

# EFFECTIVENESS OF COVID-19 VACCINATION IN POLAND

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## Main message

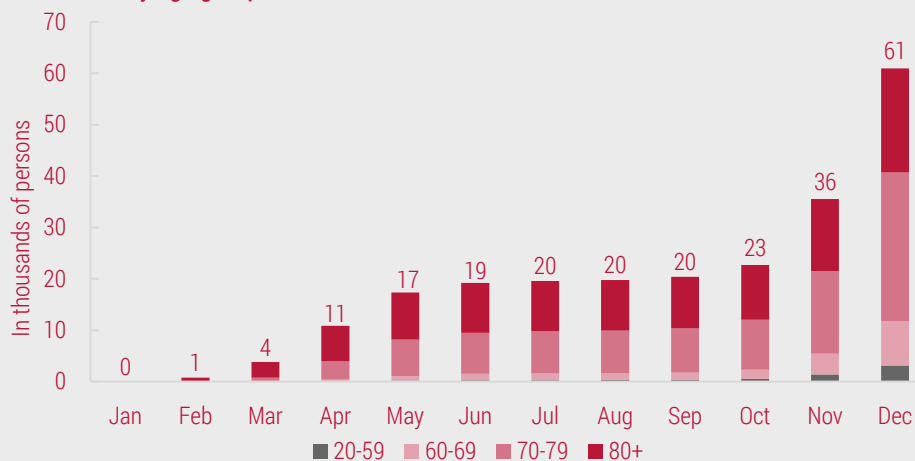
COVID-19 vaccines have proven highly effective in protecting against serious disease and death. Yet despite their introduction, Poland's COVID-19 mortality rate remains high. This results from Poland's lower vaccination rate compared to other EU countries – especially among people aged 70 or more who are at the highest risk from COVID-19. Over one million Poles aged 70+ remain unvaccinated, and they account for the majority of deaths from COVID-19.

Vaccinations halved the number of COVID-19 deaths in Poland in 2021 as compared to what would happen if a vaccine would not be available. People aged 70 and over made up the vast majority of prevented deaths. Vaccinating people aged 70+ is a much more effective method of lowering COVID-19 mortality rates than vaccinating people of working age. Increasing vaccination rates in the former age group would noticeably lower COVID-19 mortality in Poland. However, this would require an intensification of support efforts on a local level, including providing the elderly with comprehensive assistance in the vaccination process.

## Facts and figures

- **85 – 90%** – vaccine efficacy in preventing death due to COVID-19 in people aged under 80 in Poland. 80% among those aged 80 years or more
- **61,000** – number of COVID-19 patients saved from death thanks to vaccinations in 2021; 58,000 are over the age of 60
- **129,000** – estimated number of deaths attributed to COVID-19 in 2021 if not for the vaccine
- **Over 1 million** people over the age of 70 remain unvaccinated
- **114 people** aged 80+ need to be vaccinated to save one person from death from COVID-19. Among people aged 70–79, this figure rises to 162
- **11,000 people** – this is how many people aged 25–49 need to be vaccinated to save a single person from a fatal COVID-19 contraction.

**Cumulative number of people who avoided COVID-19 death thanks to vaccination in Poland in 2021, by age group**



Source: own study based on data by Centrum e-Zdrowia (CeZ), Statistics Poland (GUS) and Our World in Data.

# 1. Introduction

The COVID-19 pandemic is the most serious pandemic that the world has faced in the last century. Despite efforts to implement a number of preventive measures, as well as limitations on social interactions, a total of over 1.3 million cases and almost 29,000 deaths were identified in Poland between March 2020 and the end of that year. The availability of COVID-19 vaccines marked a milestone in the fight against the SARS-COV-2 virus. In Poland, widespread vaccination efforts began in the second half of January 2021 with people aged over 80 prioritised. Gradually, more age groups were included in the programme based on vaccination levels of groups already eligible for vaccination and the availability of various COVID-19 vaccines. By the end of 2021, almost 20 million adult people had been vaccinated in Poland. However, vaccination rates – especially among the elderly who are at the highest risk of fatally contracting COVID-19 – remain lower than in many EU countries. As a result, COVID-19 mortality rates remain alarmingly high in Poland.

The aim of this paper is to evaluate the effectiveness of COVID-19 vaccination in preventing death and infection in Poland in 2021. We account for the varying levels of COVID-19 infection and mortality risks depending on age which is a key risk factor for COVID-19 patients. Based on our analysis, we indicate how administering vaccinations to different age groups in 2022 could effectively reduce COVID-19 mortality rates in Poland.

We find that the efficacy of COVID-19 vaccines in preventing death remains high (85–90%); even in the fall, when viral infectivity and spread rises due to seasonality. We calculate that an unvaccinated person has a 7 to 10 times greater risk of death from COVID-19 than a person at the same age who has been vaccinated. This efficacy drops to 80% among people aged over 80. Taking these mortality risk differences into account, we estimate that the availability of COVID-19 vaccines in Poland prevented 61,000 additional deaths, mainly among people over 60 years of age. Were it not for the vaccination programme, the total number of COVID-19 deaths in Poland in 2021 would be nearly twice as high, reaching 129,000. Meanwhile, the efficacy of COVID-19 vaccines in preventing infection has declined over time, especially among people of working age. This means that vaccinations protect against the development of serious health problems and death to a much greater extent than against infection as such.

Public policy should prioritise reaching out to unvaccinated senior citizens. The risk of a fatal COVID-19 infection increases significantly with age, but vaccine efficacy in preventing death remains high across all age groups. Meanwhile, at the end of 2021, over one million people aged over 70 in Poland remained unvaccinated. To save one person from a fatal COVID-19 infection, it is enough to vaccinate:

- 114 people aged 80 or more; or 162 people aged 70–79, or
- over 2,000 people aged 50–59; or almost 11,000 people aged 24–49.

Low vaccine uptake among the elderly probably results from a lack of awareness, as well as challenges related to the registration process and getting to a vaccination centre rather than due to personal reasons or beliefs. In Poland, over 70% of people aged 70+ have health problems that impair their daily living, 50% live alone or with other elderly persons, and 35% have no access to the internet. There is an urgent need for local-level efforts to provide comprehensive assistance in vaccine registration and administration among the elderly.

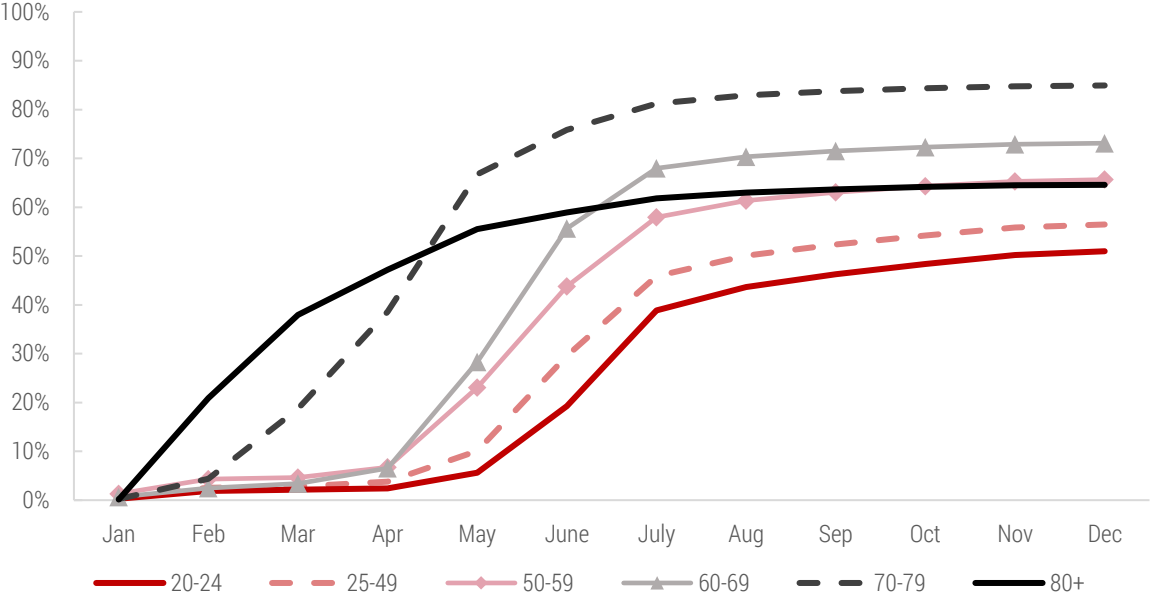
In Section 2, we provide data on infection, mortality, and vaccination rates. In Section 3 we calculate the efficacy of the vaccine in preventing death and infection, and in Section 4 we estimate the number of deaths prevented thanks to the vaccine. In Section 5 we examine which groups should be vaccinated first to reduce COVID-19 mortality the most, and in Section 6 we summarize our results and suggest policy implications.

## 2. Key data on COVID-19 infections, mortality and vaccinations in Poland

To calculate the efficacy of COVID-19 vaccinations at a population level, we use data on the number of COVID-19 infections and deaths provided by Centrum e-Zdrowia (CeZ, 2022), data on population by age group from the Local Data Bank (BDL, 2022) and data on the share of people vaccinated by age group from Our World in Data (2022). We analyse the period between the beginning of February and the end of December 2021.

The highest vaccination rate in Poland was achieved in the 70–79 age group, standing at 85% in December 2021 (Figure 1). However, this was noticeably below the vaccination rates in many other Western European countries, such as Austria (87%), Belgium (97%), France (98%) and Spain (99%), as well as some of Central Eastern European countries, such as Hungary (88%) or the Czech Republic (93%).<sup>1</sup> People aged 60–69 were the group with the second-highest vaccination rate (73%), while only 65% of people aged 50–59 and over 80 were vaccinated as of December 2021. In the case of the oldest age group, 80 years or more, the vaccination rate in Poland is also one of the lowest in Europe. Only Bulgaria (24%) and Romania (26%) vaccination rates in this age group are lower. Many other EU countries have much higher vaccination rates among people age 80 or more years, as demonstrated in e.g. Hungary (77%), France (88%) or the Czech Republic (92%). In countries such as Spain, Denmark and Austria nearly 100% of people aged over 80 have been vaccinated by the end of 2021. Between February and July 2021, over a million people aged 80+ were vaccinated in Poland. However, in the second half of that year, vaccine uptake in this age group increased by only 40,000 people. In younger age groups, vaccination rates are clearly lower – in December 2021, 56% of people aged 25–49 and 50% of people aged 20–24 had been vaccinated. Overall, vaccination levels in Poland remain relatively low when compared to other European countries.

**Figure 1. Share of fully vaccinated people by age group in Poland, 2021**

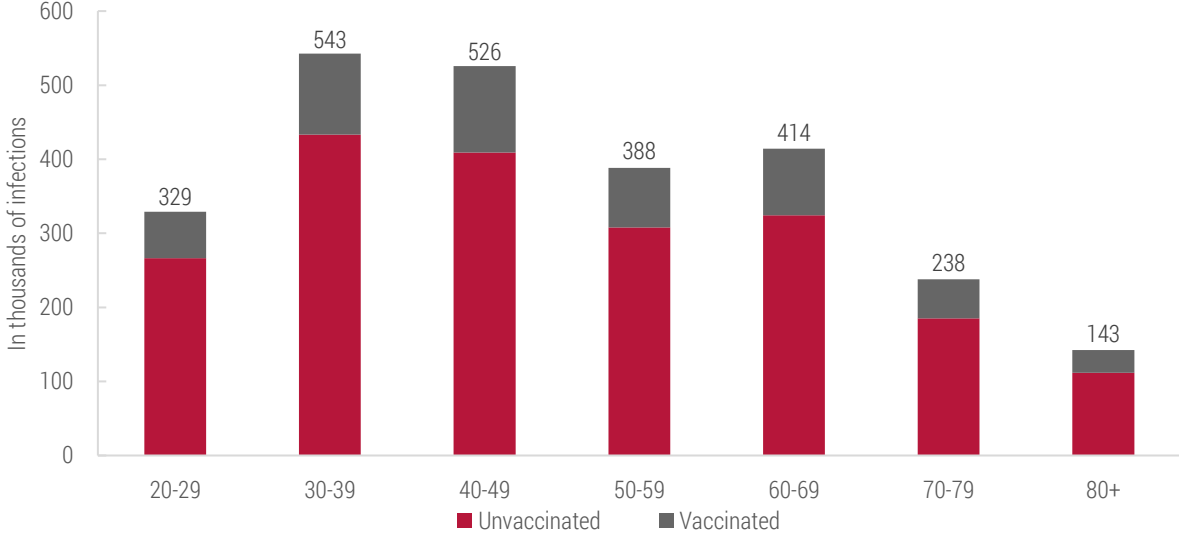


Source: own elaboration based on data by Our World in Data.

<sup>1</sup> Data for Bulgaria and Romania refer to November 26, 2021, for Belgium, France, Slovakia and Hungary – to December 3, 2021, for the Czech Republic – to January 7, 2022. For remaining countries, data refer to December 31, 2021.

The total number of SARS-COV2 infections in Poland reached 2.5 million in 2021, with 79% of these cases among unvaccinated persons (Figure 2). Most often, COVID-19 infections were identified in people aged 30–39 and 40–49 (over 1 million cases). Together, these age groups account for about 41% of all recorded infections. The total number of infections among people aged 50–59 and 60–69 was 802,000 (31% of cases). The lowest number of COVID-19 infections was detected among people over 80 years of age (143,000, 6% of all cases).

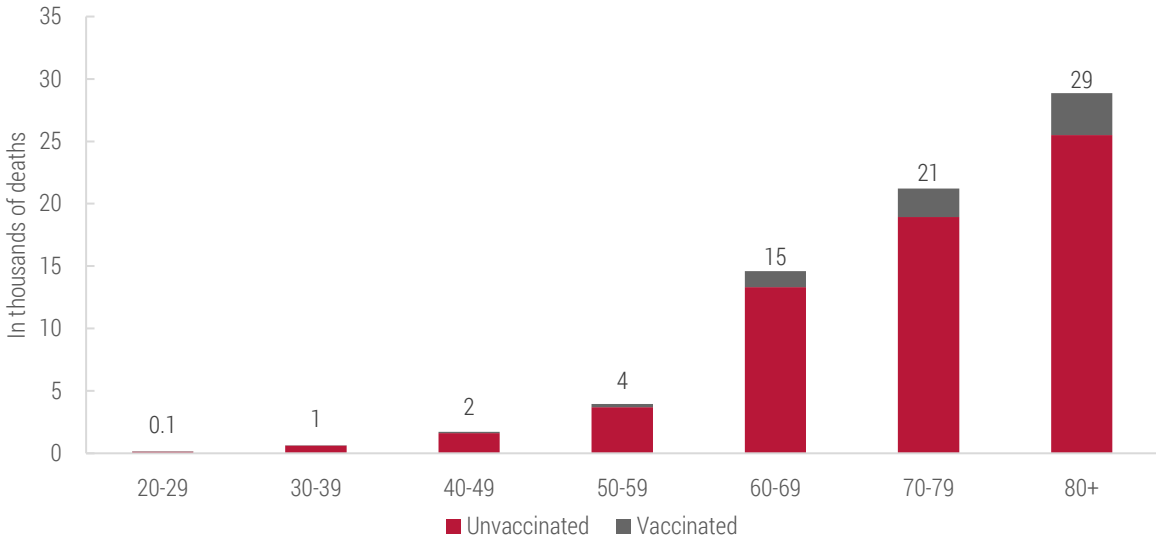
**Figure 2. Total COVID-19 infections by age group and vaccination status in Poland, 2021**



Source: own elaboration based on data by Centrum e-Zdrowia (CeZ).

The distribution of COVID-19 deaths by age is much different than the distribution of infections. The number of deaths is substantially higher in older age groups than among people of working age (Figure 3). This confirms that age is a key factor when assessing the risk of a severe COVID-19 infection or death (O'Driscoll et al., 2020). In 2021, 91% of all deaths from COVID-19 in Poland occurred among people aged over 60, who accounted for only 31% of cases. Most deaths – 29,000 (41% of all deaths) – were recorded among people over 80 years of age.

**Figure 3. Total COVID-19 deaths by age group and vaccination status in Poland, 2021**



Source: own elaboration based on data by Centrum e-Zdrowia (CeZ).

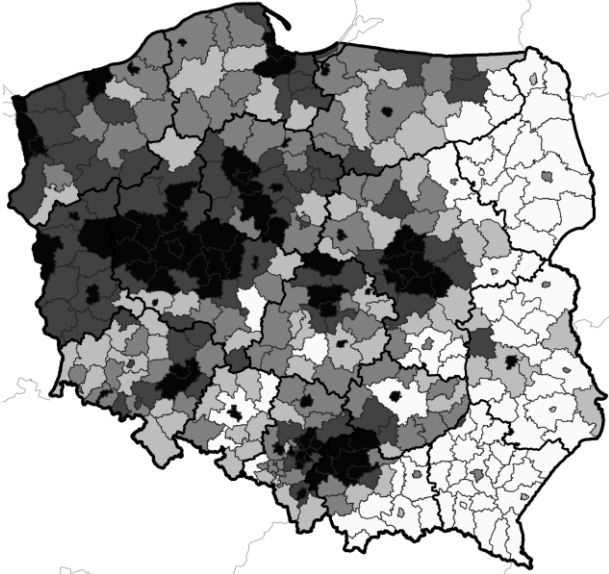
The launch of a vaccination programme resulted in a change of the spatial distribution of COVID-19 cases in Poland. At the end of 2021, the lowest vaccination rates (less than 48% of the overall population have received full vaccination treatment i.e. two doses) were observed in the country's eastern provinces – Podlaskie, Lubelskie, Świętokrzyskie – as well as in the southern part of the Małopolskie Province and part of the Opolskie Province (Map 1). The same areas saw higher COVID-19 mortality rates between the so-called third (March – May 2021) and fourth wave (October – December 2021, Map 2). Meanwhile, areas with higher vaccination rates – including larger cities in the Greater Poland and Lower Silesia Provinces – saw lower COVID-19 mortality in the fall than in the spring of 2021. There is a strong negative correlation (-0.41) across all poviats (NUTS-4 units) between vaccination rates measured at the end of 2021 and COVID-19 mortality rates between the 3<sup>rd</sup> and 4<sup>th</sup> waves (2021).

**Map 3. Share of people fully vaccinated (two doses) against COVID-19 in Poland by poviat.**

Share of people who received two doses of COVID-19 vaccine

- 57.5% - 72.7%
- 54.2% - 57.5%
- 51.8% - 54.2%
- 48.0% - 51.8%
- 30.1% - 48.0%

Data as at 14 January 2022.



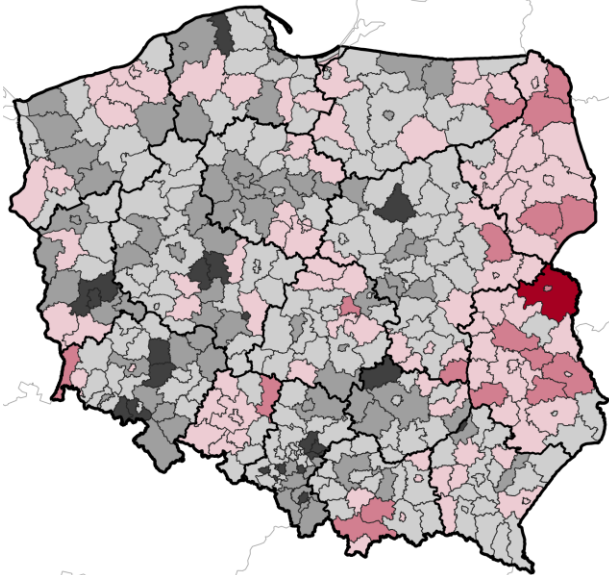
Notes: each category contains an identical number of poviats.  
 Source: own elaboration based on data from GOV.PL and BDL GUS.

**Map 4. Number of deaths from COVID-19 in the so-called fourth wave (October-December 2021) in relation to the number of deaths in the so-called third wave (March-May 2021) in Poland by poviat.**

Number of COVID-19-related deaths during the 4th wave in PL (X-XII 2021)

Reference period: 3rd wave (III-V 2021)

- more than 3x
- more than 2x
- up to 2x more
- up to 2x less
- less than 2x
- less than 3x



Notes: each category contains an identical number of poviats.  
 Source: own elaboration based on data from Centrum e-Zdrowia (CeZ) and BDL GUS.

## Box 1. Methodology

The key to accurately estimating COVID-19 vaccine efficacy is to take into account the age of the patients, which is the crucial risk factor (O'Driscoll et al., 2020). Consequently, efficacy should be analysed for individual age groups, comparing the risk of infection and death in a vaccinated and unvaccinated population of the same age. Given the data available, we analysed vaccine efficacy for the following six age groups: 20–24; 25–49; 50–59; 60–69; 70–79, and 80 and above. Due to an insufficient number of observations, we were unable to estimate vaccine efficacy in the 20–24 age bracket; in 2021, only 33 people in that group died of COVID-19, of whom 32 were unvaccinated and 1 was vaccinated.

To estimate vaccine efficacy against infection and death, we employed a standard methodology (Greenwood and Yule, 1915; Weinberg and Szilagyi, 2010). Vaccine efficacy is given by the following formula:

$$Efficacy (infection)_{t,a} = 1 - \frac{P(infection|vaccinated)}{P(infection|unvaccinated)}$$
$$Efficacy (death)_{t,a} = 1 - \frac{P(death|vaccinated)}{P(death|unvaccinated)}$$

where  $P(infection|vaccinated)$  means the probability of infection if vaccinated and  $P(infection|unvaccinated)$  the probability of infection if unvaccinated, in month  $t$  and age group  $a$ . Corresponding symbols apply to conditional probabilities of death.

The probability of infection or death in month  $t$  and age group  $a$  was estimated as the share of COVID-19 infections or deaths in a given age group, conditional on vaccination status. We defined vaccinated people as those who received a full dose of a COVID-19 vaccine (one dose of the Johnson & Johnson vaccine, or two doses of another vaccine).

The number of people who would have died if they had not been vaccinated against COVID-19 was estimated according to the following formula:

$$Avoided\ deaths_{t,a} = Vaccinated\ people_{t,a} * [P(death|unvaccinated\ person) - P(death|vaccinated\ person)]$$

We calculated the difference between the risk of death for unvaccinated and vaccinated people and multiplied it by the number of people vaccinated in month  $t$  and age group  $a$ . To estimate the number of vaccinated and unvaccinated people, we based our calculations on population size in 2020 (Local Data Bank, BDL) in a given age group and multiplied it by the percentage of the vaccinated population (Our World in Data).

The number of people who need to be vaccinated in age group  $a$  to avoid an excess death (*Number Needed to be Vaccinated*, NNV, Larkin and Waitzkin (2021)) was estimated according to the following formula:

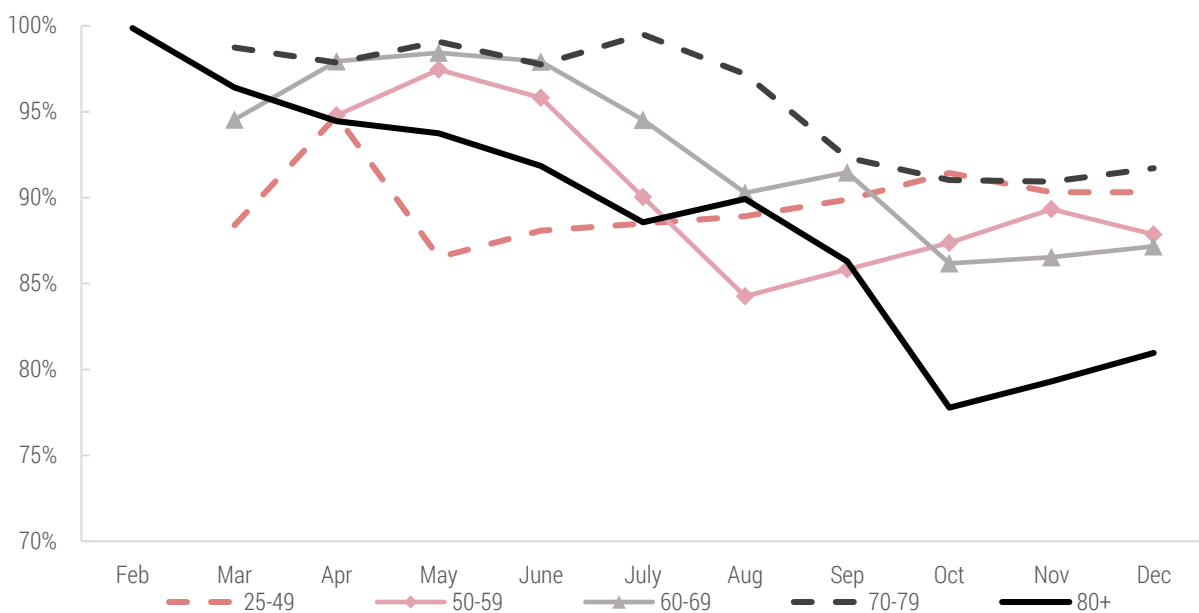
$$NNV_{t,a} = \frac{Efficacy (death)_{t,a}}{P(death|unvaccinated)}$$

Since the widespread vaccination programme began in mid-January, we analysed the period between February and December 2021. To calculate  $NNV_{t,a}$ , we used data for December 2021.

### 3. COVID-19 vaccine efficacy against infections and deaths

Vaccine efficacy against COVID-19 death has remained high but it changed depending on the phase of the pandemic. In the summer, when risks of infection are lower, vaccine efficacy was higher and ranged from 90% to nearly 100% depending on age group (Figure 4). In the autumn, when the virus spread more rapidly due to seasonality (Liu et al., 2021), efficacy declined slightly but still remained high at 85–90%. In other words, the risk of death of an unvaccinated person compared to a vaccinated person is 7 to 10 times greater.<sup>2</sup> In people aged over 80, who because of their age are at a greater risk of comorbidities than younger people, efficacy against death amount to about 80% by the end of 2021. Hence, the risk of death for an unvaccinated person in that age group was five times greater than that of an unvaccinated person.

**Figure 4. Vaccine efficacy in Poland: preventing deaths from COVID-19, by age group, 2021.**



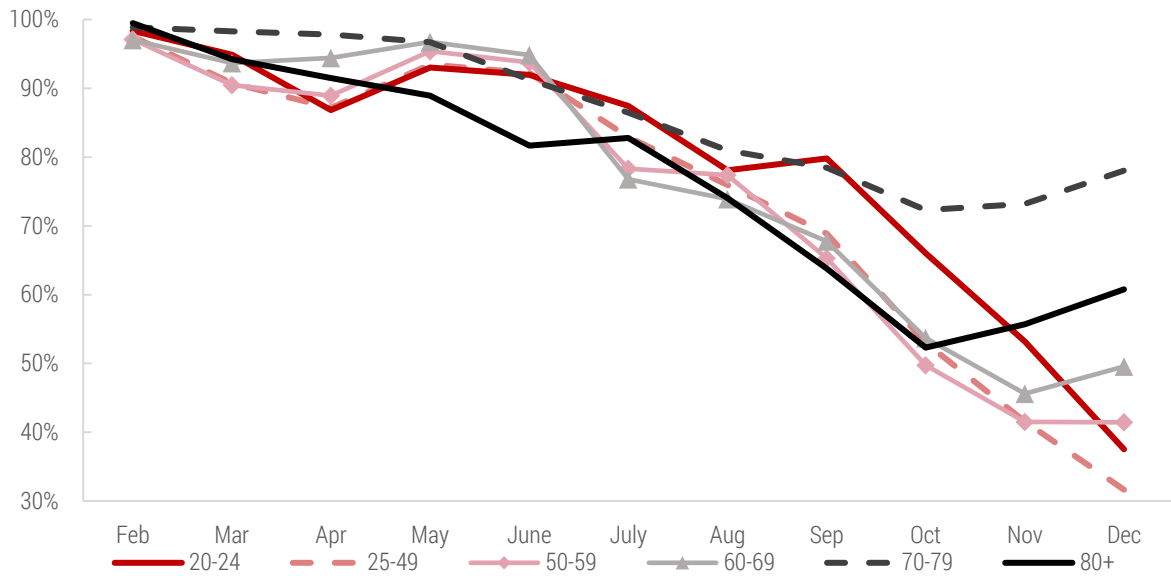
Source: own calculations based on data by Centrum e-Zdrowia (CeZ), Statistics Poland (GUS) and Our World in Data.

With time, vaccine efficacy against COVID-19 infection has declined (Figure 5). The fastest decline occurred in the fall, when the overall number of cases was on the rise, especially in the younger age brackets (20–24 and 25–49). This means that is the continued high protective efficacy against severe illness and death constitutes the key benefit from vaccination. A decline in protective efficacy against infection may stem from three effects.

- First, protection against infection at an individual level may decrease over time and as antibody levels wane (Dolgin, 2021; Goldberg et al., 2021). An assessment of this effect lies beyond our area of expertise. Furthermore, it would be impossible to assess based on the data available in Poland.
- Second, over time, a greater number of unvaccinated people acquire immunity through infection (Greenwood and Yule, 1915; Weinberg and Szilagyi, 2010). As a result, the difference in risk between the vaccinated and unvaccinated population narrows even if vaccine efficacy at an individual level is constant.
- Third, vaccinated people may engage in more active social interactions than if they were unvaccinated, which exposes them to a greater risk of infection.

<sup>2</sup> The risk in the entire population, not in patients.

Figure 5. Vaccine efficacy in Poland: preventing COVID-19 infection, by age group, 2021.



Source: own calculations based on data by Centrum e-Zdrowia (CeZ), Statistics Poland (GUS) and Our World in Data.

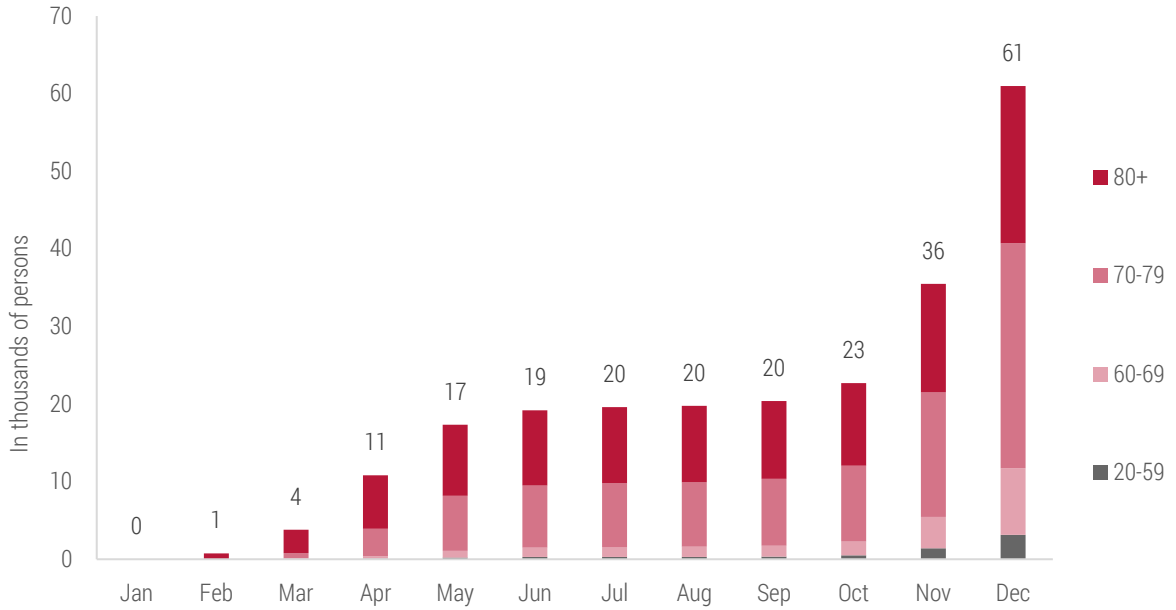
#### 4. The number of lives saved by COVID-19 vaccination

We estimate that the rollout of COVID-19 vaccination in Poland prevented about 61,000 deaths in 2021 (Figure 6). People saved from death by COVID-19 are mostly above 60 years of age (approximately 95% of all patients saved), with the average risk of death in vaccinated people in that age group being over 8 times lower than in unvaccinated people (in December 2021). The impact of vaccinations was visible already in April, at the peak of the spring wave of infections, when the number of deaths prevented reached 11,000. However, the greatest effect of the vaccination was visible during the autumn wave (when the vaccination rate in adult population reached 54%). Vaccinations saved 25,000 lives in December alone and 13,000 in November (Figure 6).

Without vaccines, the total number of COVID-19 deaths in Poland in 2021 would have nearly doubled to approximately 129,000. The total number of COVID-19 deaths in 2021 was approximately 68,000 (Figure 7), of whom 44,000 (65%) occurred during the spring wave (from January until May, when the population vaccination rate was approximately 18%). Of the 44,000 people who died during the spring wave of the pandemic, 98% were unvaccinated. During the autumn wave (October–December), 22,000 people died, of whom 73% were unvaccinated.



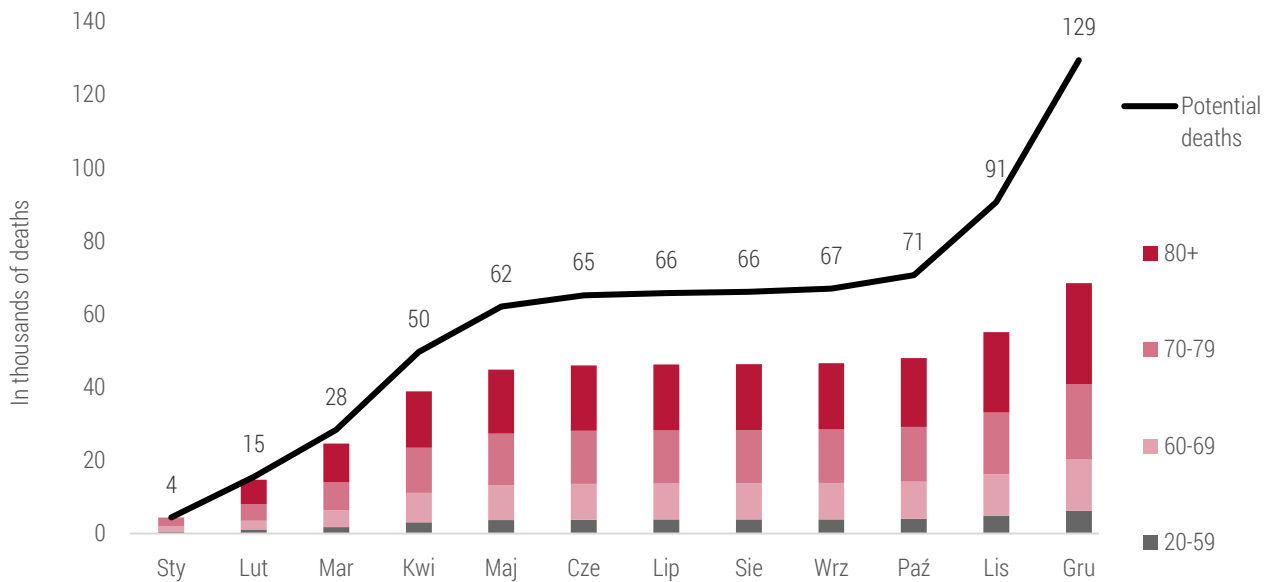
**Figure 6. Cumulative number of people who avoided COVID-19 death thanks to vaccination in Poland in 2021, by age group.**



Notes: To calculate the number of deaths avoided in December (25,000), the cumulative number of deaths avoided until November (36,000) should be subtracted from the cumulative number of deaths avoided until December (61,000); correspondingly, to calculate the number of deaths avoided in November (13,000), the cumulative number of deaths avoided until October (23,000) should be subtracted from the cumulative number of deaths avoided until November (36,000).

Source: own calculations based on data by Centrum e-Zdrowia (CeZ), Statistics Poland (GUS) and Our World in Data.

**Figure 7. Cumulative number of COVID-19 deaths by age group and the potential cumulative number of COVID-19 deaths if SARS-COV2 vaccines had not existed.**



Source: own calculations based on data by Centrum e-Zdrowia (CeZ), Statistics Poland (GUS) and Our World in Data.

## Box 2. Methodological remarks

To estimate the number of people who would have died if they had not been vaccinated against COVID-19, we made three assumptions that were necessary due to the nature of the data available.

First, we assumed that the structure of risk factors in vaccinated and unvaccinated people was the same before and after a vaccine was administered. In the general population, an average unvaccinated person enjoys better health than the vaccinated population due to their age; elderly people, who are more likely to be vaccinated, generally have poorer health than younger people who are less likely to be vaccinated. At the same time, the situation in individual age groups may be the opposite: if people who are vaccinated more often are more affluent and live in cities, vaccinated people may enjoy better health than unvaccinated people of their age.

Second, vaccinated people may engage in more intense social interactions, which in turn increase their exposure to infection compared to if they had not been vaccinated. However, their interactions are not necessarily more intense compared to unvaccinated people, especially if the decision not to receive a vaccine is associated with a lower fear of infection.

Third, we assumed that the probability of medical treatment in the event of a COVID-19 infection is identical for the vaccinated and unvaccinated populations. People who avoid vaccination may also disregard symptoms associated with COVID-19 infection, which may increase the risk of severe illness and death. Also, unvaccinated people are more likely to live in rural areas and may also have worse access to health care, especially intensive care, than the urban population, which is more likely to be vaccinated.

Finally, we estimate the direct effect of vaccinations. We do not estimate indirect effects, e.g. related to the fact that vaccinations reduced the number of seriously ill patients with COVID-19, which in turn reduced the risk of lack of places in intensive care units.

## 5. Who should be vaccinated first to reduce the COVID-19 mortality in Poland?

Stepping up the vaccination uptake among the elderly can visibly reduce the COVID-19 mortality rate in Poland. A measure which helps to identify what vaccine allocation scheme could bring the greatest benefits in terms of reducing mortality is the number of people who need to be vaccinated in a given group to avoid a single extra death.

Prioritising vaccination of the elderly would unquestionably save the highest number of patients. We estimate<sup>3</sup> that in order to save one person from COVID-19 death, the following number of people need to be vaccinated (Figure 8):

- 114 people aged 80 years or more,
- 162 people aged 70–79 years,
- over 630 people aged 60–69 years,
- over 2,000 people aged 50–59 years,
- nearly 11,000 people aged 25–49 years.

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<sup>3</sup> Based on the risk of death in unvaccinated people and vaccine efficacy in December 2021.

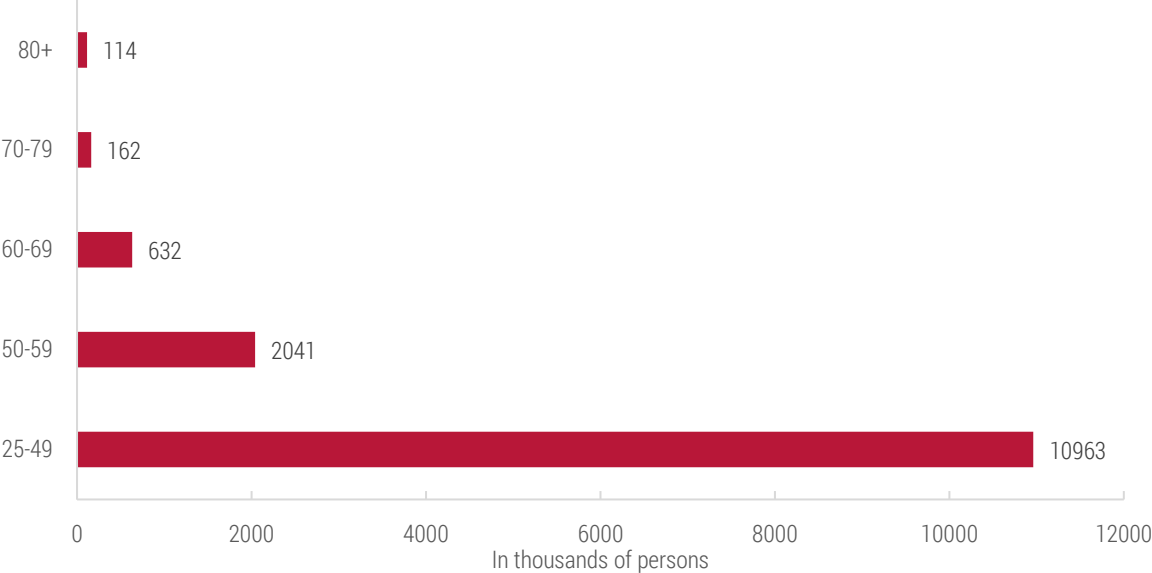
The fewer people need to be vaccinated to save a single person, the easier it is to implement a vaccination campaign and achieve a measurable result in the form of lower mortality for given resources committed.

The COVID-19 mortality rate in Poland would be reduced the most by stepping up the vaccination drive in people aged over 70, as opposed to vaccinating younger people (aged 25–49). Vaccinating a given number of people aged over 70 would reduce the number of deaths by 70 to 100 times more than vaccinating the same number of people aged 25–49, and approximately 15 times more than vaccinating the same number of people aged 50–59. At the same time, the number of unvaccinated people aged over 70 at the end of 2021 exceeded 1 million (Table 1).

Considering the limited capabilities of the healthcare system in terms of widespread vaccination drive, and assuming it could vaccinate 100,000 people a week, within 10 weeks it would be possible to vaccinate:

- all (1 million) people aged over 70 and save approximately 8,000 patients in two months,<sup>4</sup> or
- 1 million people aged 25–49 (approximately 15% of the unvaccinated population in that age group) and save only 91 lives in two months.

**Figure 8. Estimated number of people who need to be vaccinated to avoid a single excess COVID-19 death (NNV) in Poland, by age group.**



Source: own calculations based on data by Centrum e-Zdrowia (CeZ), Statistics Poland (GUS) and Our World in Data.

**Table 1. Estimated number of unvaccinated people in Poland, by age group, as of December 2021**

Age group	20–59	50–59	60–69	70–79	80+
Number of people (thousands)	6,190	1,582	1,394	442	596
Share in age group (%)	44%	34%	27%	15%	35%

Source: own calculations based on data by Statistics Poland (GUS) and Our World in Data.

<sup>4</sup> We assumed that the course of the pandemic and risks of infection in the first quarter of 2022 would be the same as in December 2021.

## 6. Summary and conclusions for public policy

The arrival of widely available COVID-19 vaccines marked a milestone in the fight against the COVID-19 pandemic. With the vaccination campaign initiated in Poland in January 2021, about 20 million adults were vaccinated until the end of the year. Nonetheless, many remained unvaccinated, especially in eastern Poland, rural areas and remote locations away from main metropolitan areas. With vaccine efficacy against COVID-19 death remaining high across all age groups, vaccines saved more than 60,000 lives in 2021, mostly elderly people. Without vaccinations, the number of COVID-19 deaths in 2021 in Poland would have been twice as high. At the same time, vaccine efficacy against infection decreased. This means that unvaccinated people are poorly protected by others' vaccinations, and the main benefit of COVID-19 vaccinations is individual – it greatly reduces the risk of severe illness and death and moderately reduces the risk of infection. The spread of the Omicron variant is likely to amplify this effect. In the case of Omicron, the risk of infection is higher in both people who had COVID-19 in the past and those who are fully vaccinated, although vaccine efficacy against severe illness and death remains high (Shrestha et al., 2022).

The COVID-19 mortality rate in Poland remains high because the vaccination rate in elderly people, who face the highest risk associated with COVID-19, is lower than in most other EU countries. Without raising vaccination rates amongst the elderly, the COVID-19 mortality rate in Poland will continue to be high. Stepping up the vaccination campaign, particularly making it a priority to reach, support and convince senior citizens to get vaccinated, may bring greater benefits in terms of the number of lives saved than raising the vaccination rate among young or prime-aged people. A vaccination programme focused on people aged 70 or more could reduce the number of COVID-19 deaths several times more than a vaccination programme focused on people aged 25–49.

At the same time, it will be more difficult to reach the unvaccinated elderly with vaccines than it was in the first half of 2021. It can be assumed that elderly people who remain unvaccinated have issues with mobility or vaccine registration, have no family members who could help them, live far from vaccination sites, or in communities that show distrust of vaccination. In Poland, 50% of people aged 70 or more (2.3 million people) live or with another person aged 70 plus. Over 70% of people aged 70-79 and over 80% of people aged 80 or more have health problems that may hinder their daily activities (Kotowska, Chłoń-Domińczak, and Holzer-Żelażewska 2019). 44% of people aged 70 or more live in a household without a smartphone, and 35% – with no internet access.<sup>5</sup> Reaching those people requires building trust and local action, engaging healthcare professionals, social workers and local leaders, and taking into account people's attitudes without stigmatising their fears and lack of knowledge (Brunson et al., 2021). Literature has stressed the need for simple and honest communication, addressing unvaccinated people's doubts, and highlighting the individual benefits of vaccination and risks of infection (Lindholt et al., 2021). It should also be noted that the so-called COVID verification bill, which would allow employers to verify the vaccination status of their employees, would have no impact on vaccination rates in high-risk groups who are of retirement age.

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<sup>5</sup> Among people aged less than 70 years in Poland, only 10% have no smartphone in their household, and 5% have no access to internet (Household Budget Survey data).

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