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ORIGINAL ARTICLE

Lessons from the COVID-19 pandemic: Mortality impacts in Poland versus European Union

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Abstract
With COVID-19 moving toward an endemic phase, it is worthwhile to identify lessons from the pandemic that can promote the effective strengthening of national health systems. We look at a single country, Poland, and compare it with the European Union (EU) to contrast approaches and outcomes. Among possible relevant indices, we examine characteristics of COVID-19-related mortality and excess all-cause mortality from March 2020 to February 2022. We demonstrate that both the numbers of COVID-related deaths and all-cause deaths in Poland were much higher than the EU average for most months in the study period. We juxtapose the percentage of fully vaccinated population and cumulative COVID-19 deaths per million people for EU Member States and show that typically higher vaccination rates are accompanied by lower mortality. We also show that, in addition to medical science, the use of a risk science toolbox would have been valuable in the management of the COVID-19 pandemic in Poland. Better and more widespread understanding of risk perception of the pandemic and the COVID-19 vaccines would have improved managing vaccine hesitancy, potentially leading to more effective pro-vaccination measures.

KEYWORDS
COVID-19 management, disaster risk reduction, European Union, mortality, Poland

> ''How many deaths will it take till he knows
>
> that too many people have died?''
>
> [Bob Dylan, winner of the 2016 Nobel Prize in Literature]

1 | INTRODUCTION

With COVID-19 moving toward an endemic phase, the time has come to identify lessons from the pandemic that can promote the effective strengthening of national health systems. In this article, we compare the situation in Poland with that in the 27-state European Union (EU) to highlight the important role of political decisions in the effective management of the pandemic response.

Poland is the fifth largest EU country in terms of population and area. Until March 22, 2022, Poland (38 million population) and EU (447 million population) reported, respectively, 5.92 and 121.21 million COVID-19 cases as well as 114,355 and 1.04 million COVID-19 deaths (Our World in Data, 2022).

Our objective is to compare the time series of COVID-19-related mortality per million inhabitants and the number of excess all-cause deaths in Poland and in EU Member States; the percentage of fully vaccinated populations; and the cumulative number of COVID-19 deaths per million inhabitants.

The organization of the article is as follows. After the introductory section, we present the statistics that illustrate the pandemic. We document the counts of COVID-19 deaths and excess all-cause deaths in Poland and in the EU. We then highlight the link between the percentage of fully vaccinated population and the cumulative number of COVID-19 deaths per million people in EU Member States. Further, we discuss multi-objective pandemic governance, with health and the economy being the most essential dimensions. Next, we present perspectives on vaccinations. Then, we discuss challenges and inspirations to risk science and its applicability and examine some lessons learned. The article ends with a few final, concluding, remarks.

The article is framed as studying the pandemic in an EU versus Poland context. However, some references to other

TABLE 1 List of 8 months with highest number of all-cause deaths in Poland from January 2010 to March 2022.

Rank	Number of all-cause deaths, in thousands	Month
1	66.0	November 2020
2	61.1	December 2021
3	55.0	April 2021
4	54.3	December 2020
5	53.1	March 2021
6	50.9	November 2021
7	48.3	January 2022
8	46.3	October 2020

Source: Data from Statistics Poland (2022b).

countries that illustrate important general issues of direct relevance to the material tackled in this article are also given.

This article is original in relation to existing literature. To the knowledge of the authors, there have been no similar studies related to either Poland or Poland versus EU.

2 | MORTALITY STATISTICS

There are many indices quantifying the pandemic and its impact. In this article, we analyze the numbers of reported COVID-19 deaths and numbers of all-cause excess deaths from March 2020 to February 2022.

As illustrated in Figure 1 (bottom panel), Poland successfully managed the first phase of COVID-19, with considerably fewer COVID-19 deaths per million than the EU average. However, although the human toll was low, the economic cost resulting from strict anti-COVID-19 policy, including the lockdown, was high, with a GDP drop of 8.2%, year-to-year, in the second quarter of 2020. In addition, there was a considerable increase of public debt.

Starting in October 2020, the number of COVID-19 deaths per million people in Poland was considerably higher than the EU average, except for the summer of 2021 (Figure 1, bottom panel).

International comparability of confirmed COVID-19 deaths is problematic because of uneven reporting of cases, unequal access to testing (and number of tests per million inhabitants), and other sources of underestimation, even if it is assumed that deaths "with COVID" are tracked rather than deaths "from COVID." Therefore, it is important to compare excess all-cause mortality, expressed as the percentage rate of additional deaths from all causes during one calendar month of the pandemic, related to a baseline value for that month in 2016–2019. Values of excess deaths also reflect the general worsening of access to health care for non-COVID patients.

Data collected by Eurostat, the statistical service of the EU, showed that there were few months during the pandemic for which EU average number of excess deaths exceeded 25% (Eurostat, 2022). Two EU countries with the lowest numbers of maximum monthly excess deaths were Finland (14.7%) and Denmark (17.5%). The maximum monthly percentage of additional deaths in Poland in November 2020 was 97%. This was the highest value among EU Member States for that month.

TABLE 2 Percentage of fully vaccinated population and cumulative number of COVID-19 deaths per million people in European Union (EU) Member Countries.

EU Member State	Percentage of fully vaccinated population	Cumulative number of COVID-19 deaths per million people
Austria	72.85	1713
Belgium	78.41	2628
Bulgaria	29.70	5271
Croatia	54.80	3788
Cyprus	72.02	951
Czechia	63.93	3675
Denmark	81.48	934
Estonia	63.56	1810
Finland	77.55	502
France	77.74	2096
Germany	75.17	1516
Greece	73.13	2606
Hungary	64.19	4686
Ireland	80.31	1341
Italy	79.13	2619
Latvia	69.73	2959
Lithuania	69.60	3253
Luxemburg	71.85	1548
Malta	90.25	1209
The Netherlands	71.99	1275
Poland	59.06	3026
Portugal	92.60	2006
Romania	42.25	3385
Slovakia	50.68	3507
Slovenia	58.68	3103
Spain	85.52	2170
Sweden	74.91	1777
EU mean	**72.95**	**2322**

Note: Data in Table 2 correspond to those presented in Figure 2. Additionally, the EU mean is included.
Source: Data from Our World in Data (2022).

The upper panel in Figure 1 illustrates the comparison of monthly excess deaths above reference (%) in Poland and in the EU during the pandemic. The variability of the time series of numbers of all-cause excess deaths in Poland was similar to the course of counts of new confirmed COVID-19 deaths presented in the lower panel of Figure 1.

Table 1 lists the eight deadliest months in Poland in 2010–2022, all occurring during the pandemic. In 2020, the total numbers of deaths and births were 477,355 and 355,309,

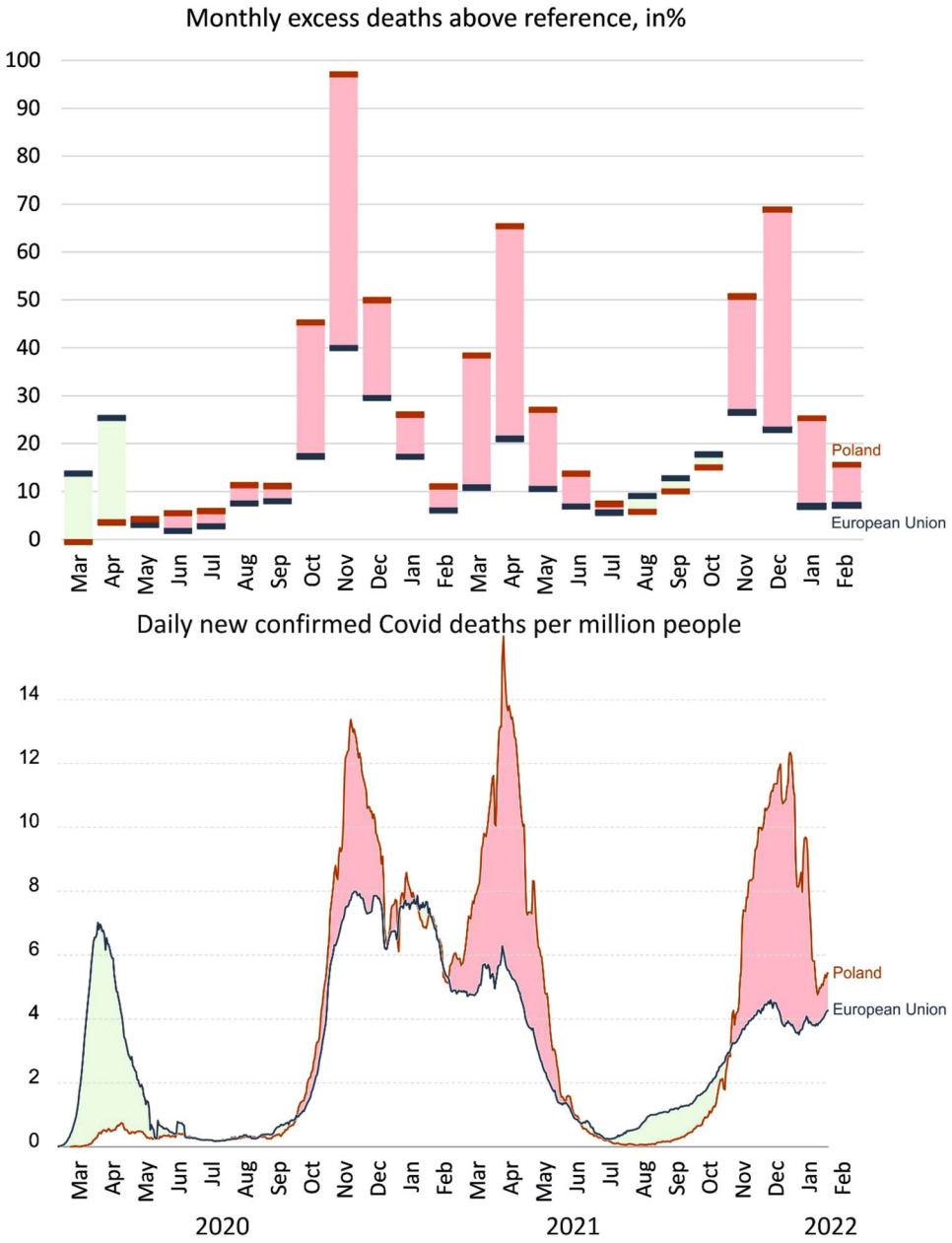

FIGURE 1 Comparison of confirmed COVID-19 deaths and excess all-cause deaths in Poland and the European Union (EU). Lower panel: Daily new confirmed COVID-19 deaths per million people (7-day rolling average). Upper panel: Monthly excess all-cause deaths above reference (in %). Areas marked in green and red refer to Polish indices being, respectively, better and worse than that for the EU. *Source*: Authors' analysis of data from references Our World in Data (2022) and Eurostat (2022).

respectively, so that the population decline was 122,046, whereas in 2021, these numbers were, respectively, 519,517; 331,511; and 188,006 (Statistics Poland, 2022a).

One of the likely reasons why the numbers of COVID-19 deaths and all-cause deaths per million in Poland were much higher than the EU average (Figure 1) was the low national vaccination rate in the country. Most Polish COVID-19 deaths since 2021 were in the unvaccinated. By March 22, 2022, only 59.06% of Poles were fully vaccinated and only 30.76% boosted, far below EU average values of 72.95% and 49.56%, respectively (Our World in Data, 2022). The fully vaccination rate of seniors (categories 60+ and 70+), who were most vulnerable, was below 80%. Furthermore, many of the infected people tried to recover at home, generally going to hospital when it was too late. Mortality rates among patients with COVID-19 subject to mechanical ventilation were very high in Poland (a value of 67% was reported by Flisiak et al. (2021)). The reported case-fatality among hospitalized patients in Poland was 11.7% on average, staying below 5% for patients 60 years or less, and increasing to 10.6% for those 60–69 years, 21.3% for 70–79, 30.9% for 80–89, and 34% for 90–99 (Kanecki et al., 2021).

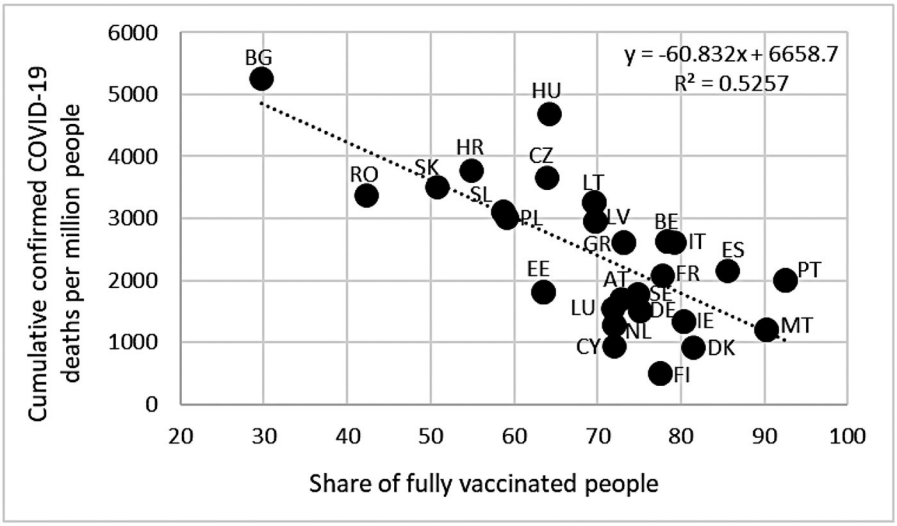

FIGURE 2 Illustration of link between percentage of fully vaccinated population and cumulative COVID-19 deaths per million people in European Union (EU) Member States. Data on vaccination status refer for most countries to March 22, 2022. Because data for 22 March were not available in the database for some countries, proxy dates were used: 23 March for Finland, 21 March for Belgium, 20 March for Slovakia, 19 March for Malta, 16 March for Spain, 10 March for Portugal, 26 February for Cyprus, and 20 February for Luxembourg. Two-letter shortenings of names of EU Member States follow the standard of ISO 3166-1 α-2, that is, AT—Austria, BE—Belgium, BG—Bulgaria, HR—Croatia, CY—Cyprus, CZ—the Czech Republic, DK—Denmark, EE—Estonia, FI—Finland, FR—France, DE—Germany, GR—Greece, HU—Hungary, IE—Ireland, IT—Italy, LV—Latvia, LT—Lithuania, LU—Luxembourg, MT—Malta, NL—The Netherlands, PL—Poland, PT—Portugal, RO—Romania, SK—Slovakia, SI—Slovenia, ES—Spain, SE—Sweden. *Source*: Data from Our World in Data (2022).

The performance of European countries during the pandemic crisis, measured by such indices as number of COVID-19 cases and deaths with COVID-19 per million inhabitants, varied significantly (Coccia, 2022). So did the national vaccination rates. Figure 2 shows evidence of a statistically significant (at <0.001 level) association between the share of people who completed the initial COVID-19 vaccination protocol (i.e., the total number of people who received all doses prescribed by the initial vaccination protocol, divided by the total population of the country eligible for vaccination) and cumulative COVID-19 deaths per million. Figure 2 gives a broad overview for each of the 27 EU Member Countries. Mortality in the "new" EU Member Countries located in Central and Eastern Europe that accessed the Union in 2004 and later was generally higher than in "old" Member Countries that joined the Union before 2004.

Table 2 presents the raw data visualized in Figure 2, on the percentage of fully vaccinated population and cumulative number of COVID-19 deaths per million people in EU Member States.

Each of 27 EU Member States represented in Figure 2 and Table 2 merits national interpretation. Bulgaria had the highest mortality and the lowest vaccination rate. The vaccination rate exceeded 90% in Portugal and Malta, with mortality below the EU average. However, most COVID-related deaths in Portugal occurred before the first person was fully vaccinated. Interestingly, there was a wide mortality range in three EU Member States in Central and Eastern Europe (Hungary, Czechia, and Estonia) with similar vaccination rates, ranging from 63.56% to 64.19%. There were many COVID-19 deaths per million in Hungary (4686, second highest mortality in EU), less (3675) in the Czech Republic, and far less (1810) in Estonia. This clearly shows that, in addition to vaccination rate, there were other important factors responsible for differences in COVID-19 mortality among countries.

3 | MULTI-OBJECTIVE PANDEMIC GOVERNANCE—HEALTH AND ECONOMY

The present section studies the multi-objective pandemic governance in Poland. Health and economy issues are analyzed, using examples from other, mostly EU, but also a few non-EU states. A dedicated subsection on perspectives on vaccination is also provided.

The numbers of COVID-19 deaths and excess all-cause deaths recorded in Poland in the first stage of the pandemic, in the spring of 2020, were smaller than the EU average. This was likely due to a drastic lockdown introduced "to flatten the curve" on March 31, 2020 and due to the exemplary discipline of the Polish population.

Effective lockdowns in early 2020 were reported in many countries and regions, backed by relevant quantitative indices. During the nationwide lockdown in Greece in March 2020, multiple distancing measures reduced daily contacts by 86.9% and the effective reproductive number by 81% (Sypsa et al., 2021). In Italy, 2 weeks after the national lockdown, the net reproductive number dropped below 1 and remained stable at around 0.76 in all regions for more than 3 weeks (Guzzetta et al., 2021). In February and March of 2020, multilevel policies, including extensive testing, contact tracing, and quarantine, largely reduced contact rates and the spread of the epidemic in South Korea. The absence of this prompt response could have increased COVID-19 infec-

tions, hospitalizations, and deaths by more than 10-fold (Kim et al., 2021). A study from Colorado, USA, showed that early COVID-19 policy measures, including a stay-at-home order, led to a significant decrease in the effective reproductive number, to a value well below 1 (Buchwald et al., 2021). Study of data from 165 countries (Yang et al., 2022) showed that early implementation of international travel controls delayed the first epidemic peak of cases by 5 weeks on average.

However, heavy financial and social costs of the lockdown and actions aimed at curbing the COVID-19 spread were reported, including psychological impacts (Tudu, 2022) and detriments for mental health (de Miranda et al., 2020). In France, although the March 2020 lockdown was effective in curbing disease spread, the public support remained fragile, especially among low-income citizens, because the lockdown exacerbated preexisting social inequities and conflicts (Peretti-Watel et al., 2021). Examination of the COVID-19 impact on the labor market in the USA (Katare et al., 2021) demonstrated that a large or moderate negative effect was felt by 90% of small businesses.

In the summer of 2020, COVID-19 management in Poland became less consistent. The restrictions were lighter and poorly enforced.

Political decisions in Poland affected the effectiveness of physical distancing. Hundreds of thousands of people demonstrated in Poland on several days after the judgment of the Constitutional Tribunal (October 22, 2020) on family planning, including the grounds for permitting the termination of a pregnancy (Constitutional Tribunal, 2020). There were further large demonstrations by many tens of thousands of people triggered by other political decisions.

Large gatherings can have widespread effects on COVID-19 transmission, and even fully vaccinated people should take precautions—masks, distance, and disinfection (Gharpure et al., 2022). After the autumn of 2020, the Polish government often updated regulations on physical distancing. This included changing the allowed maximum number of attendees in gatherings or passengers in public transport; percentage of occupancy in churches, restaurants, hotels, cultural and sports facilities, and so forth; as well as minimum space per person in shops, gyms, fitness clubs, museums, galleries, exhibitions, and so forth. However, these changes were implemented inconsistently, increasing and decreasing in no coherent pattern. In fact, enforcing the wearing of face masks and limiting the number of people in closed spaces were not successful because many people did not obey to the rules.

Late in 2021, stricter physical distancing restrictions were issued in Poland, except for New Year's Eve, when parties in clubs and discotheques allowed up to 100 participants. Moreover, two mass gatherings were organized, bringing together tens of thousands of people. The pandemic was bureaucratically "suspended" for 2 days (this is not dissimilar to other countries—e.g., in Italy, the restrictions were weakened in the holiday season of December 2020). A green light for organized mass gatherings on December 31, 2021 was set in Poland when 7-day averages of daily numbers of new COVID-19 infections and fatalities reached 285.05 and 11.39 per million, respectively. These indices were very much lower (even by two orders of magnitude), respectively, at 5.33 and 0.09 per million (Our World in Data, 2022), when a strict (and strongly contested) ban on entry to forests and public parks was issued in Poland with the lockdown on March 31, 2020.

At times, the pandemic was perceived in Poland as conflicting objectives from health and economic concerns. Health was clearly the priority in spring 2020. The lockdown caused disruptions of productive activity in many companies while reducing COVID-19 cases and deaths. Costly "anti-crisis shields" were installed by the government, preventing bankruptcies, stabilizing employment, and maintaining control of supply and demand of labor and goods. In contrast, imposing soft restrictions from autumn 2020 onward affected economic activity only to a smaller extent; these were ineffective in controlling the epidemic.

The COVID-19 Advisory Team of the Polish Academy of Sciences (2022b) noted that the alternative "either health of citizens or healthy economy" is false. In fact, a healthy society is a necessary condition of a healthy economy.

An important Polish think tank (*Klub Jagiellonski*) rated the national COVID-19 policy as poor in 2020 (Klub Jagiellonski, 2021), despite its success in curbing the epidemic spread in spring, and very poor in 2021 (Klub Jagiellonski, 2022).

3.1 | Perspectives on vaccination

The controversy related to COVID-19 vaccination entered the public discourse in Poland long before vaccines were available. In June 2020, that is, 6 months before vaccines would be available, 1 of 5 questions posed to the 11 presidential candidates in the only organized state TV debate was about attitudes toward obligatory vaccination. In this TV debate, the ruling president, who was reelected, expressed strong objections against obligatory vaccination. Public messaging on vaccines was inconsistent. Ethical reservations (claiming that aborted foetus cell lines were used for the production of vaccines) were expressed in December 2020 by the Team of Experts on Bioethics of the Polish Episcopal Conference on vaccines (2020). At the same time, the COVID-19 Advisory Team at the Polish Academy of Sciences strongly encouraged vaccinations. The Appendix illustrates contrasting expert attitudes.

The Polish National Vaccination Program was initiated on December 27, 2020, with a network of vaccination points and reasonable logistical arrangements, although it was not successful in convincing the unconvinced segment of the population. In Poland, COVID-19 vaccination certificates have not been used as a condition for the availability of services, in contrast to many other EU Member States. Many citizens subscribed to the opinion that the world was chasing the mutating (and escaping) virus with changes in the binding affinity and trying to counteract it. But vaccines were developed for an earlier version of the virus, for which high vaccine effectiveness was reported (cf., Glatman-Freedman et al., 2021), but they might be less effective for the newest

version. High vaccination coverage remains critical to protect people, but it is difficult to prevent infection and transmission opportunities by the mutating virus (del Cura-Bilbao et al., 2022). It was not commonly known in Poland (Arbel et al., 2021) that receiving a booster at least 5 months after a second dose of the BNT162b2 vaccine yields 90% reduction in mortality due to COVID-19 in comparison to those who did not receive a booster.

Large area-wise and sparsely populated Finland had the lowest COVID-19 mortality in the EU, with a vaccination rate higher than the EU average. It is interesting to note that in 2021, for the fourth year in a row (and despite the pandemic), Finland was ranked as the happiest country in the world (Helliwell et al., 2021). Compared to other EU countries, Finland navigated the COVID-19 pandemic more safely than other countries. There is exemplary mutual trust and communal support among people of Finland.

The concerns of many Polish people about vaccines referred, as elsewhere (Nguyen et al., 2021), to potential side effects, lack of safety, and lack of trust in vaccines developed more than four times faster than the fastest vaccine so far (Ball, 2021a). Some Poles adhered to conspiracy theories and pseudo-scientific statements, as elsewhere (Ball, 2021b). In late 2021, when COVID-19 mortality and all-cause mortality reached their peaks, vaccination was strongly encouraged by the Ministry of Health, the Prime Minister's Medical Council, and the COVID-19 Advisory Team at the Polish Academy of Sciences. In contrast, some politicians, mostly from the ruling camp, delivered anti-vaccination statements in the public domain, using a libertarian narrative. This corroborates the recognized limitations in command-and-control tactics in an emergency (Cawthorn et al., 2021). In January 2022, 13 of 17 members of Prime Minister's Medical Council resigned because their recommendations were not heeded (Holt, 2022).

A major international recognition related to vaccines against COVID-19 was announced on October 2, 2023. The Nobel Assembly at the Karolinska Institutet awarded the 2023 Nobel Prize in Physiology or Medicine jointly to Katalin Karikó and Drew Weissman[1] "for their discoveries concerning nucleoside base modifications that enabled the development of effective mRNA vaccines against COVID-19." The citation noted that "the laureates contributed to the unprecedented rate of vaccine development and that the vaccines have saved millions of lives and prevented severe disease in many more, … during one of the biggest health crises of our time."

4 | CHALLENGES AND INSPIRATIONS TO RISK SCIENCE AND ITS APPLICABILITY

During the COVID-19 pandemic, societies worldwide struggled to assess and handle pandemic-related risks at a variety of levels, ranging from an individual, a family, an institution, a town, a county, or a professional group to a state or an international level. The situation was indeed "wicked" in the sense that decisions were urgently needed under considerable time pressure in the presence of vastly incomplete knowledge, scarcity of robust facts, and abundant uncertainties and surprises (e.g., related to the direction of mutations and efficiency of vaccines). Moreover, the transfer function from action (such as policy decision, e.g., imposed restriction) to effect (impact on the spread and the severity of the pandemic) was not known with sufficient accuracy and reasonable credibility.

Aven and Bouder (2020) demonstrated that risk science is, generally, an important knowledge basis for handling the COVID pandemic, being of potential use in multiple ways. The international scientific literature contains ample ideas from the risk-science toolbox that could lend themselves well to managing the COVID-19 pandemic in Poland (cf. Siegrist et al., 2021; Vieira et al., 2022; Ju & You, 2022; Cohen et al., 2022; Wang Chenyang et al., 2022; Wong & Yang, 2022).

The notion of risk, focusing on adverse, undesirable effects, may mean different things to different people—experts, laymen, and decision-makers. They may understand risk differently, so that disagreements may arise. Experts commonly define risk via technical terms (e.g., probability times consequence, reported as annual fatalities), whereas the lay public may interpret risk by considering other factors such as catastrophic potential, controllability, equity, effects on future generations, and involuntariness (Slovic, 1987; Wong & Yang, 2022). Hence, the lay public may allot comparatively less weight to technical risk assessments conducted by experts.

There are many definitions and conceptualizations of risk. In this article, we adopt risk conceptualization via adverse consequences and associated probabilities and disaggregation of risk into three components: hazard, exposure, and vulnerability. Practical definitions of these terms can be found in the SRA and in the IPCC glossaries (respectively, Agard & Schipper, 2014; Aven et al., 2018).

Specifications embraced by the notions of hazard, exposure, and vulnerability, pertaining to factors that humans value, such as health and well-being, wealth, and prosperity, lend themselves well to applications in the COVID-19 pandemic domain. The changing hazard could embrace the mutating virus, changing actions and perceptions, as well as the availability of effective vaccines. The exposure refers to localities (e.g., passengers and crew of a ship, or inhabitants of a multistory apartment house) and professional groups, such as healthcare and school personnel, as well as pupils and students, who are likely to have many contacts with COVID-infected people. Regulations related to the reduction of exposure pathways via social-distance restrictions and—in a more extreme case—a lockdown helped reduce the spread of the pandemic and its intensity. Finally, a range of vulnerable groups were identified. The principal determinants of vulnerability are advanced age and multimorbidity, with the likelihood of the latter increasing with

[1] https://www.nobelprize.org/uploads/2023/10/press-medicineprize2023-3.pdf

advancing age. Several determinants increased human vulnerability. Williamson et al. (2020) examined factors associated with COVID-19-related death in a large cohort study. They found that COVID-19-related death was associated with greater age and deprivation; being male; diabetes; severe asthma; and other medical conditions. The COVID-19 regulations undertaken in Poland aimed at reducing vulnerability, for example, via the order of right to vaccination, identified seniors first and then exposed groups, such as healthcare and school personnel. The rule of "time window for seniors only" that was introduced in shops in Poland helped older people shop more safely, via exposure reduction, during a predefined period every working day.

Slovic (1987) created the foundations of risk perception science, by providing a basis for understanding and anticipating responses of individuals to hazards. Risk perception is a subjective affect- and reason-driven judgment that people make about risk characteristics and severity (Wong & Yang, 2022).

During the years of the COVID-19 epidemic, many Polish people regularly undertook intuitive risk assessment (at least qualitatively estimating the probability and the consequences of getting infected) and risk handling at the individual level. In the spring of 2020, the Polish nation generally followed the recommendations on behavioral measures imposed by the authorities, with exemplary discipline. Most people heeded the "stay-at-home" call and kept physical distancing (so-called social distance), avoiding crowded and confined spaces, and avoiding close contact with others. Obligatory use of face masks covering the mouth and nose was generally implemented in public spaces, especially in the first months of the pandemic and then in the autumn of 2020, the winter of 2020/2021, and the spring of 2021. Hygienic behavior, with frequent hand washing and using disinfectants, was common. The situation deteriorated after the first phase of the pandemic, when some decisions of Polish authorities (see examples in Section 3) were contested; hence, frustration and anger in citizens grew. Many Polish people trusted the vaccines (see statistics in Section 3.1), but the number of skeptics was high. Contradictory opinions about the vaccinations were disseminated in the public domain (see Appendix), so that many citizens were puzzled due to cognitive dissonance. There was no way to impose compulsory vaccinations, even in vulnerable population segments, nor to render vaccination the preferred option.

Cohen et al. (2022) addressed the concept of actively open-minded thinking (AOT) serving "as a norm accounting for how one should search for and use information in judgment and decision making"; as "a thinking style that one may adopt in accordance with the norm"; and setting "standards for evaluating the thinking of others, particularly the trustworthiness of sources that claim authority." These concepts are of relevance during the COVID-19 crisis. Cohen et al. (2022) found that AOT leads people to place greater trust in public health experts and that trust in experts is positively associated with high perceived risk, which positively influences compliance with experts' recommendations. They also found that AOT, as a self-directed thinking style, directly influences risk perception and, by extension, compliance.

In their study on a pandemic risk perception scale, Vieira et al. (2022) demonstrated that people considered the following three risks as dominant: emotional health, health system, and alimentary risks (of inadequate supply of food), whereas infection and financial risks (of worsening financial situation) caused less concern. The personal perceptions of risk during the COVID-19 pandemic aggregated to the societal risk perception, with important implications for public health and financial domains. Vieira et al. (2022) expressed the opinion that the aftermath of COVID-19 can "provide important insights into the psychology of risk and the best course of action that policymakers and technical experts can develop to deal with the perception of the general public."

Wong and Yang (2022) characterized risk perceptions of the COVID-19 pandemic and the COVID-19 vaccines along the dread and unknown dimensions of the psychometric paradigm. They found that dread risk was more prominent in influencing risk perception and risk mitigation behaviors. Their results indicate that differences in the way in which people perceive the pandemic versus the vaccines may contribute to vaccine hesitancy and explain the reluctance of a segment of the population to get vaccinated.

5 | LESSONS LEARNT

The COVID-19 pandemic urges us to learn many lessons at a range of spatial and temporal scales. Spatial scales of relevance range from individuals to nations to global community. Indeed, local, national, and global solutions were needed during the pandemic, continue to be needed during recovery, and will be needed further to improve preparedness for the advent of a new pandemic. There were also a range of time scales of concern, from very short-term (hours to days) to long-term (years to decades). During the pandemic, there was an urgency to deal, operationally, with an advancing virus that spread very fast.

To see the big picture, a multidisciplinary, broader context is needed. In the global supersystem, everything is connected to everything else. Human health and the natural environment are a global responsibility. There exist essential links between human health and well-being, biodiversity, and climate change (McNeely, 2021; Watson et al., 2022). There is a clear environmental dimension of emerging infectious diseases. It is important to limit direct contact between humans and wild animals because of the existence of a pool of about 700,000 viruses in birds and animals that could be transmitted to humans (Watson et al., 2022). Likewise, it is important to limit direct contact between wild and farmed animals. Spreading COVID via farming of wild species, such as wild mink, was reported (McNeely, 2021). The large pandemic propagation scheme goes from pathogen spillover at the wildlife–livestock–human nexus to human-to-human transmission—within cities, between cities, and across countries (Wu, 2021).

It may well be (Wu, 2021) that the intensification of the socioeconomic and environmental drivers explains the dynamics of the COVID pandemic and the policies adopted to mitigate the risks. There are links between increasing concentrations of people (urbanization), connectivity (increase of the number of air travel passengers), and virus spread.

Mankind should ensure that post-COVID-19 development is more equitable and more sustainable (McNeely, 2021). We should "explore policy options about how to build back better" (McNeely & Munasinghe, 2021). Many dimensions are at stake, including food security and policy implications (Chiwona-Karltun et al., 2021). Sanderson Bellamy et al. (2021) advocated for resiliency and justice of food systems that can be affected by extremes, such as climate events and the pandemic (or the superposition of them). Yet another food emergency dimension became clearly visible because of Russia's invasion of Ukraine on February 24, 2022. The pandemic occurred in places where extreme climatic events hit hard (McNeely, 2021). For COVID and floods, see Simonovic et al. (2021); for COVID, droughts, and earthquakes, see Nugroho et al. (2022). Cawthorn et al. (2021) revisited the challenges to sustainability in the context of the global crisis emanating from the virus and the drastic sanctions to contain it. Further, there is a serious risk of short-term unsustainable economic growth (Watson et al., 2022).

Slovic (1987) called for improving the communication of risk information among lay people, technical experts, and decision-makers. He urged that those who promote and regulate health and safety need to understand how people think about and respond to risk or else well-intended policies may turn out to be ineffective. Heeding this wisdom could have made a difference during the pandemic in Poland.

It is necessary to improve understanding of risk perception—people's judgments, attitudes, beliefs, and feelings that are important for rational preventive behavior as well as building an individual and collective resiliency (Samadipour et al., 2022). Ju and You (2022) demonstrated that risk perception may depend on the political orientation and the frequency of media use. It is recognized that social media has become an important strategic tool for public outreach. Armed with celebrity involvement and infographics, it can counter misinformation (Malik et al., 2021). However, social media can also disseminate misinformation (Superio et al., 2021).

Siegrist et al. (2021) identified essential factors determining the success of risk management during the COVID-19 crisis: risk perception, social trust, and the appropriate balance between health and economic concerns. Risk perception can largely differ among people. In particular, the Polish nation has been deeply divided into two large camps residing in information bubbles that do not communicate with each other. If people do not trust health authorities, they are not likely to follow recommendations. This was a big problem in Poland, where the level of public trust in the government, institutions, media, experts, and scientists was not high. Risk messages were neither clear nor consistent and were not delivered by commonly trusted sources. It was difficult for a layman to weigh multiple sources of evidence, delivering contradictory messages, to separate true and false statements, as well as concepts and misconceptions.

A comparative, 13-country (Poland not included) study of government response measures and epidemic trend characteristics (Wang et al., 2022) demonstrated a significant negative correlation between the two. As could be expected, stringent government response measures were found to curb the spread of COVID-19, limit the infections, and flatten the curve.

An adaptive (learning) management framework is needed to solve complex problems bound with deep uncertainty (Samadipour et al., 2022). In this sense, dozens of subsequent statements, issued by the multidisciplinary COVID-19 Advisory Team of the Polish Academy of Sciences, can be regarded as useful advice regarding adaptation of relevance to decision-makers. Unfortunately, their voice was not carefully heeded by the politicians.

There is an obvious need in every country to improve resilience, to be better prepared to mitigate future emergencies and the next pandemic. But first, it is necessary to subject the COVID-19 management, and in particular the implementation of the vaccination program, to an independent, critical, scrutiny, and audit.

There is no doubt that vaccine confidence should be increased, and that the public should be better educated about the value of being vaccinated (Nguyen et al., 2022). Moreover, authorities should adjust their COVID-19 communication strategies to actively influence public perceptions and public responses and to tailor the information for different audiences (de Vries et al., 2021).

Certainly, in addition to medical science, the use of risk science would be valuable in the management of the COVID-19 pandemic in Poland. Unfortunately, the concepts of risk assessment, awareness, perception, communication, mitigation, and handling were not among the competences and the priority interests of the nation, including the politicians. There is an urgent need to better inform and educate Polish people (including decision-makers) about risk and to improve critical reasoning ability.

Watson et al. (2022) urged us to rethink the use of scientific knowledge for policy-making and communication with the public. At times, there is a selective uptake of convenient scientific evidence (e.g., information that supports a predetermined position) by policymakers and decision-makers. This general observation pertains to COVID-19 and to climate change and biodiversity loss (Watson et al., 2022). In many countries, including Poland, well-thought-out specific actions were identified by the scientific community, so that, notwithstanding the uncertainties, there was no shortage of knowledge but rather a shortage of political will to act and to reduce the risk. Unfortunately, the transfer of scientific knowledge to evidence-based policies and actions in Poland has been deficient. However, it is fair to make a general statement, valid ubiquitously, that the pandemic of unprecedented size challenged risk science by demanding concrete decisions under deep and multifaceted uncertainty in a multi-objective setting.

6 | FINAL REMARKS

Countries managed the pandemic crisis with varying levels of success measured by a range of statistics, such as the numbers of COVID cases, COVID-19 deaths, and all excess all-cause deaths (Coccia, 2022; Wang et al., 2022). Cohen et al. (2022) stated that "many … infections and deaths across the United States (and elsewhere) could have been avoided through a better coordinated and science-based response," referring to the final report[2] of the Independent Panel for Pandemic Preparedness and Response. We corroborate these findings and demonstrate considerable differences in the numbers of COVID-19 deaths in EU Member States. It is likely that many deaths could have been avoided in Poland through a better science-based response and through higher vaccination rates. Development of a Polish report by an independent panel for pandemic preparedness and response would be of much use for strengthening of the national health system.

In August 2023, the Supreme Audit Office (NIK) of Poland, whose mission is independent, professional, control of public tasks in the interest of citizens and the state, published information on the results of the audit regarding the implementation of tasks financed from the COVID-19 Counteraction Fund[3] in Poland. A number of irregularities were demonstrated. For instance, NIK negatively assessed the contracting of too many COVID-19 vaccines in comparison to the needs, so that over 13.1 million vaccine doses (as at the end of 2022) were expired and then disposed of, generating the total loss of almost 1 billion PLN (approximately 227 million USD[4]). "Although the COVID-19 Counteraction Fund's resources were intended only to help mitigate the effects of the pandemic, they also became an extra budget at the disposal of the Prime Minister to finance any selected tasks," unrelated to the pandemic management. The Supreme Audit Office also noted that "there was a significant 'redirection' of health care system resources to fight the epidemic, which resulted in restrictions in access to treatment for a wide group of patients diagnosed with diseases other than COVID-19, and as a further consequence, the increase in the so-called 'health debt'." Adequate health care for many non-COVID patients could not be provided, so that their health deteriorated and many excess deaths occurred, as discussed in Section 2 of the present article.

In this article, we show that the numbers of deaths with COVID-19 and excess all-cause deaths in Poland were much higher than the EU average, except for the spring of 2020. The 8 months with the highest number of all-cause deaths in 2010–2022 in Poland were during the COVID-19 pandemic. We juxtapose the percentage of fully vaccinated population and a cumulative number of COVID-19 deaths per million people for EU Member States and demonstrate that typically higher vaccination in a country was accompanied by lower mortality in this country.

[2] https://theindependentpanel.org/mainreport
[3] https://www.nik.gov.pl/plik/id,28245,vp,31071.pdf
[4] https://www.exchangerates.org.uk/USD-PLN-spot-exchange-rates-history-2022.html

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known conflicts of interest or personal relationships that could have appeared to influence the work reported in this article.

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APPENDIX

CONTRASTING ATTITUDES OF COLLECTIVE BODIES OF EXPERTS ON THE TOPIC OF VACCINATIONS

Excerpts from "The position of the Team of Experts on Bioethics of the Polish Episcopal Conference on vaccines," dated December 23, 2020 (reference Team of Experts on Bioethics of the Polish Episcopal Conference, 2020):

> ''The ethical dimension of vaccine production
>
> 11. Among many people, some biotechnological elements of vaccine production also arouse moral resistance. The source of legitimate opposition is the use in their production of cell lines made from aborted fetal.''
>
> "15. … [A]nyone, including a Catholic, can benefit from vaccines, even those developed using aborted fetal cell lines, unless other vaccines are available that do not raise such objections."
>
> "19. … [I]t should be noted that vaccination is not the only way to obtain immunity to infection with the SARS-CoV-2 virus. It is also obtained naturally by the production of antibodies by the body of the cured person. Therefore, the team encourages recovered patients to donate plasma containing antibodies. It can support the treatment of the sick."
>
> "21. Justified doubts … justify the refusal to vaccinate oneself or children."

Excerpts from three statements of the Advisory Council for COVID-19 at the President of the Polish Academy of Sciences, # 7, 26 and 28 (references: COVID-19 Advisory Team of the Polish Academy of Sciences, 2020, 2021, 2022a):

Statement No. 7 of December 15, 2020 (reference COVID-19 Advisory Team of the Polish Academy of Sciences, 2020*)*:

> "Vaccination is the only rational choice which will help us emerge from the pandemic, save the lives and health of countless people and limit the damage already inflicted on the economy."

Statement No. 26 of December 8, 2021 (reference COVID-19 Advisory Team of the Polish Academy of Sciences, 2021):

> ''Our health in the time of an epidemic largely depends on our behavior—the decisions made by government officials and people's readiness to comply with restrictions.
>
> Our country is now seeing several hundred deaths a day, and yet many people in Poland do not follow even the basic recommendations regarding mask-wearing, social distancing, disinfection, and ventilation. Almost half of those eligible for vaccination have not been vaccinated, despite the fact that vaccines are effective and widely accessible. The reasons for this situation include insufficient state involvement in the fight against the pandemic and contradictory messages sent out by government officials on such topics as vaccination.
>
> From an epidemiological perspective, government inaction should be considered reprehensible, given that the Poles took a serious approach to the pandemic at the beginning of 2020, and decision-makers were given a considerable dose of public trust and the time to implement adequate solutions. However, this time was wasted, and the public trust was exhausted. The practical absence of the state in the fight against the pandemic and failure to implement a policy of restrictions against unvaccinated individuals is probably a result of political calculations.''

Statement No. 28 of February 2, 2022 (reference COVID-19 Advisory Team of the Polish Academy of Sciences, 2022a):

> "It is high time to stop thinking that we still do not know much about SARS-CoV-2 or vaccines. COVID-19 is one of the best-studied infectious diseases in the history of medicine, and the vaccine against this disease is the best-studied vaccine in the history of vaccination. However, what is apparently lacking is sufficient will on the part of those in power to combat the COVID-19 epidemic … People's freedom to make irrational choices that contradict scientific opinions ends at the point when they start threatening the health and lives of their fellow citizens … We also know that the risk of death for vaccinated and recovered people is many times lower, even if they are not fully protected from infection and the disease."