ORIGINAL ARTICLE

Annals of Agricultural and Environmental Medicine
www.aaem.pl

National trends in influenza mortality in Poland from 2009–2023 with regard to the periods before, during and after the COVID-19 pandemic

Monika Kaczoruk[1,A,C-F], Piotr Tyszko[2,A-F], Andrzej Szpak[1,A,E-F], Aneta Nitsch-Osuch[2,A-B,E-F]

[1] *Department of Epidemiology, Institute of Rural Health, Lublin, Poland*
[2] *Department of Social Medicine and Public Health, Medical University, Warsaw, Poland*
A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

Kaczoruk M, Tyszko P, Szpak A, Nitsch-Osuch A. National trends in influenza mortality in Poland from 2009 to 2023 with regard to the periods before, during and after the COVID-19 pandemic. Ann Agric Environ Med. doi:10.26444/aaem/215366

Abstract

Introduction and Objective. In the 21st century two pandemics occurred, caused by viral respiratory infections. Both influenza and COVID-19 viruses exhibit high infectivity, have a rapid onset and mutate easily. Considering the fact that the influenza virus is characterized by rotational circulation of strains, while SARS-CoV-2 is constantly evolving, the difficulty is to effectively control the transmission. The extension of lifespan and the emergence of new diseases emphasize the need to assess the risk of death in endemic diseases. The aim of the study is determination of the scale and conditioning of mortality due to influenza in Poland in pre-Covid, Covid, and post-Covid years.
Materials and Method. The study is a retrospective analysis of public statistics data concerning the causes of deaths. The data analyzed were obtained from the Central Statistical Office.
Results. In Poland during 2009 – 2023, 1,545 deaths due to influenza were registered, of which 875 in the pre-Covid period, and 670 during the Covid and post-Covid periods. During the COVID-19 pandemic the incidence of influenza significantly decreased. In Europe, in the season 2022–2023, a four-fold increase in the number of cases of influenza was recorded. In the assessed period of 15 years, the number of deaths among males slightly predominated over that among females, and more than doubled among the urban population, compared to the rural population.
Conclusions. An increase in life expectancy and the growing threat of emerging diseases has important implications for public health. The national health policy strategy should prioritize and improve vaccination coverage, especially among groups at high risk.

Key words
influenza, deaths, pandemic, mortality, Covid, immunoprophylaxis, post-Covid, pre-Covid

INTRODUCTION AND OBJECTIVE

In the 21st century, humanity experienced two pandemics caused by infections with respiratory viruses. Influenza A virus subtype H1N1 (pdm09) was identified as the cause of an infectious disease that initially spread in Mexico in 2009, the first pandemic in the 21st century. A decade later, in the city of Wuhan in China, the first case of infection with a new coronavirus – SARS-CoV-2 – causing the COVID-19 disease was detected. This was the beginning of the second pandemic in the 21st century, and the first pandemic known in the history of mankind caused by a coronavirus [1, 2]. The occurrence of a so-called triple viral threat is alarming, because influenza A and B viruses, and the Respiratory Syncytial Virus (RSV) are responsible for the majority of co-infections, contributing to even twice as high hospitalization rates, as well as to mortality among those infected [3]. The SARS-CoV-2 virus constantly evolves, whereas influenza pathogens are characterized by the rotational circulation of strains, which hinders the undertaking of effective actions aimed at limiting their transmission [4]. However, both diseases have common population determinants, such as similar trends in incidence/mortality, transmission patterns, effectiveness of non-pharmaceutical interventions, concomitant diseases and under-diagnosing [5].

Both the COVID-19 and influenza viruses are highly infectious (Ro for influenza is 2–3, while Ro for Sars-Cov-2 depends on the variant of the virus, and ranges from 2.5 to even 8), have a rapid onset and easily mutate [6]. The speed of SARS-CoV-2 transmission is higher than that of seasonal influenza, whereas mortality in the latter is considerably lower than in the case of COVID-19. The European Centre for Disease Prevention and Control (ECDC) estimates seasonal influenza causes at up to 50 million symptomatic infections in the European Union/European Economic Area (EU/EEA) each year, and 15,000–70,000 of European citizens, on average, die annually due to causes related with influenza [7]. The majority of influenza-related deaths occur among the older population [8]. In turn, according to the estimations by the WHO, since the beginning of the COVID-19 pandemic until 23 March 2025, 777,684 506 cases of SARS-CoV-2 were reported. By May 2023, in the European Region, more than 2 million people died due to this disease [9, 10]. Infection with the virus may be complicated by bacterial superinfection

Address for correspondence: Monika Kaczoruk, Institute of Rural Health in Lublin, Institute of Rural Health in Lublin, Jaczewskiego 2, 20-090 Lublin, Poland
E-mail: monika.kaczoruk@gmail.com

Received: 25.09.2025; accepted: 08.12.2025; first published: 07.01.2026

(the most frequently identified bacteria being Streptococcus pneumoniae), co-infections are also possible, both viral and bacterial. In the case of viral co-infections, the most often diagnosed are simultaneous infections with the influenza virus and such viruses as SARS- Cov-2, RSV or HRV, which may hinder diagnostics and aggravate the course of the disease [9]. It is an alarming fact that influenza viruses will probably become the cause of future pandemics [11], although the last flu pandemic ended in 2010. Influenza A virus H1N1 and other influenza virus types and subtypes circulate in the environment as seasonal viruses, leading to annual seasonal influenza epidemics [12]. Currently, it is known that also COVID-19 will not be eliminated, and similar to influenza, will have a seasonal character [13].

Analysis of trends related with mortality due to influenza is important for communication purposes in the area of public health, calculation of costs associated with the implementation of preventive actions, and comparison of the effect of mortality and other causes of deaths, including COVID-19 [14]. This also allows the improvement of actions in the field of primary and secondary diagnostics, in order to develop targeted strategies for the most vulnerable groups [15, 16]. The presented study serves to emphasize the importance of surveillance systems, which may signal important epidemiological information and, therefore, accelerate timely actions and responses in order to secure the health needs of the population. Specification of the number of deaths may also be of a key importance for optimisation of prevention as a part of preparations for the development of potential pandemics [17].

The aim of the study is quantitative determination of influenza-related mortality in Poland during 2009 – 2023, and assessment of its relationships with gender, age, and place of residence.

MATERIALS AND METHOD

Data source. The study is a retrospective analysis of public statistics data concerning the causes of deaths, using data regarding deaths and population structure obtained from the Central Statistical Office (GUS). The set of data concerning deaths due to influenza was obtained from the Central Statistical Office, using statutory funds of the Medical University of Warsaw, Poland.

Case definition and classification. The set of data about deaths due to influenza was extracted from the data set covering all cases of deaths in Poland, based on the ICD10 codes, and covers data from the years 2009–2023. These data are based on medical diagnosis and are coded by physicians using the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD – 10). Among 1,545 cases of deaths, 1,318 (85.31%) were those due to influenza caused by the identified influenza virus, including J10.0 (influenza with pneumonia, seasonal influenza virus identified) – 1,048 cases, J10.1 code (influenza and pneumonia, influenza with other respiratory manifestations, influenza virus identified) – 126 cases identified, J10.8 (influenza and pneumonia. influenza with other manifestations, influenza virus identified) – 144, and the remaining 228 cases of death (14.69%) due to influenza caused by an unidentified virus, including J11.0 (influenza with pneumonia, virus not identified) – 157 cases, J11.1 (influenza and pneumonia. influenza with other respiratory manifestations, virus not identified) – 34 cases, J11.8 (influenza and pneumonia. influenza with other manifestations, virus not identified) – 36 cases. Analysis included the set of a total number of cases jointly, which allowed to avoid the limitations in the analysis of relationships due to small sample sizes.

Variables and grouping. The relationship was investigated between the occurrence of deaths and gender, age, and place of residence. Also, the occurrence of deaths was compared between the pre-Covid (2009 – 2019), Covid and post-Covid years (2020 – 2023).

Statistical analysis. The analysis covered absolute numbers and percentages of the cases of deaths, death rate per 1,000,000 population, and the mean age values. The Statistica version 13.3 package (StatSoft Inc., Tulsa, OK, USA) was used to analyze the data. The chi-square Pearson test of independence was used. A p – value of less than 0.05 was considered statistically significant. The time series was assessed by the method of linear regression.

Ethical Considerations. Considering the nature of the study, which consisted in the analysis of secondary, fully anonymized public statistics data, the consent from the Ethics Committee was not required.

RESULTS

In Poland, during 2009–2023, 1,545 deaths due to influenza were registered, including 875 in the pre-Covid period, and 670 in the Covid and post-Covid periods. The number of deaths was from 4 (0.10 per 1,000,000) in 2012 up to 409 (11.41 per 1,000,000) in 2023 (Tab. 1).

During the assessed period of 15 years, the number of deaths among males was slightly higher than that among females, and the number of deaths among urban inhabitants was more than twice as high than that among rural inhabitants. The differences are statistically insignificant (Tab. 2).

Table 1. Total number of deaths due to influenza in Poland, 2009–2023

Year	No. of deaths	per 1,000,000
2009	87	2.28
2010	28	0.73
2011	95	2.47
2012	4	0.10
2013	115	2.99
2014	11	0.29
2015	17	0.44
2016	103	2.68
2017	79	2.06
2018	110	2.86
2019	226	5.86
2020	142	3.75
2021	10	0.26
2022	109	2.33
2023	409	11.41
2009–2023	1,545,00	2.69

Table 2. Total number of deaths due to influenza in Poland according to gender and place of residence, 2009–2023

Place of residence/ Gender		Males	Females	Total
Rural area	N	249	237	486
	%	51.23%	48.77%	31.46%
	per 1,000,000	0.43	0.41	0.85
Urban area	N	534	525	1059
	%	50.42%	49.58%	68.54%
	per 1,000,000	0.93	0.91	1.84
Total	Total	783	762	1545
	%	50.68%	49.32%	100.00%
	per 1,000,000	1.36	1.33	2.69

Chi-square Pearson statistic – 0.0874; p value – 0.768

Table 3. Total deaths during 2009–2023 in age groups according to gender and place of residence

Place of residence/ Gender/ Age	Males*	Females*	Urban area**	Rural area**	Total
0–4	12	8	15	5	20
	1.53%	1.05%	1%	1%	1.29%
5–19	21	24	27	18	45
	2.68%	3.15%	3%	4%	2.91%
20–64	350	190	367	173	540
	44.70%	24.93%	35%	36%	34.95%
65 +	400	540	650	290	940
	51.09%	70.87%	61%	60%	60.84%
sum N	783	762	1059	486	1545
sum%	100%	100%	100%	100%	100%

*males-females: chi-square Pearson statistic – 68.9858; p-value – < 0.000.
**urban area-rural area: chi-square Pearson statistic – 2.1543; p-value – 0.541.

The number of deaths in the age group up to 29 did not exceed 20 deaths annually, and systematically increased from the age of 30 in the subsequent 5 year age groups, and showed the highest values among persons aged from 60–90 (Fig. 1). The number of deaths at the age from 60–94 constituted 67.38% of the total number of deaths.

During the assessed period of 15 years, the structure of the number of deaths in age groups in epidemiological analyses of influenza demonstrated statistically significant differences between males and females. The highest percentage of deaths among males and females was noted in the age group 65 +; however, this percentage was lower by nearly 20% among males. Simultaneously, among males, the percentage of deaths in the age group 20–64 was higher by more than 20%, compared to females. No statistically significant differences were observed according to the place of residence (Tab. 3).

When taking into account the binary variable age (i.e. 0 – 64 and 65 +) the percentage of females aged 65+ was 70.87%, which was significantly higher than that of males – 51.09% (chi^2=63.422; p <0.05).

The mean age of the deceased was 66.95 ±20.6 years and showed a statistically upward tendency (Fig. 2).

The percentage of deaths in the age group 20–65 decreased from 45.71% during the pre-Covid period, down to 20.90% in the Covid and post-Covid periods. At the same time, the percentage of deaths in the age group 65+ increased from 49.49% to 75.67%, respectively (Fig. 3).

From among 1,545 deaths in the pre-Covid period there were 875 cases of death (2.07 per 1,000,000), while during the Covid and post-Covid periods – 670 (4.42 per 1,000,000). The percentage of deaths among males during the pre-Covid period was higher by more than 10% statistically than that of females, whereas during the Covid and post-Covid periods, the percentage of females was higher by more than

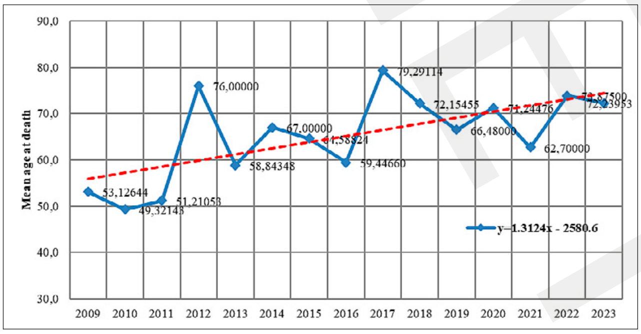

Figure 2. Mean age at death due to influenza

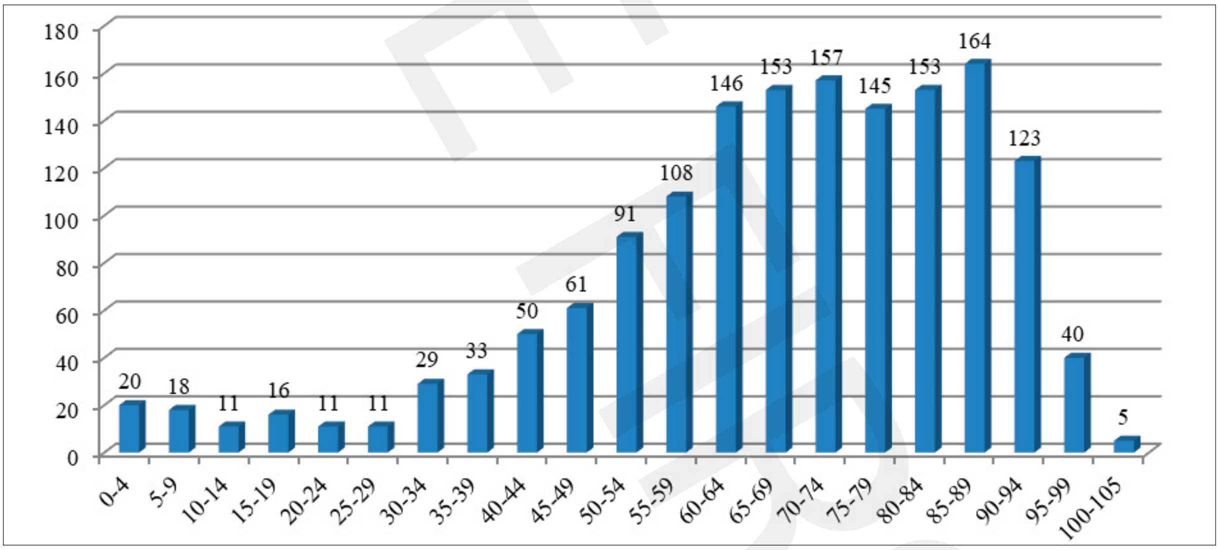

Figure 1. Number of deaths due to influenza in individual age groups, 2009–2023

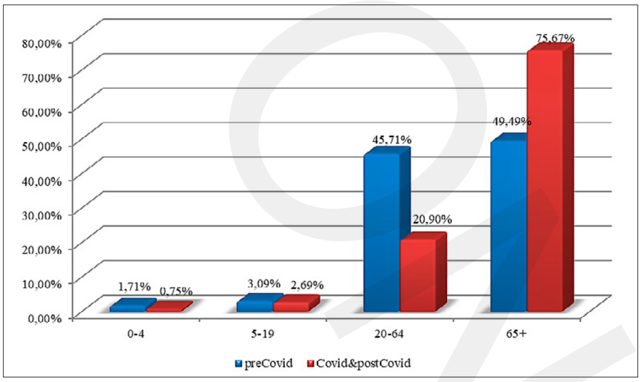

Figure 3. Percentage of deaths during the pre-Covid, Covid and post-Covid periods. Chi-square Pearson statistic – 112.5923; p-value – < 0.000

10%, and the difference was statistically significant. During the same time, the change in the number of deaths among urban and rural inhabitants was slight. The differences were statistically insignificant (Tab. 4).

Table 4. Deaths during the pre-Covid-Covid & post-Covid periods according to gender and place of residence**.**

Covid / Gender / Place of residence		Males	Females	Rural area	Urban area	Total
Pre-Covid*/**	N	485	390	267	608	875
	%	61.94%	51.18%	54.94%	57.41%	56.63%
	per 1,000,000	1.15	0.92	0.63	1.44	2.07
Covid & post-Covid*/**	N	298	372	219	451	670
	%	38.06%	48.82%	45.06%	42.59%	43.37%
	per 1,000,000	1.96	2.45	1.44	2.97	4.42
Total	N	783.00	762.00	486.00	1059.00	1545.00
	%	100.00%	100.00%	100.00%	100.00%	100.00%
	per 1,000,000	1.36	1.33	0.85	1.84	2.69

*Pre-Covid-Covid & post-Covid according to gender; chi-square Pearson statistic – 18.21. The p-value is < 0.000. **Pre-Covid-Covid and post-Covid according to place of residence: Chi-square Pearson statistic – 0.83. The p-value is 0.362.

DISCUSSION

The analysis performed concerned trends related with mortality due to influenza during the period 2009 – 2023. The above-mentioned time frames were used due to the occurrence in 2009 of a new variant of influenza virus which contributed to the development of pandemic. In turn, in 2023, the WHO abolished the international declaration concerning the state of public health emergency due to the Sars-Cov-2 pandemic [18].

The first cases of influenza A/H1N1 were noted in 2009 in North America (Mexico). Within a few weeks, the disease spread to many countries and continents. Global trade and travel contributed to the spread of swine flu in 122 countries within six weeks, while the previous pandemics of influenza escalated within six months. In June 2009, the WHO confirmed this epidemic as a pandemic [19]. Although influenza has been considered as an important cause of deaths, especially among the older population, mortality rates were generally low, because their considerable part was not ascribed to primary influenza infection, but to complications and secondary infections. This problem caused inconsistencies in the classification of influenza as the primary or co-occurring cause of death [20].

Analysis of the data by the GUS performed in this study showed that in Poland, in 2009, deaths due to influenza concerned 87 persons (2.28/1,000,000), whereas in Mexico, where the first cases of influenza A/H1N1 occurred, 63 persons died (<1%) [21]. According to the WHO, the influenza pandemic contributed to 18,449 laboratory-confirmed deaths [14]. In turn, the GLaMOR project estimated the number of deaths due to respiratory disorders resulting from influenza at 123,000–203,000 cases on a global scale. Deaths due to influenza H1N1p estimated in the GLaMOR project in the EU (including the UK) as of 18 January 2010, amounted to 2,269, a half of which came from the UK (16%), France (13%), Spain (12%), and Italy (9%). The highest percentage of patients concerned persons aged under 30 (78%), and schoolchildren aged 5–19 years – 47% of the total number of cases [22]. Although this was a type of influenza virus which has never been previously observed, an earlier exposure to a probably similar anti-genically influenza virus that circulated in the 1950s, provided immunity to most of the older population. This fact explains two of its important differences, compared to interpandemic, i.e. seasonal flu: generally lower mortality, and higher than expected relative burden of the disease and mortality among young population [23]. In the vast majority of cases (96%), no concomitant diseases were observed [22]. The general males to females ratio was 1:1; however, among persons aged under 30, males were over-represented by approximately 20% [23].

From among 1,545 deaths due to influenza (code ICD10: J10 or J11) registered during 2009 – 2023, before the occurrence of the COVID-19 pandemic, a total number of 875 fatal cases of this influenza occurred (56.63%). In turn, the data collected by the WHO regarding mortality in five consecutive calendar years before the occurrence of COVID-19 (2014–2018), indicate that the lowest mortality rates among adults due to influenza were noted in four countries of Central and Eastern Europe: in Poland, Hungary, Romania, and Serbia, while the highest in Sweden and two UE-15 member countries, i.e. Netherlands, Belgium, and Austria. Considering the lower level of vaccination rate and a worse state of health of population in Central and Eastern Europe, as well as lower mortality rates due to influenza observed among the older population in Poland, Hungary, Romania and Serbia, compared to the EU – 15 member countries, the data presented by the WHO evoke doubts. The probable explanation is underestimation of the actual number of deaths, resulting from ascribing them to concomitant diseases or non-specific diagnosis, such as, e.g. viral pneumonia. The scope of this underestimation shows significant differences between countries and requires correction using multipliers taking into account the specificity of the disease, country, age, and gender [8, 24].

It is worth noting that during the COVID-19 pandemic the activity of influenza considerably decreased, which is confirmed by the analysis of data performed.

The Pandemic caused by infection with SARS-CoV-2 virus began in December 2019, during the typical influenza season. On 11 March 2020, the term 'global pandemic' was recognized by the WHO [25]. In Poland, 670 deaths due to influenza were registered which, during the period analyzed, constituted 43.36% of deaths (2020–2023) vs. 56.63% during 2009–2019. The justification for the above situation may be the implementation at that time of special personal protection equipment, and an increased social distance. The researchers also indicate some cross-immunity against influenza by non-specific mechanisms, which stimulate antiviral defence or trigger an adaptive response to secondary infection with influenza [13].

The factor distinguishing the post-Covid season 2022–2023 in Europe was a four-fold increase in the number of influenza cases, compared to previous seasons. The influenza season of 2022–2023 meant a resurgence in the influenza virus on the level almost the same as that prior to pandemic in the EU/EEA countries – 42% [26]. This was also confirmed by analysis of the data by GUS performed in the current study, which demonstrated that mortality during this period was on the level of 518 deaths (33.53%). Importantly, current epidemiological data, which the analysis does not cover but which comes from the National Institute of Public Health of the National Institute of Hygiene – National Research Institute report, also presents a worrying picture of the escalation of infectious diseases. The data showed that in January 2025, the monthly number of confirmed cases of influenza exceeded the monthly number of confirmed cases in the epidemic season 2023–2024 (January 2025: morbidity on the level of 6.01, N=2 259; January 2024: morbidity on the level of 2.46, N=924) [27]. In-hospital mortality due to influenza in January 2024 was less than 3%, whereas a year later it reached the value on the border of 11% [28].

The escalation of the number of cases and deaths observed in 2025 was probably caused by a higher level of circulation of the virus in the vulnerable population, and not an increased intensification of infection [29]. Analysis of the reasons of the above situation performed within the FluTer project indicated that this was the effect of multimorbidity, chronic circulatory failure, and immune deficiency. It is an alarming fact that almost all those who were hospitalized and died due to influenza, had not been vaccinated (98.5%) [28,30,31]. In Poland during 2009–2023, significant fluctuations were observed in the number of people vaccinated against influenza. After the peak of vaccination rates in 2009 (more than 1.5 million people), there was a rapid decline in 2011, and the number of those vaccinated in the total population fell below 60,000 people.

During the period of the COVID-19 pandemic (2020 – 2023) a clear increase was observed in the number of vaccinations against influenza, reaching the level exceeding a million persons annually (more than 1.26 million in 2023), the highest since 2009. A significant increase concerned the population group aged ≥65, where the number of vaccinations increased from ~550,000 (2018–2019) up to more than 700,000 (2021 and 2023). However, this level was still insufficient to ensure population immunity [15,32]. According to the recommendations by the WHO, vaccinations against influenza should be carried out in individual countries on the level of 75%. Despite the abolition of national financial barriers concerning vaccination against influenza, the vaccination level in the group of persons aged over 65 did not exceed 15% (in the season 2023–24 – 12%) [32].

In addition, the analysis performed showed significant differences in the number of deaths in the population according to age and gender. Over the 15 years analyzed, females died more often due to influenza at older age (65+), whereas males more died more frequently between the ages of 20–64. The above relationship was confirmed in a study by D.A.M Mejs et al., justifying that in infectious diseases, biological factors related with gender exert an effect on viral susceptibility, response to the virus, disease progression, as well as side-effects of anti-infective or anti-inflammatory therapy [33]. The theoretical framework developed by Heise et al. indicate that gender also affects health through, among other things, varied exposure to risk, health behaviours, and access to health care, as well as studies on health considering gender which additionally create and strengthen inequalities [34]. In turn, a study by C. Gebhard et al. demonstrates that males were tested more rarely; however, more frequently obtained positive results of tests were more often hospitalized, and had a higher case fatality rate, which led to consistently higher mortality rates compared to females [35]. Therefore, it seems justifiable to consider the postulate by D. Auderset concerning the necessity for carrying out educational campaigns addressed to males in the area of observance of medical recommendations. It is also important to adjust the organization of occupational medicine to varied occupational risk, conditioned by gender, in order to reduce the existing disparities and support equality in the area of public health, especially in the context of emerging infectious diseases [36].

The analysis performed also showed that the experiences of rural communities in the face of deaths due to influenza differed considerably from those of urban communities. Based on data obtained from the GUS, more than twice as many deaths were registered among urban inhabitants, compared to rural inhabitants. The justification for the above may be the concept developed during the plague pandemic, introducing the term 'urban cemeteries'. Cities have a larger and more dense population than small towns and rural areas, and for this reason the risk of transmission and therefore death, is higher [37]. However, the above justification does not exhaust all possible interpretations, because cross-sectional study carried out in Taiwan during the pandemic of H1N1 virus in the years 2009–2010 demonstrated that more densely populated areas were associated with a longer occurrence of the epidemic. Another explanation of the phenomenon visible in the analyzed data by GUS, may also be a growing degree of integration with the global communication network. Cities, as nodes of global transport networks, play an important role in the cross-border transition of infectious agents [38]. Although a lower mobility of the population living in rural areas may partially explain the observed trend, the risk associated with a limited access to health care in rural and depopulation areas should be emphasized. Benefits from better access to medical infrastructure may outweigh the negative consequences of urbanization and globalization [39].

It should be emphasised that understanding the mortality burden associated with epidemic diseases enables the development of new treatment methods and the proper targeting of preventive strategies, which are important for optimising prevention [17]. The concept proposed in the 1960s by Abdel Omran and developed in the 1980s by S. Jay Olshanski, explains that the domination of individual diseases does not exert any effect on the reduction of others. An example is the epidemic of influenza and the COVID-19 pandemic which, to a considerable extent, reached developed countries where non-infectious chronic diseases are a dominant cause of morbidity and mortality [40].

The dynamic of transmission and increased burden additionally drives the aging process of societies. The deterioration of immune function progressing with age enhances the risk of infection and serious health effects in the case of occurrence of diseases [17]. Relative decrease in immunity (immunosenescence), potentially accompanying chronic low-grade inflammatory condition (inflammaging), and a higher incidence of chronic concomitant diseases at older age, increases the risk of fatal complications of infectious origin [41]. This type of positive feedback, in which a simultaneous increase in life expectancy is visible, and a growing threat from emerging diseases is important for developing effective strategies for public health strategies.

CONCLUSIONS

1. Over the last 15 years (2009 – 2023), a significant increase has been observed in mortality rates due to influenza. The lowest rate concerned the year 2012 (pre-Covid) – 0.10 per 1,000,000 (4 cases), whereas the highest rate was noted in 2023 (post-Covid) – 11.41 per 1,000,000 (409 deaths).
2. An especially clear acceleration in the number of deaths due to influenza was observed during the last four years related with the COVID-19 pandemic (2020–2023). During 2009–2019, covering the period of pandemic of influenza A(H1N1)pdm09 (2009–2010), and the subsequent influenza non-pandemic years, a total number of 875 deaths due to influenza were registered. In turn, during the COVID-19 pandemic and directly after the pandemic (2020–2023) 670 deaths were registered. This pattern may reflect the reduced circulation of influenza viruses during periods of strict non-pharmaceutical interventions, followed by a resurgence after pandemic restrictions were lifted.
3. Analysis of the demographic profile of the deceased revealed that the dominant group were males, urban inhabitants, and older persons. During the period analyzed, deaths among urban inhabitants occurred twice as frequently as among inhabitants of rural areas. The dominant group were persons aged over 60 (67.38% of the total number of cases).
4. The COVID-19 pandemic especially negatively affected older persons (65+) and females. The percentage of deaths in the age group ≥65 increased from 49.49% up to 75.67%, whereas in the age group 20–65, it decreased from 45.71% down to 20.90%. During the pre-Covid period, deaths due to influenza more frequently concerned males, whereas the percentage of deaths during the Covid and post-Covid periods was higher by more than 10% among females.
5. Future plans of responding to pandemics should consider threats adjusted to the changing conditions. Experiences acquired in association with the COVID-19 pandemic and earlier influenza pandemic, confirm that it is crucial to understand vulnerabilities and threats in advance, which favours the optimum allocation of health resources and rational planning of health policy, also in the implementation of active immunoprophylaxis.

REFERENCES

1. Li Y, Liu P, Hao T, et al. Rational design of an influenza-COVID-19 chimeric protective vaccine with HA-stalk and S-RBD. Emerg Microbes Infect. 2023;12(2):2231573. doi:10.1080/22221751.
2. Daemi HB, Kulyar MF, He X, et al. Progression and Trends in Virus from Influenza A to COVID-19: An Overview of Recent Studies. Viruses. 2021;13(6):1145. Published 2021 Jun 15. doi:10.3390/v13061145
3. Toribio-Avedillo D, Gómez-Gómez C, Sala-Comorera L, et al. Monitoring influenza and respiratory syncytial virus in wastewater. Beyond COVID-19. Sci Total Environ. 2023;892:164495. doi:10.1016/j.scitotenv.2023.164495
4. Liang J, Wang Y, Lin Z, He W, et al. Influenza and COVID-19 co-infection and vaccine effectiveness against severe cases: a mathematical modeling study. Front Cell Infect Microbiol. 2024;4(14):1347710. doi:10.3389/fcimb.2024.1347710
5. Baral SD, Rucinski KB, Twahirwa Rwema JO, et al. The Relationship Between the Global Burden of Influenza From 2017 to 2019 and COVID-19: Descriptive Epidemiological Assessment. JMIR Public Health Surveill. 2021;7(3):e24696. doi:10.2196/24696
6. Karimizadeh Z, Dowran R, Mokhtari-azad T, et al. The reproduction rate of severe acute respiratory syndrome coronavirus 2 different variants recently circulated in human: a narrative review. Eur J Med Res. 2023;28(94). doi:https://doi.org/10.1186/s40001-023-01047-0
7. European Centre for Disease Prevention and Control (ECDC), Factsheet About Seasonal Influenza https://www.ecdc.europa.eu/en/seasonal-influenza/facts/factsheet (access: 2025.08.06).
8. Pitter JG, Mihajlović J, Nagy D, et al. Underreported influenza mortality in Central and Eastern Europe hinders the extension of seasonal influenza vaccination programs in older adults. Vaccine. 2025;22(56):127184. doi:10.1016/j.vaccine.2025.127184
9. Jain R, Sharma H, Pena L, et al. Influenza virus: Genomic insights, evolution, and its clinical presentation. Microb Pathog. 2025;205:107671. doi:10.1016/j.micpath.2025.107671
10. World Health Organization. Coronavirus disease (COVID-19) pandemic https://www.who.int/europe/emergencies/situations/covid-19 (access: 2025.08.06).
11. Kang M, Wang LF, Sun BW, et al. Zoonotic infections by avian influenza virus: changing global epidemiology, investigation, and control. Lancet Infect Dis. 2024;24:e522–e531. doi:10.1016/S1473-3099(24)00234-2
12. WHO declares that H1N1 pandemic is officially over. BMJ. 2010;341:c4393. doi:https://doi.org/10.1136/bmj.c4393
13. Han Y, Wang Z, Li X, Zhong Z. Differences of the Chest Images Between Coronavirus Disease 2019 (COVID-19) Patients and Influenza Patients: A Systematic Review and Meta-analysis. Int J Med Sci. 2025;22(3):641–650. doi:10.7150/ijms.98194
14. Staadegaard L, Taylor RJ, Spreeuwenberg P, et al. Monitoring the mortality impact of COVID-19 in Europe: What can be learned from 2009 influenza H1N1p mortality studies? Int J Infect Dis. 2020;16;S1201–9712(20)32241–4. doi:10.1016/j.ijid.2020.10.037
15. Kanecki, K, Lewtak K, Tyszko P, et al. Hospitalizations and In-Hospital Fatality Among Influenza Patients in the Pre-Pandemic and COVID-19 Pandemic Periods. J Clin Med. 2025;14:1785. doi:https://doi.org/10.3390/jcm14061785
16. Martínez-Baz I, Navascués A, Trobajo-Sanmartín C, et al. Effectiveness of influenza vaccination in preventing confirmed influenza cases and hospitalizations in Northern Spain, 2023/24 season: A population-based test-negative case-control study. Int J Infect Dis. 2025;151:107364. doi:https://doi.org/10.1016/j.ijid.2024.107364
17. Nitsch-Osuch A, Jankowski P, Kokoszka-Paszkot J, et al. Towards better protection of older people against influenza and its complications. Polish recommendations for HD influenza vaccine. Fam Med Primary Care Rev. 2024;26(1):116–122. doi:10.5114/fmpcr.2024.134715
18. World Health Organization. COVID-19 epidemiological update – 16 February 2024. https://www.who.int/publications/m/item/covid-19-epidemiological-update-16-february-2024 (access: 2025.08.06).
19. Akin L, Gözel MG. Understanding dynamics of pandemics. Turk J Med Sci. 2020;50(SI-1):515–519. doi:10.3906/sag-2004-133
20. Petti S, Cowling BJ. Ecologic association between influenza and COVID-19 mortality rates in European countries. Epidemiol Infect. 2020;148:e209. doi:10.1017/S0950268820002125
21. Echevarría-Zuno S, Mejía-Aranguré JM, Mar-Obeso AJ, et al. Infection and death from influenza A H1N1 virus in Mexico: a retrospective analysis. The Lancet. 2009;374(9707), 2072–2079. doi:https://doi.org/10.1016/s0140-6736(09)61638-x
22. European Centre for Disease Prevention and Control. Influenza in Europe 2011–2012 surveillance report. https://www.ecdc.europa.eu/en/publications-data/influenza-europe-2011-2012-surveillance-report (access: 2025.08.06).
23. European Centre for Disease Prevention and Control. The 2009 A(H1N1) pandemic in Europe Stockholm: ECDC; 2010. https://www.ecdc.europa.eu/sites/default/files/media/en/publications/Publications/101108_SPR_pandemic_experience.pdf (access: 2025.08.06).
24. Eurostat. Population density by NUTS 3 region. https://ec.europa.eu/eurostat/databrowser/view/DEMO_R_D3DENS__custom_13422070/default/map?lang=en (access: 2025.08.06).

25. World Health Organization Director-General's opening remarks at the media briefing on COVID-19–11 March 2020 https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-11-march-2020 (access: 2025.08.06).
26. Kondratiuk K, Poznańska A, Szymański K, Czajkowska E, et al. Occurrence of Circulating Antibodies against the Hemagglutinins of Influenza Viruses in the 2022/2023 Epidemic Season in Poland. Viruses. 2024;16(7):1105. doi:10.3390/v16071105
27. Zachorowania na wybrane choroby zakaźne w Polsce od 1 stycznia do 31 stycznia 2025 r. oraz w porównywalnym okresie 2024 r. Zakład Epidemiologii Chorób Zakaźnych i Nadzoru NIZP PZH – PIB. Departament Zapobiegania i Kontroli Chorób Zakaźnych GIS.
28. Rzymski P. Projekt FluTer. Wstępna analiza hospitalizacji z powodu grypy w sezonie 2024/2025. 8. Forum Wirusologiczne 2025 March 14–15; Warszawa; 2025.
29. Rzymski P, Piekarska A, Pleśniak R, et al. Unraveling Poland's unprecedented influenza surge in early 2025: increased viral severity or post-pandemic vulnerability? Pharmacol Rep. 2025;77(4):1134–1141. doi:10.1007/s43440-025-00731-8
30. Rzymski P, Pleśniak R, Piekarska A, et al. Tracking clinical severity of influenza in adult hospitalized patients in 2024: Data from the FluTer registry in Poland. Vaccine. 2025;61,127443. doi:https://doi.org/10.1016/j.vaccine.2025.127443
31. Sobierajski T, Rzymski P, Wanke-Rytt M. The Influence of Recommendation of Medical and Non-Medical Authorities on the Decision to Vaccinate against Influenza from a Social Vaccinology Perspective: Cross-Sectional, Representative Study of Polish Society. Vaccines (Basel). 2023;11(5):994. doi:10.3390/vaccines11050994
32. Szczepienia Przeciw Grypie Polska. https://wwwold.pzh.gov.pl/oldpage/epimeld/index_p.html (access: 2025.08.06).
33. Meijs DAM, van Bussel BCT, Stessel B, et al. Better COVID-19 Intensive Care Unit survival in females, independent of age, disease severity, comorbidities, and treatment. Scientific Reports. 2022;12 (1):734. doi:10.1038/s41598-021-04531-x
34. Heise L, Greene ME, Opper N, et al. Gender Equality, Norms, and Health Steering Committee. Gender inequality and restrictive gender norms: framing the challenges to health. Lancet. 2019;15,393(10189):2440–2454. doi:10.1016/S0140-6736(19)30652-X
35. Gebhard C, Regitz-Zagrosek V, Neuhauser HK, Morgan R. Klein Impact of sex and gender on COVID-19 outcomes in Europe Biology of Sex Differences. 2020;11(1):29, doi:10.1186/s13293-020-00304-9
36. Auderset D, Riou J, Clair C, et al. Why gender and sex matter in infectious disease modelling: A conceptual framework. SSM Popul Health. 2025;12(30):101775. doi:10.1016/j.ssmph.2025.101775
37. Naudé W, Nagler P. COVID-19 and the city: Did urbanized countries suffer more fatalities? Cities. 2022;131:103909. doi:10.1016/j.cities.2022.103909.
38. Tsiotas D, Tselios V. Understanding the uneven spread of COVID-19 in the context of the global interconnected economy. Science Reports. 2022;12(666). doi:10.1038/s41598-021-04717-3
39. Han S, Su B, Zhao Y, et al. Widening rural-urban gap in life expectancy in China since COVID-19. BMJ Glob Health. 2023;8(9):e012646. doi:10.1136/bmjgh-2023-012646
40. Pruszyński J, Cianciara D, Grudziąż-Sękowska J, et al. Czy w nieodległej przyszłości można spodziewać się ponownej dominacji chorób zakaźnych? J Educ Health Sport. 2022;12(9):658–676. doi:10.12775/JEHS.2022.12.09.079
41. Hernandez-Ruiz V, Letenneur L, Fülöp T, et al. Infectious diseases and cognition: do we have to worry? Neurol Sci. 2022;43(11):6215–6224. doi:10.1007/s10072-022-06280-9

ONLINE FIRST