that in the absence of vaccination, all those that received vaccination would have been infected then the

number of incidents would have been 183,253 + 20,125 = 203,378. Expressed as a percentage, the morbidity rate would have been 11.22 percent in this age group.
With zero vaccination effectiveness – that is, if vaccination has no effect on morbidity – the number of those that fell ill would have been identical with the number of those that actually developed influenza, that is, 183,253. It means that the morbidity rate in the age group of minors would have been between 10.11 and 11.22 percent regardless of vaccination.
The age group of over 60 shows similarity to the age group of minors based on their health status. Both age groups are at risk, the body of elderly age group is already weakening, and the body of minor's age group still needs to get stronger. Due to the different physical status of the active population, this age group shows the largest natural, successful immune response to the virus, the measurement and quantification of which would be far beyond the scope of this study. Therefore, a comparison of the morbidity data of the minor age group with the morbidity data of the elderly age group provides a well-founded picture of the effectiveness of vaccination.
Let us examine the age group of those over 60 years of age.
In the total Hungarian population, the number of people over 60 and the ratio of this age group to the total population between 2013 and 2017 (Table 14) developed as follows:

Table 14: Number and ratio of people over 60 years of 2013-2017
14. táblázat: A 60 év felettiek száma és aránya 2013-2017 között

Year	2013	2014	2015	2016	2017
Total population	9 908 798	9 877 365	9 855 571	9 830 485	9 797 561
Over 60 (people)	2 364 420	2 411 429	2 472 802	2 521 684	2 559 600
Ratio of those over 60 (%)	23.86	24.41	25.09	25.65	26.12

Source: Health Statistics Yearbook, (2017)

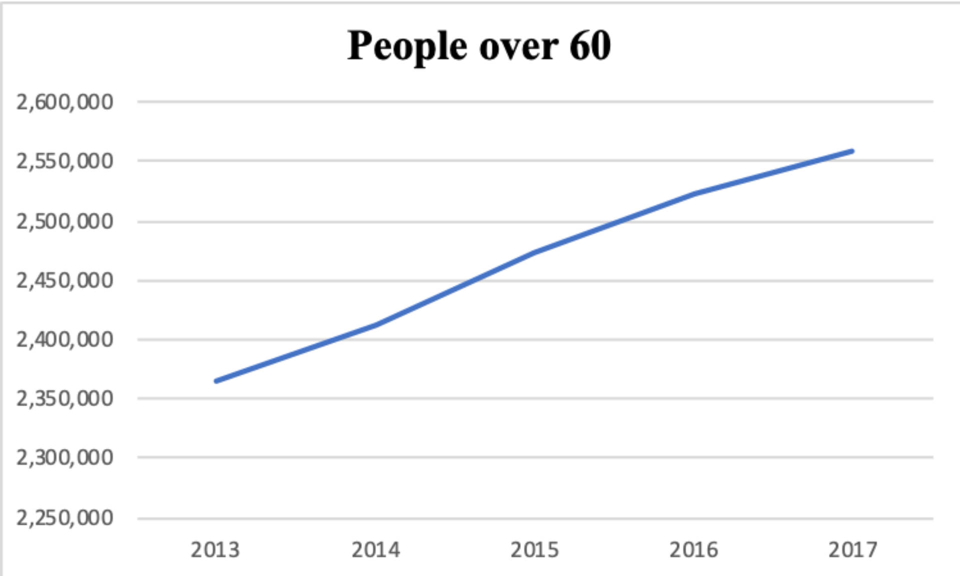

Figure 14: People over 60
14. ábra: 60 év felettiek
Source: Own edit Vajo, (2020)

It can be seen that the number of people over 60 is steadily increasing both in absolute and in relative terms (Figure14). In four years the proportion of this age group increased by 2.26 percent.
One year later, in 2018, there were even more people (2,573,867) in the age group over 60. Based on their vaccine-independent morbidity rate of 10.11 to 11.22, the age group of minors should have had 260,218 and 288,788 incidents. In contrast, there were only 44,666 cases, which is 215,552 and 244,122 cases less than expected, which would have occurred if no vaccination had been applied. This decrease in the number of cases occurred with 510,705 people over 60 years who were vaccinated. In other words, the vaccination of 510,705 people prevented influenza for 215,552 to 244,122 people.

This justifies effectiveness between 42.2 and 47.8 percent based on objective facts. It matched the efficiency band approved of in the sector, i.e. it is considered a reliable result.
In the following, it is advisable to perform calculations only with a specific efficiency value calculated on the basis of facts and numbers. The exact value thereof can be expressed with the following equation:
H = ((((183.253 + 20.125 H) /1.813.388) * 2.573.867) – 44.666) / 510.705
where H is the degree of effectiveness.
Solving the equation gives the value of H = 0.444836, from which the efficiency calculated on the basis of the fact is 44.68 percent.
Accordingly, 8,992 cases were avoided in the age group of minors. Thus, in the absence of vaccination, there would have been 183,253 + 8,992 = 192,245 cases in this age group, which would have resulted in a morbidity rate of 10.6014 % of the total number of people in this age group. Projecting this morbidity rate for the elderly, there are 272,866 calculated cases compared to the 44,666 cases that actually occurred, which means 228,200 cases avoided. The latter age group results in effectiveness of 44.68 % relative to the total number of those vaccinated which is thus supported and justified by adequate facts.
With the known effectiveness, the number of avoided cases can now be determined precisely for the active age group as well. 187,566 vaccines were administered in this group. Taking into account the 44.68 % effectiveness calculated above, the number of avoided cases is 187,566 * 0.4448 = 83,804 cases.
In summary, the number of non-occurred cases of influenza illness achieved by means of vaccination (*3Fluart suspension for injection, 6 µg hemagglutinin/strain seasonal influenza vaccine*) at the vaccination level in the influenza season of 2018/2019 is as follows:

age group of minors: 8,992 cases
age group of active people: 83,804 cases
age group of the elderly: 228,200 cases
} Total: 320,996 cases.

3. CONCLUSIONS, RECOMMENDATIONS

The data listed above on the disease caused by the influenza virus, the course and frequency of influenza infections, and the specific characteristics of influenza virus clearly accentuate the extreme hazards of the influenza virus and the disease it causes, as well as the paramount importance of protection against the virus. The only effective way to control the virus and the disease is by means of vaccination.
The production and use of influenza virus vaccines is therefore of strategic importance for all countries. Accordingly, all nations and vaccine manufacturers must make every effort to ensure that the vaccines they produce are the most effective in protecting against viral infection.
In addition to the new viruses appearing these days, the old enemy, the flu, is still the greatest threat. Experts say there could be an influenza pandemic before 2050 that would kill millions around the world. Even a “simple” i.e. normal annual seasonal flu epidemic has a death toll of half a million people every year. WHO experts believe that the most devastating disease with the most widespread consequences could be severe worldwide influenza pandemics.

Summary

In our study we could prove our initial hypothesis that – in addition to maintaining the supply of free of charge vaccines to the age group over 60 years of age – more emphasis should be placed on increasing vaccination in the active (19-59 years) and the pediatric and minors age groups (0-18 years).
The presented facts, numbers, the results of the calculations, and the conclusions drawn clearly show – excluding subjectivity – the preventive effect and effectiveness of vaccination, which was quantified for the first time in Hungarian literature.
It is necessary to extend the scope of vaccinations in order to prevent severe consequences that could easily become unpredictable. Vaccination should cover not only people in the hazard age groups and

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those already suffering from other diseases but also minors and those in the active age group. The anti-vaccination sentiments typical of our age need to be addressed assertively. Vaccine acceptance can make a major contribution to mitigating the devastating consequences of a severe pandemic predicted by the WHO.
After ample time will have elapsed and the situation will have been normalized, and extensive data will have been collected, we intend to present the effects of the ongoing COVID-19 pandemic in a subsequent publication using the method discussed in this article.

References

WHO, *Manual for estimating the economic burden of seasonal influenza, WHO/IVB/16.04, Department of Immunization, Vaccines and Biologicals, Initiative for Vaccine Research (IVR), September, 2016*
Egészségkalauz, *https://www.egeszsegkalauz.hu/betegsegek/leguti-betegsegek/dobbenet-az-influenza-elleni-vedooltas-idopontja-is-szamit/tr076lp, 2019*
KSH (Central Statistics Office, Hungary), *Health Statistics Yearbook, 2017*
Regions of Hungary map, *http://www.terport.hu/regiok/magyarorszag-regioi, 2019*
KSH (Central Statistics Office, Hungary), *Health Statistics Yearbook, 2018*
National Public Health Center,
Influenza Surveillance Service data issued by the Department of Epidemiology and Infection Control, National Public Health Center, Week 40, 2018 – Week 20, 2019
https://www.antsz.hu/felso_menu/temaink/jarvany/influenza/influenza_2019, 2019
University of Debrecen, *Welcome message https://unideb.hu/hu/node/1222, 2019*
Zsuzsanna Molnár MD, *National Center for Public Health: Consumption of 3Fluart influenza vaccine by vaccination indication groups (3-18 years of age, 18-65 years of age, over 65 years of age), 2019*