

Considerations on mortality in 2020 in Poland in the context of the coronavirus pandemic

Kinga Janik-Konieczna^{1,2}, Alicja Basiak-Rasała³, Katarzyna Zatońska^{3,4}, Maciej Karczewski⁵, Witold A. Zatoński^{1,2}

¹Institute – European Observatory of Health Inequalities, Calisia University, Kalisz, Poland

²Health Promotion Foundation, Nadarzyn, Poland

³Department of Population Health, Wrocław Medical University, Wrocław, Poland

⁴Calisia University, Kalisz, Poland

⁵Department of Applied Mathematics, Wrocław University of Environmental and Life Sciences, Wrocław, Poland

ABSTRACT

Introduction: This study presents an epidemiological analysis of excess deaths in Poland as a proxy of the coronavirus pandemic in 2020.

Material and methods: The absolute number of weekly excess deaths from all causes was calculated as the difference between the number of deaths in 2020 and the average number of deaths in the previous time period (2015-2019). Data were extracted from the repository of the National Statistical Office.

Results: From January until the end of March 2020 (10th week) there were no substantial difference in the number of all-cause deaths in men and women compared to the average from the five previous years (2015-2019). Since the beginning of the pandemic in mid-March 2020 we could observe 76,655 excess deaths. We observed 3 phases of the phenomenon: (1) a 7-month period of relatively low number of weekly excess deaths (in total 13,823) until the turn of September and October, (2) a period of sharp increase until the beginning of November with a peak in the 45th week and 8,746 excess deaths, and (3) the last 7-week period of 2020 with declining rates to the level of 3,843 excess deaths. The number of excess deaths was substantially higher in men than women (41,789 vs. 34,866). Excess deaths in age groups above 60 years in both men and women constituted 99% of all excess deaths. In younger age groups excess deaths were rare. The number of excess deaths was almost twice as high in urban compared to rural area (48,443 vs. 26,974).

Conclusions: The coronavirus epidemic in Poland had its own trajectory. Its course was slower and delayed compared with some Western and European countries. In spite of the seven-month period of a relatively controlled course of the epidemic, Poland was a country with one of the largest increases in excess deaths in 2020.

KEY WORDS: coronavirus pandemic, COVID-19, SARS-CoV-2, excess deaths, Poland.

ADDRESS FOR CORRESPONDENCE: Witold A. Zatoński, Institute – European Observatory of Health Inequalities, Calisia University, 4 Nowy Świat, 62-800 Kalisz, Poland, e-mail: wazatonski@promocjazdrowia.pl

INTRODUCTION

Since the beginning of 2020, the global coronavirus pandemic has become a world health catastrophe. Due to the fact that the health condition of Poles has deteriorated since 2003 and that the life expectancy of Poles has begun to decline in the last few years [1, 2], the COVID-19 pandemic struck an already compromised population.

The first case of SARS-CoV-2 infection in Poland was diagnosed on March 4, 2020, and in the following weeks hospitals started to report the first deaths caused by coronavirus confirmed with the biological test. The development of the coronavirus epidemic in Poland was significantly slower and delayed compared to other European countries, especially in comparison to the United Kingdom, Italy or Spain.

It is difficult to compare the course of the pandemic between different European countries. Reporting of COVID-related deaths varies, influencing available statistics and comparability between countries. As the WHO recommended defining COVID-related death as a result of compatible illness in suspected or confirmed COVID-19, if no other cause can be indicated [3], we could observe some ambiguity in the interpretation of this recommendation. Especially at the beginning of the pandemic, some countries included in the COVID-19 death count only deaths which occurred in the hospital (e.g. Spain), while others required a confirmation of the COVID-19 infection in the autopsy (Russia) [4], which possibly underestimated the real number of deaths and prevents reliable comparison between countries. On the other hand, some countries included not only confirmed, but also suspected cases. Most of the countries published daily reports of newly diagnosed COVID-19 cases and COVID-attributable deaths [5]. However, daily reported infections with SARS-CoV-2 were also burdened with the risk of bias – they were dependent on testing coverage, which varies considerably between countries. In this situation science and evidence-based monitoring or comparing the course of an epidemic over time and space is difficult. Thus, in the search for a more reliable and accurate indicator of the real burden of COVID-19 pandemic, excess mortality has been proposed as one of the most objective measures [4, 6, 7]. Excess mortality compares the number of deaths reported in a current year with the average number of deaths in previous years. This metric not only allows reliable comparisons of changes in time and between countries, but can also reveal the real death toll of the pandemic. It has been considered a gold standard in measuring the impact of the pandemic [4].

According to officially recorded data, in 2020, SARS-CoV-2 killed 370,650 people in the European Union, of whom almost 8% were Polish inhabitants [8]. Since the development of the coronavirus pandemic in Poland and associated mortality was unique in terms of size of the phenomenon, it requires scientific attention and use of special measures to fully understand it and discuss its potential causes and possibilities for control. This study aimed to analyse excess deaths in Poland in 2020, only in the first calendar year of the pandemic.

MATERIAL AND METHODS

This analysis presents calculations of excess deaths in Poland in the period from mid-March 2020, when the first case was diagnosed, until the end of the year (weeks 11-52). The excess deaths were used as a proxy of COVID-19 deaths to estimate the course and the volume of the SARS-CoV-2 pandemic in Poland. Excess mortality was defined as an increase in mortality from all causes in a specific period in a given population over the mortality expected based on historic data [4, 9] (Appendix A). Absolute number of excess deaths in Poland was calcu-

lated as the difference between the number of deaths in 2020 and the average number of deaths recorded in the previous 5 years (2015-2019) with corresponding 95% confidence intervals. Similar methodology was used by different scientific groups [10-12].

We present the excess deaths from all causes in Poland in 2020 (weeks 11-52) expressed in weekly absolute numbers. Data on number of deaths from all causes in particular weeks in years 2015-2020 for men, women and both sexes were retrieved from the National Statistical Office [13]. In comparing results from Poland with other Western European countries it must be considered that the beginning of the coronavirus epidemic in those countries differs. In example, in Italy infection outbreaks broke out in the second half of February.

To avoid ambiguity concerning the week number, a uniform international system determined by the ISO8601 was used, as referred to by the National Statistical Office. This system is structured in way that the first week of the year may contain days from the previous year, and the last week may contain days from the next calendar year; therefore particular weeks of the year do not add up to individual months of the year, nor to the total years. For example, the first week of 2020 begins on 30 December 2019 and the 53rd week of 2020 ends on 3 January 2021. In our analysis the 53rd week was excluded as there were not available data for the 53rd week in the years 2015-2019 to calculate the average number of deaths.

To analyse trends of weekly excess mortality in 2020 in Poland the joinpoint analysis was done using Joinpoint Regression Program (version 4.6.0.0 – April 2018, available from the Surveillance Research Program of the US National Cancer Institute [14]). It is a model that identifies the points in a trend (joinpoints) where the linear slope of the trend changes significantly. Modelling with a maximum of 3 joinpoints (corresponding to up to 4 different trends) was applied. The software computed the annual percentage change (APC) with the corresponding 95% confidence intervals. To analyse excess deaths in 2020 by age group and place of residence we used annual data on all-cause deaths prepared and published by the National Statistical Office [15].

RESULTS

In Poland, from the beginning of the 2020 until the end of March (10th week) there was no substantial difference in the number of all-cause deaths in men and women compared to the average from the five previous years (2015-2019). This is consistent with the annual dynamics of changes in average weekly number of deaths between 2015 and 2019. It is characterized by some seasonal changes with rates of over 8,000 deaths between mid-December and the end of March and rates below 8,000 deaths between April and mid-December (Figure 1).

On 9 March (11th week), the number of excess deaths in Poland totalled 76,655 (41,789 in men and 34,866

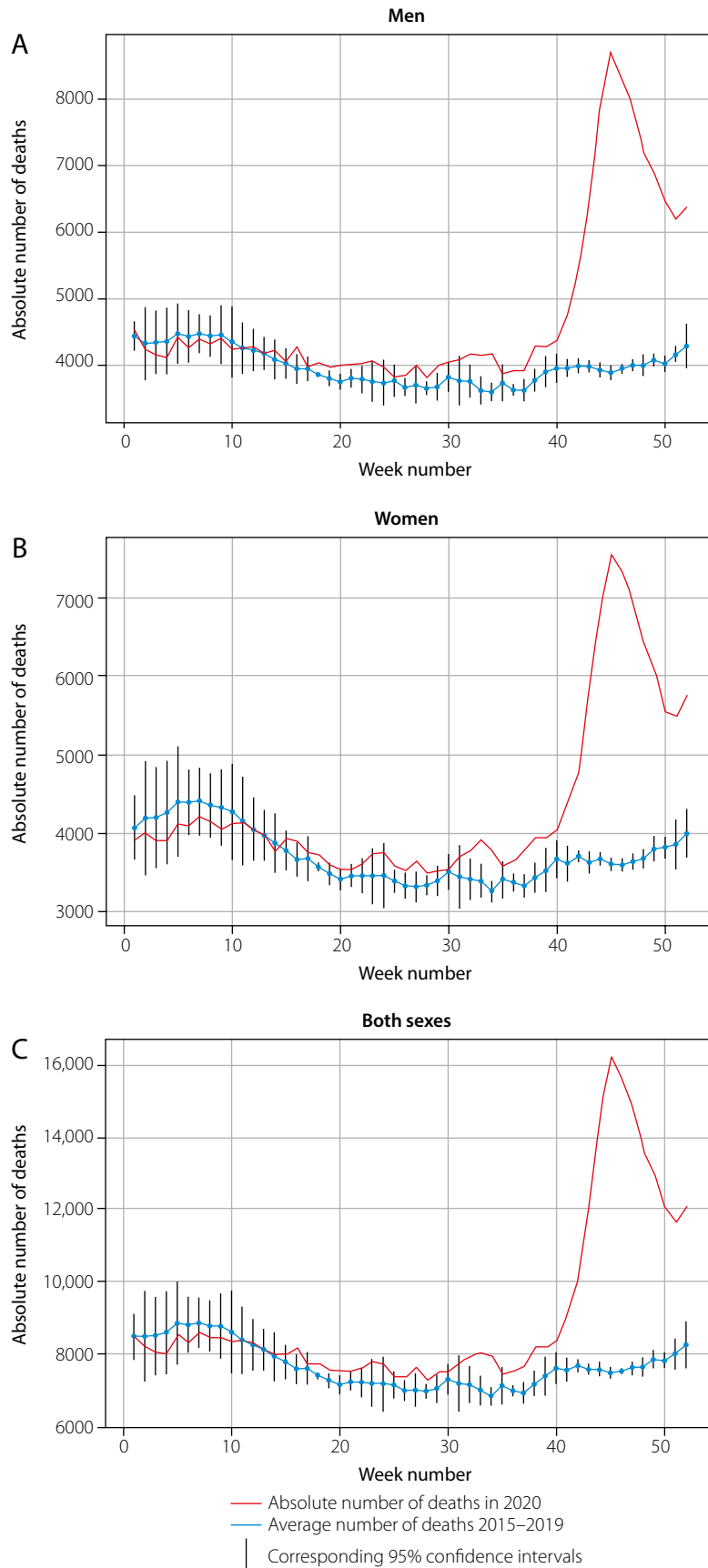


FIGURE 1. Average number of deaths between 2015–2019 in comparison to number of deaths in 2020 in Poland by week

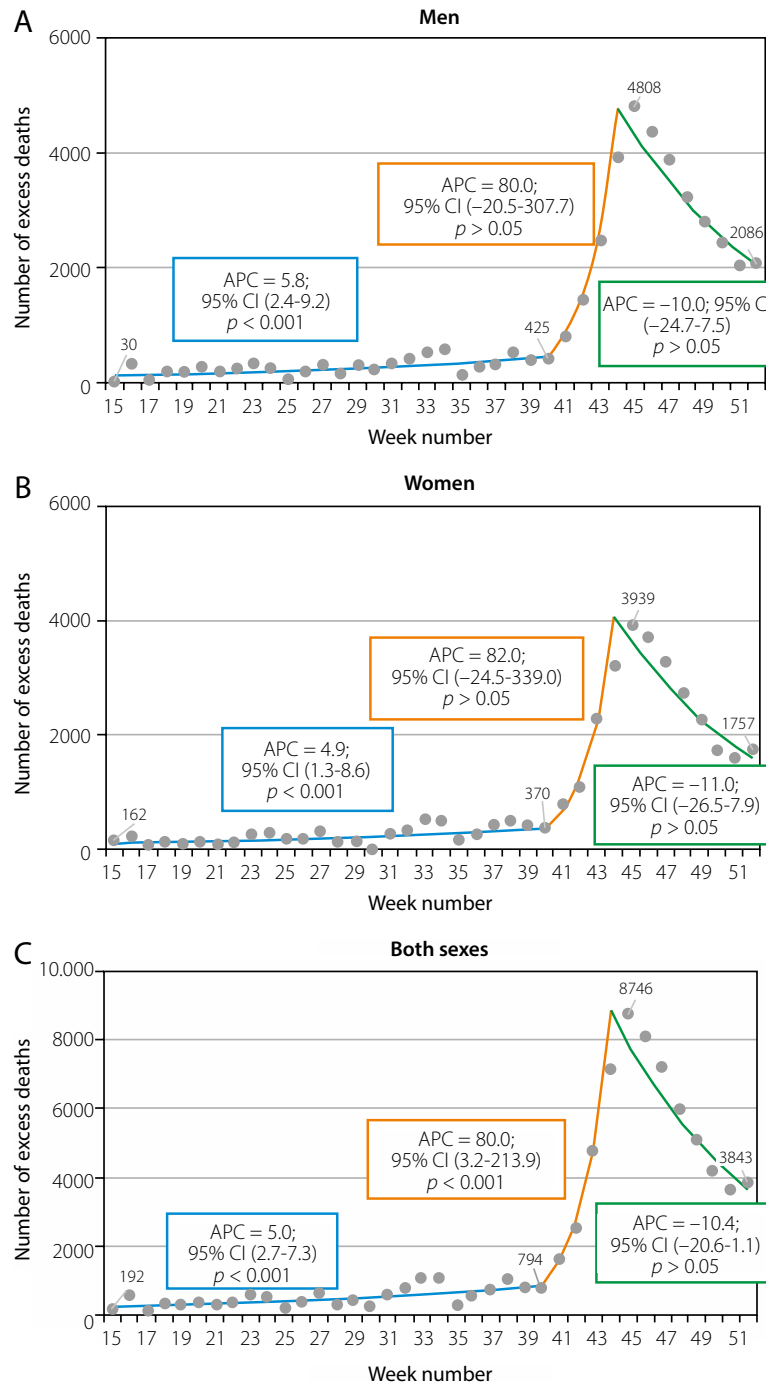


FIGURE 2. Trends in weekly number of excess deaths in Poland since the beginning of pandemic in 2020. Joinpoint analysis based on data from National Statistical Office; series in points present observed data, series in lines present modelled trends; different colours express different periods of trends divided by joinpoints

in women) and there were 3 phases of the phenomenon. The first phase of the coronavirus pandemic in Poland started in March 9th-15th (11th week). For about 7 months, until the beginning of October (40th week), the number of weekly excess deaths did not exceed 1,100 (13,823 excess deaths in total, 7,407 in men and 6,416 in women).

From October 5th to 11th (41st week) the number of excess deaths began to increase sharply, reaching a peak

during 2nd-8th November (45th week) with 8746 excess deaths (4,808 excess deaths in men and 3,939 in women) (Figures 1 and 2). It was the second phase of the epidemic in Poland. During these 5 weeks the number of excess deaths reached 24,807 in total (13,484 in men and 11,323 in women). Analysis of the trend showed an approx. 80% increase in both sexes, but also in men and women separately (Figure 2). The increase in excess deaths was significantly higher in men than in women.

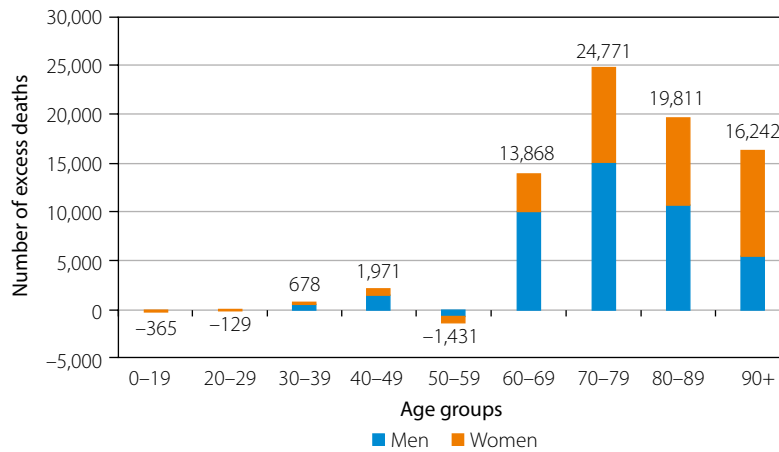


FIGURE 3. Excess deaths in Poland in 2020 by age groups

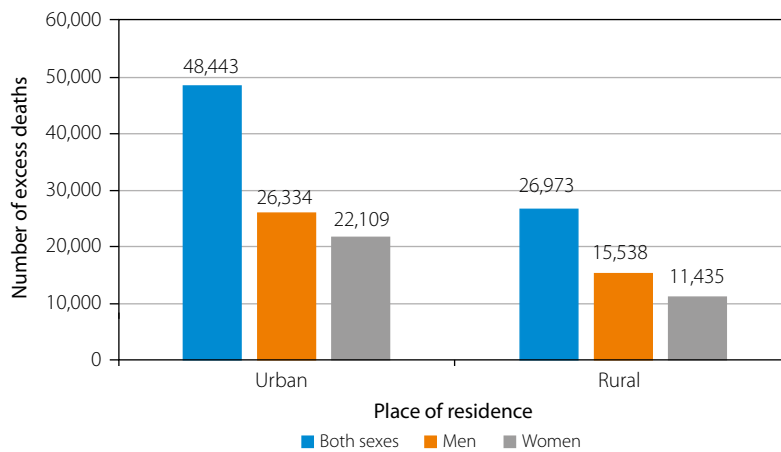


FIGURE 4. Excess deaths in Poland in 2020 by place of residence

For the next 7 weeks of 2020 (46th-52nd week) the number of excess deaths was declining and in the last week of the year it reached the level of around 3,800 excess deaths in both sexes (2,086 excess deaths in men and 1,757 in women) (Figures 1 and 2). It was the third phase of the pandemic in Poland in 2020. Between the end of October (44th week) and the end of the year (52nd week) the trend showed an approx. 10% decrease in the number of excess deaths (Figure 2). However, the cumulative number of deaths in this period was the highest, reaching 38,025 (20,898 in men and 17,127 in women).

We have analysed available data by sex, age and place of residence. Figure 3 presents the overall number of excess deaths by age group in Poland in 2020. The number of excess deaths was substantially higher in age groups over 59 years of age compared to younger age groups, in which the level of excess deaths was lower than 2,000 (age groups 30-39 and 40-49) in both sexes. Overall, excess death in age groups above 60 years in both men and women constituted 99% of all excess deaths. In age groups 0-19, 20-29 and 50-59 years the number of deaths in 2020 was lower than the average between 2015 and 2019. Overall, in the age group 70-79

years it reached the highest level (27,771). In age groups 60-69, 70-79, 80-89 years the number of excess deaths was higher in men than in women. The male to female ratio in excess deaths was the highest in the age group 60-69 years (2.5). However, in the oldest age group the number of excess deaths was twice as high in women as in men (5,490 vs. 10,752, respectively).

Comparison of excess deaths according to place of residence showed almost double the rate in urban than in rural areas (48,443 vs. 26,974 excess deaths, respectively). The difference was slightly larger in women than in men (Figure 4).

DISCUSSION

The assessment of the health situation in Poland should be science- and evidence-based. The assessment of coronavirus morbidity that has been conducted in Poland has not been reliable. The available data do not allow for an epidemiological assessment of coronavirus morbidity in Poland in regard to either time or space. For example, the numbers of COVID-19 cases published daily for different regions of the country, without any reference to the size of the population in these regions,

and without reference to the number of coronavirus tests performed, were of little informative value. Assessment of mortality due to COVID-19 presents similar difficulties. One of the few reliable sources is the total number of deaths published each week by the National Statistical Office, which can be used as a proxy in assessment of COVID-19 mortality.

One of the typical metrics used to assess the impact of COVID-19 in a particular country is the number of cause-specific deaths reported daily by the national administration. This metric is affected *inter alia* by testing availability and different hospital procedures. Therefore, the most objective indicator to estimate the true toll of the pandemic is excess mortality [6]. Internationally recognized as the gold standard, it has been widely used to monitor the pandemic of coronavirus in many countries [4, 16-18]. It seems that in the case of underreporting or discrepancies in reporting deaths caused by the coronavirus (deaths that are misclassified to other causes of death and deaths indirectly related to the COVID-19 pandemic), it is the best available tool to assess the volume of the pandemic, and especially to compare data between countries. This tool is essential also due to notable differences in the quantity and quality of testing between the European countries (it should be noted that Poland was one of the countries with the lowest numbers of performed tests; it was estimated that in 2020, 774 tests per 1,000 of the population were performed in the UK, while in Poland that figure was 193 per 1,000). In Denmark the number of tests performed per 1,000 people in 2020 was 9 times higher, in the USA 4 times higher and in the United Kingdom over 3 times higher than in Poland [19]. Thus for all these reasons, excess deaths seem to be the best available and reliable measure of the epidemic in Poland.

Depending on the country, there are significant differences between the number of deaths due to COVID-19 reported by the government and the number of excess deaths. Karlinsky and Kobak [6] calculated the ratio of the excess mortality to the officially reported COVID-19 death count in the same period, which differed between countries. The majority of analysed countries showed a ratio above 1, suggesting an undercount of COVID-19 deaths. Poland was found to have a ratio of 1.7, which means that official statistics on COVID-19 deaths were nearly twice as low as excess deaths. A recently published analysis prepared by COVID-19 Excess Mortality Collaborators estimated that in fact 18.2 million people died worldwide because of the pandemic, not merely 5.94 million as officially reported [20].

Our analysis showed that from March to December 2020 more than 76,000 deaths in Poland were related to the COVID-19 pandemic. In Poland the COVID-19 pandemic is notable for its own specific trajectory. Tracking mortality, we could distinguish three phases of the pandemic. From January to mid-March 2020 weekly all-cause mortality

in Poland was similar to previous years. From the beginning of the pandemic (mid-March) until the beginning of October there were 13,823 excess deaths in both men and women, and the R_0 reproduction rate (meaning the average number of people infected by a virus carrier) was probably lower than 1. During this time, there was a chance to eradicate the virus completely, or to keep the epidemic at a low level, as in the case of Norway, Finland, New Zealand, Australia, Korea, Taiwan or China. At the beginning of 2020 in Poland, preventive measures were introduced promptly and strictly, but were gradually loosened later in the year, which might have contributed to rapid deterioration of the epidemic situation towards the end of the year [21]. The 7-month phase of pandemic control lulled the vigilance of the state administration and population, restrictions were loosened and as a result mortality peaked. The first phase of the pandemic in Poland and examples from other countries show that the epidemiological status of mortality in Poland could have had a completely different course. In fact, in countries such as Norway, Finland or Denmark the mortality rate in 2020 declined, which indicates that the health gain during this period counteracted the detrimental effect of COVID-19. However, it was followed by the second phase of the epidemic, from the beginning of October 2020, in which there was an exponential increase in weekly excess deaths from 1,618 to 8,746. The R_0 number in Poland in October-December 2020 varied from 0.73 to 1.73 [22]. The peak of excess deaths occurred from 2nd to 8th November (8,746 excess deaths). After reaching this peak, excess deaths began to decline, and at the end of December we were able to report an average of around 3,800 excess deaths per week. However, our observation finished at the end of the year, but the phase of decline lasted for the following weeks of 2021. During the last seven weeks of the year the number of excess deaths totalled 38,025. The number of excess deaths was substantially higher in age groups over 59 years compared to younger age groups in both sexes. Overall, excess deaths in both men and women aged 60 years and above constituted 99% of all excess deaths. The number of excess deaths in urban areas was almost two-fold higher than that in rural areas, which is consistent with population density. Overmortality of Polish adults aged 60 years and more has led to demographic changes and a reduction in life expectancy. The National Statistical Office announced a decrease in life expectancy due to the pandemic in Poland in 2020 by 1.46 years for men and 1.04 years for women compared to the previous year [23]. In addition, in 2021 the average life expectancy compared to 2019 decreased by 2.3 and 2.1 years, respectively [24].

Similar analysis of excess deaths in Poland was performed by Walkowiak and Walkowiak [25]. The authors used different methodology using a mixed linear model, and the analysis showed similar numbers of excess deaths in 2020. The authors applied additional statistical methods to account for the timing of excess deaths

in order to link them more precisely to the pandemic. The substantial increase in excess deaths in all age groups points toward COVID-19 as a direct cause, since otherwise such an increase would be highly unlikely. The authors underlined that the number of excess deaths was substantially higher than the number officially reported in all phases of the epidemic between 2 March 2020 and 4 July 2021 [25]. According to the authors, 95% of excess deaths could be attributed to COVID-19.

In 2020, Poland was one of the countries with the highest mortality rates due to coronavirus in the world [26-28]. In March 2021, a group of Oxford epidemiologists [28] analysed excess mortality among a group of selected countries in 2020. This analysis showed that Poland, with a 14.4% increase in excess deaths, was the country with the highest increase in excess deaths (the United States was the second, with an increase of 12.9%). Similarly, the age standardized excess mortality rates per 100,000 of the population in Poland were among the highest in the group of analysed countries (175/100,000). This rate was 132 in the US, 108 in Spain, 100 in United Kingdom, 63 in Italy, 56 in France and 33 in Germany. In conclusion, Poland had suffered a health decline over the last two decades and the coronavirus pandemic has been simply a further stage [1, 21, 29-34].

According to the National Statistical Office, the number of excess deaths declined from its peak in November 2020 until early February 2021 when it reached relatively low numbers. Unfortunately, it then suddenly began to rise again. However, also due to the initiation of the vaccination process, this new phase of the pandemic requires separate analysis.

Between October and December 2020, the period in which the vast majority of excess deaths occurred (about 60,000), there were no additional circumstances that could have led to such an extreme increase in deaths (due to e.g. cardiovascular diseases, cancer, diabetes). Perhaps only alcohol-related diseases require careful analysis [1, 35]. The average reported time lag between infection and death in COVID-19 was 18 days [36, 37]. Therefore the peak excess mortality between 2nd and 8th of November in Poland could be tracked to the surge of new infections between 12th and 25th of October, which marked the beginning of the second wave of the pandemic. At the same time, the increase in excess deaths involved a very clear and specific time dependence, allowing no other reasonable epidemiological hypothesis. The excess deaths observed from March to December 2020 should be nearly entirely attributed to COVID-19.

We can expect that the vast majority of excess deaths was directly linked to the COVID-19 epidemic, but it is possible that the fraction of all excess deaths was not directly attributable to SARS-CoV-2 infection. On the other hand, excess deaths not attributed to COVID-19 can include deaths involving COVID-19 that have been misclassified as other causes of death, and deaths indi-

rectly related to COVID-19. Stokes *et al.* [38] reported that the U.S. National Center for Health Statistics studied the number of excess deaths that were not attributed to COVID-19. The authors suggested that a significant proportion of deaths of people with pre-existing chronic diseases who were infected with SARS-CoV-2 and died as a result of COVID-19 were assigned to a pre-existing disease. These pre-existing conditions can represent many of the excess deaths not attributed to COVID-19, including in Poland. Stokes *et al.* confirmed that mortality not assigned to coronavirus was higher in countries with a lower health status and higher prevalence of diabetes [38]. They published a list of conditions contributing to deaths in the United States in patients with confirmed or presumed COVID-19 (coded to ICD-10 code U07.1) which shows the magnitude of possible causes of deaths that could have been misclassified as COVID-19.

Undoubtedly, the COVID-19 pandemic has put a large strain on the healthcare systems worldwide. Many planned procedures had been postponed in order to cope with the increasing number of patients requiring hospitalization due to COVID. During the first wave of the pandemic in the United States, it was observed that visits to the emergency departments decreased by 42% (by 23% for myocardial infarction, 20% for stroke, and 10% for hyperglycaemic crisis [39]). A similar (43%) decline in hospitalizations due to acute myocardial infarction was observed in Poland [40]. Bodilsen *et al.* reported decreased hospital admissions for all major COVID-unrelated groups of diseases in Denmark [41]. Later in the year the hospitalizations began to increase, which may indicate that in the initial phase of the pandemic people were reluctant to seek medical help due to the fear of infection. This phenomenon could have partially contributed to excess deaths.

There are some limitations of our analysis to discuss. Life expectancy in Poland has been declining and therefore the mortality rates increased over time. Considering the average mortality from the years 2015-2019 as a reference value, the excess mortality in 2020 may be slightly overestimated. On the other hand, taking into account the limitations of this measurement, excess mortality is considered the most reliable tool in the analysis of the direct and indirect impact of the pandemic [42]. Excess mortality captures overall mortality regardless of the cause of death.

CONCLUSIONS

The number of excess deaths in Poland in 2020 was one of the highest in Europe. The coronavirus epidemic in Poland had its own trajectory. Its course was slower and delayed compared with some Western and European countries.

The number of excess deaths in 2020 suggests severe official underreporting of COVID deaths in Poland. The true toll of the pandemic seems to have been higher than was officially reported. There is an urgent need for fur-

ther studies and cooperation between the state administration and public health researchers to plan an intervention to tackle the ongoing health crisis in Poland.

SUMMARY AND KEY:

1. This analysis concerns the coronavirus epidemic only in 2020.
2. The first case of SARS-CoV-2 infection was diagnosed in Poland on March 4, 2020. From then until the end of 2020, **76,655 excess deaths were observed in Poland** (41,789 in men and 34,866 in women).
3. The coronavirus epidemic in Poland in 2020 was characterized by **3 phases**. **The first phase** started in the 11th week (9-15 March) and lasted for about 7 months until the beginning of October (40th week). The number of excess deaths weekly in this period did not exceed 1,100 and in total reached **13,823** (7,407 in men and 6,416 in women). **The second phase** of the coronavirus epidemic lasted from week 40 to 45. The number of excess deaths increased dramatically and reached a peak in the 45th week (2-8 November) with 8,746 excess deaths. During this 5-week phase the number of excess deaths in total was twice as high as that in the first phase and averaged **24,807** (13,484 in men and 11,323 in women). The last 7 weeks (45th-52nd week) of 2020 (**third phase**) showed a decline in the number of excess deaths, but the cumulative number of excess deaths reached **38,025** (20,898 in men and 17,127 in women). The analysis concerned only 2020 and finished in the 52nd week. However, according to the National Statistical Office, the number of excess deaths was declining from its peak in November 2020 until early February 2021.
4. The number of excess deaths in 2020 in Poland was **substantially higher in men than in women** (41,789 vs. 34,866).
5. Overall, excess deaths in **age groups above 60 years** in both men and women constituted **99% of all excess deaths**.
6. The number of excess deaths was twice as high in **urban as in rural areas** (48,443 vs. 26,974).
7. The course of the coronavirus epidemic in Poland had its own trajectory. It was slower and delayed compared with some Western and European countries. Generally, in 2020, Poland was among the European countries with the largest increases of excess deaths, in spite of the seven-month period of a relatively mild course of the epidemic.
8. During the first phase of the epidemic in Poland, **there was a chance to substantially control the virus, or to keep the epidemic at a low level**, as was achieved in Norway, Finland, New Zealand, Australia, Korea, Taiwan and China.
9. The overall number of excess deaths in Poland in 2020 was **substantially higher than officially reported** in all phases of the epidemic.

FUNDING

KZ collaborated in preparing the article within the framework of the topic “Ocena rozpowszechnienia wybranych czynników ryzyka chorób cywilizacyjnych w okresie przed i w trakcie pandemii Covid-19 w populacji osób dorosłych oraz dzieci w wieku szkolnym z uwzględnieniem miejsca zamieszkania (miasto-wieś)” (“Assessment of the prevalence of selected risk factors for non-communicable diseases in the period before and during the COVID-19 pandemic in the population of adults and school-aged children with respect to place of residence (urban-rural)” task recorded in the SIMPLE system: SUB.Z.260.22.074; and ABR within the framework of the topic “Ocena wpływu pandemii COVID-19 na skład masy ciała i zachowania zdrowotne dzieci w wieku 7-14 lat oraz ich opiekunów” (“Assessment of the impact of the COVID-19 pandemic on the body mass composition and health behaviours of children aged 7-14 and their guardians”) task recorded in the SIMPLE system: SUBK.E260.22.019.

DISCLOSURE

The authors report no conflict of interest.

References

1. Zatoński WA, Zatoński M, Janik-Konieczny K, Wojtyła A. Alcohol-related deaths in Poland during a period of weakening alcohol control measures. *JAMA* 2021; 325(11): 1108-1109.
2. Zatoński WA, Janik-Konieczny K, Zatoński M. Life expectancy and alcohol use health burden in Poland after 2002. *J Health Inequal* 2022; 8(1): 4-16.
3. World Health Organization. International guidelines for certification and classification (coding) of Covid-19 as cause of death based on ICD International Statistical Classification of Diseases; 2020. Available from: [https://www.who.int/publications/m/item/international-guidelines-for-certification-and-classification-\(coding\)-of-covid-19-as-cause-of-death](https://www.who.int/publications/m/item/international-guidelines-for-certification-and-classification-(coding)-of-covid-19-as-cause-of-death) (accessed: 21 March 2022).
4. Beaney T, Clarke JM, Jain V, et al. Excess mortality: the gold standard in measuring the impact of COVID-19 worldwide? *J R Soc Med* 2020; 113(9): 329-334.
5. Johns Hopkins Coronavirus Resource Center. New COVID-19 Cases Worldwide: 7-day moving average. Available from: <https://coronavirus.jhu.edu/data/new-cases> (accessed: 21 March 2022).
6. Karlinsky A, Kobak D. Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset. *eLife* 2021; 10: e69336.
7. Leon DA, Shkolnikov VM, Smeeth L, et al. COVID-19: a need for real-time monitoring of weekly excess deaths. *Lancet* 2020; 395(10234): e81.
8. Our World in Data. Coronavirus Pandemic (COVID-19). Available from: <https://ourworldindata.org/coronavirus> (accessed: 21 March 2022).
9. Eurostat. Statistics explained. Glossary: Excess mortality. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Excess_mortality (accessed: 21 March 2022).
10. Kobak D. Excess mortality reveals Covid's true toll in Russia. *Significance* 2021; 18: 16-19.

11. Blangiardo M, Cameletti M, Pirani M, et al. Estimating weekly excess mortality at sub-national level in Italy during the COVID-19 pandemic. *PLoS One* 2020; 15(10): e0240286.
12. Weinberger DM, Chen J, Cohen T, et al. Estimation of excess deaths associated with the COVID-19 pandemic in the United States, March to May 2020. *JAMA Intern Med* 2020; 180(10): 1336-1344.
13. Główny Urząd Statystyczny [National Statistical Office]. Zgony według tygodni [Deaths by week]. Available from: <https://stat.gov.pl/obszary-tematyczne/ludnosc/ludnosc/zgony-wedlug-tygodni,39,2.html> (accessed: 18 March 2021).
14. National Cancer Institute. Joinpoint Trend Analysis Software. Available from: <https://surveillance.cancer.gov/joinpoint/> (accessed: 5 February 2021).
15. National Statistical Office. Results of current research. Available from: <https://demografia.stat.gov.pl/BazaDemografia/Tables.aspx> (accessed: 15 May 2022).
16. Kontis V, Bennett JE, Rashid T, et al. Magnitude, demographics and dynamics of the effect of the first wave of the COVID-19 pandemic on all-cause mortality in 21 industrialized countries. *Nat Med* 2020; 26(12): 1919-1928.
17. Alicandro G, Remuzzi G, La Vecchia C. Italy's first wave of the COVID-19 pandemic has ended: no excess mortality in May, 2020. *Lancet* 2020; 396(10253): e27-e28.
18. Woolf SH, Chapman DA, Sabo RT, et al. Excess deaths from COVID-19 and other causes, March-July 2020. *JAMA* 2020; 324(15): 1562-1564.
19. Our World in Data. Total COVID-19 tests per 1,000 people. Available from: <https://ourworldindata.org/grapher/full-list-cumulative-total-tests-per-thousand?time=2020-02-20..2020-12-31> (accessed: 6 January 2022).
20. COVID-19 Excess Mortality Collaborators. Estimating excess mortality due to the COVID-19 pandemic: a systematic analysis of COVID-19-related mortality, 2020-21. *Lancet* 2022; 399(10334): 1513-1536.
21. Gruszczynski L, Zatoński M, McKee M. Do regulations matter in fighting the COVID-19 pandemic? Lessons from Poland. *Eur J Risk Regul* 2021; 12(4): 739-757.
22. Arroyo-Marioli F, Bullano F, Kucinkas S, Rondón-Moreno C. Tracking R of COVID-19: a new real-time estimation using the Kalman filter. *PLoS One* 2021; 16(1): e0244474.
23. National Statistical Office. Life tables. Available from: <https://demografia.stat.gov.pl/BazaDemografia/TrwanieZycia.aspx> (accessed: 6 September 2022).
24. National Statistical Office. Life expectancy in 2021. Available from: <https://stat.gov.pl/obszary-tematyczne/ludnosc/trwanie-zycia/trwanie-zycia-w-2021-roku,2,16.html> (accessed: 9 September 2022).
25. Walkowiak MP, Walkowiak D. Underestimation in reporting excess COVID-19 death data in Poland during the first three pandemic waves. *Int J Environ Res Public Health* 2022; 19: 3692.
26. Zatoński WA, Janik-Koncewicz K, Pawlikowska-Chechłacz K, Wojtyła A. O koronawirusie wiemy, że nic nie wiemy [We know about the coronavirus that we know nothing]. Available from: <https://www.termedia.pl/mz/O-koronawirusie-wiemy-ze-nic-nie-wiemy,41818.html> (accessed: 1 April 2022).
27. Opolska Z. Szczepić powinni się wszyscy, którzy chcą żyć. Czy to wystarczy, by chronić się przed Omikronem? [Everyone who wants to live should get vaccinated. Is it enough to protect yourself from the Omicron?]. Available from: <https://www.medonet.pl/koronawirus/koronawirus-w-polsce,lekarz-o-sile-razenia-omikronu--szczepic-powinni-sie-wszyscy--ktorzy-chca-zyc,artykul,03389410.html> (accessed: 1 April 2022).
28. The Centre for Evidence-Based Medicine. Excess mortality across countries in 2020. Available from: <https://www.cebm.net/covid-19/excess-mortality-across-countries-in-2020/> (accessed: 21 March 2022).
29. Pawłowska D. Zgony. Niestety, 2020 rok zapisze się w naszej powojennej historii jako rekordowy [Deaths. Unfortunately, 2020 will go down in our post-war history as a record year]. Available from: <https://biqdata.wyborcza.pl/biqdata/7,159116,26642808,zgony-niestety-2020-r-zapise-sie-w-naszej-powojennej-historii.html> (accessed: 21 March 2022).
30. Zatoński WA, Sulkowska U, Zatoński MZ, et al. Alcohol taxation and premature mortality in Europe. *Lancet* 2015; 385(9974): 1181.
31. Zatoński WA. One hundred years of health in Poland. *J Health Inequal* 2019; 5(1): 11-19.
32. Zatoński WA, Zatoński M, Janik-Koncewicz K, McKee M. Alcohol-related liver cirrhosis in Poland: the reservoir effect. *Lancet Gastroenterol Hepatol* 2020; 5(12): 1035.
33. Wojtyński B, Goryński P. (eds). Health status of the Polish population and its determinants 2020. Available from: https://www.pzh.gov.pl/wp-content/uploads/2021/01/Raport_ang_OK.pdf (accessed: 21 March 2022).
34. World Health Organization. Global status report on alcohol and health 2018. Available from: <https://www.who.int/publications/i/item/9789241565639> (accessed: 21 March 2022).
35. Zatoński W. The alcohol crisis in Polish public health. *J Health Inequal* 2019; 5(2): 122-123.
36. Verity R, Okell LC, Dorigatti I, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. *Lancet Infect Dis* 2020; 20(6): 669-677.
37. Marschner IC. Estimating age-specific COVID-19 fatality risk and time to death by comparing population diagnosis and death patterns: Australian data. *BMC Med Res Methodol* 2021; 21(1): 126.
38. Stokes AC, Lundberg DJ, Elo IT, et al. COVID-19 and excess mortality in the United States: a county-level analysis. *PLoS Med* 2021; 18: e1003571.
39. Lange SJ, Ritchey MD, Goodman AB, et al. Potential indirect effects of the COVID-19 pandemic on use of emergency departments for acute life-threatening conditions – United States, January-May 2020. *MMWR Morb Mortal Wkly Rep* 2020; 69(25): 795-800.
40. Gašior M, Gierlotka M, Tycińska A, et al. Effects of the coronavirus disease 2019 pandemic on the number of hospitalizations for myocardial infarction: regional differences. Population analysis of 7 million people. *Kardiol Pol* 2020; 78(10): 1039-1042.
41. Bodilsen J, Nielsen PB, Søgaard M, et al. Hospital admission and mortality rates for non-covid diseases in Denmark during

- covid-19 pandemic: nationwide population based cohort study. *BMJ* 2021; 373: n1135.
42. World Health Organization. 14.9 million excess deaths associated with the COVID-19 pandemic in 2020 and 2021. Available from: <https://www.who.int/news/item/05-05-2022-14.9-million-excess-deaths-were-associated-with-the-covid-19-pandemic-in-2020-and-2021> (accessed: 21 March 2022).
 43. Leung NHL. Transmissibility and transmission of respiratory viruses. *Nat Rev Microbiol* 2021; 19: 528-545.
 44. McKee M. The coronavirus pandemic: learning from international experience. *J Health Inequal* 2020; 6(2): 80-83.
 45. Locatelli I, Trächsel B, Rousson V. Estimating the basic reproduction number for COVID-19 in Western Europe. *PLoS One* 2021; 16(3): e0248731.
 46. Davies NG, Abbott S, Barnard RC, et al. Estimated transmissibility and impact of SARS-CoV-2 lineage B.1.1.7 in England. *Science* 2021; 372(6538): eabg3055.
 47. Centers for Disease Control and Prevention. Measures of Risk. Available from: <https://www.cdc.gov/csels/dsepd/ss1978/lesson3/section2.html> (accessed: 15 January 2022).

AUTHORS' CONTRIBUTIONS

KJK – took part in preparing the concept of the article, collected and analysed data, prepared the first draft of the article and worked on the final version; ABR – literature search, contribution to drafting the manuscript and revising it; KZ – revising the manuscript; MK – formal analysis and visualization; WAZ – prepared the concept of the article, took part in preparing the draft of the article, revised it and approved it.