

Big Data Analysis Suggests COVID Vaccination Increases Excess Mortality Of Highly Vaccinated North Temperate Zone and North Frigid Zone Countries

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Abstract : COVID vaccines were reported to be effective for reducing COVID infection, hospitalization, mortality rate and as a result, suppressing excess mortality during the pandemic period. However, since they were developed in limited period of time and didn't complete the regular drug-approval process, there is high uncertainty on long-term side effects. Serious long-term side effects will increase the non-COVID mortality rate, which may leads to increasing excess mortality. Therefore, whether the COVID vaccines could reduce or increase excess mortality in both short term and long term needs to be studied. In this study, relationships between Vaccination Amount of Post-Vaccination Period(VA-PVP) and excess mortality are evaluated. Other factors that affect global excess mortality like COVID death, potential post-COVID sequelae effect related factors and pull-forward effect(PFE) are also discussed to make sure the relationship between VA-PVP and excess mortality is exclusive. Multiple Linear Regression(MLR) model is used to evaluate the relationships between these factors and excess mortality. Data of highly vaccinated 29 north temperate zone and north frigid countries representing 1.19 billion population are used in the models, which is the largest dataset as far as we know. The result clearly shows that COVID vaccination increases excess mortality in post-vaccination periods and the effect keeps increasing. Furthermore, according to our model, the excess mortality caused by COVID vaccination is higher than COVID itself. The massive vaccination campaign is proven to be a huge mistake and should be stopped immediately.

Keywords: COVID vaccine, COVID vaccination, excess mortality, linear regression model, post-vaccination periods, pull-forward effect

1. Introduction

1.1 COVID-19 pandemic and COVID vaccines

SARS-CoV-2 virus emerged in 2019 and caused a global pandemic named COVID-19 as a result of its high infectiousness[1]. Until Jan. 2024, over 6.96 million death has been confirmed all over the world[2]. COVID vaccines were approved for emergency use since Dec. 2020[3] and were the first officially admitted solution for the pandemic. They were reported to be effective for reducing infection, hospitalization and mortality[4].

1.2 Concerns on COVID vaccine side effects

Since the COVID vaccines are developed within less than one year, there are concerns on how the mid-term and long-term side effects will affect human health. Among all types of COVID vaccines, generating or containing partial or whole length spike proteins of the virus is the key goal[5][6], or anti-spike antibodies play a key role in their immunity mechanism[7]. However, it is soon proved that SARS-CoV-2 spike protein alone can cause disease[8]. And the review paper [9] summarized multiple studies and concluded "the spike protein on its own can recapitulate key aspects of the pathogenesis observed following infection with SARS-CoV-2". These studies provide a theoretical basis for concerns about the side effects of all current COVID vaccines. It is possible that taking spike protein to avoid damage by SARS-CoV-2 virus could actually result in more similar negative effects. In paper[10], it was already demonstrated that COVID vaccines could cause comparative or even more myocarditis than COVID infection in under 40 age group. Furthermore, the

paper[11] using a large dataset covering 99 million population shows that, the risk of myocarditis and pericarditis of vaccinated group is 1.19~6.91 times that of the unvaccinated group. Besides other long term side effects, it is also possible the vaccinated population could have higher COVID mortality risk than that of the unvaccinated in the long run. It is shown that the 2 dose and 3 dose vaccinated population are having higher infection risk than that of the unvaccinated population several months after vaccination[12-15]. Data in [12] shows effectiveness of 2 dose vaccination turns negative after 9 months during dominance of Delta variant. Data in [13-15] show effectiveness of 2 dose and 3 dose vaccination turns negative after 5~7 months during dominance of Omicron variant. Data in [16] shows effectiveness of 1 dose Pfizer BNT162b2 vaccine turned negative after 5~6 months in children no matter with or without previous infection. Furthermore, the study[17] based on 51,017 employees from Cleveland Clinic has shown the correlation that the more dose vaccinated, the higher infection rate. Negative effectiveness against infection is a bad side effect which is not expected. This negative effect occurs several months after vaccination, which strengthens the concern that other side effects would also occur in long term. Serious long term fatal side effects could possibly cause excess mortality. To verify this, the relationship between effect in each post-vaccination period and excess mortality need to be studied among worldwide countries. In our previous study[18], it was shown that later Time Periods After Vaccination Initiation(TPAVIs) positively correlate with excess mortality. However, only one-hot categorical variables indicating different time periods after vaccination initiation were applied, while the correlation between vaccination amount(ratio) and excess mortality was not studied. If the later TPAVIs are causing higher excess mortality, vaccination amount will also positively contribute to that effect. Therefore, further study on the relationship between Vaccination Amount of Post-Vaccination Period(VA-PVP) and excess mortality is needed.

1.3 Approaches in this study

In this study, relationships between VA-PVP with excess mortality of north temperate zone countries are evaluated. Factors that affect global excess mortality like COVID death, and potential post-COVID sequelae effect related factors and pull-forward effect(or mortality displacement) are also discussed. In session 2, excess mortality data and the current abnormal situation across worldwide countries are introduced. In session 3, the ever-infected rate related factor is used to represent potential post-COVID sequelae effect. How it could affect excess mortality is discussed and according variables are proposed. In session 4, Pull-forward effect(PFE) and its potential effect on excess mortality is explained and according variables are proposed. In session 5, Multiple Linear regression(MLR) model is used to evaluate the relationships between the factors like COVID death, VA-PVPs, and ever-infected rate related factors, PFE, and the outcome excess mortality. In session 6, the amount of excess mortality rate caused by VA-PVPs are mainly discussed. In session 7, the conclusions are made.

The source code used in this study is published in [19].

2. Excess mortality data across countries

2.1 Excess mortality and its importance

Excess mortality is a term used in epidemiology and public health that refers to the number of deaths from all causes during a crisis above and beyond what we would have expected to see under ‘normal’ conditions[20]. During COVID-19 pandemic, excess mortality captures not only the confirmed COVID-19 deaths, but also

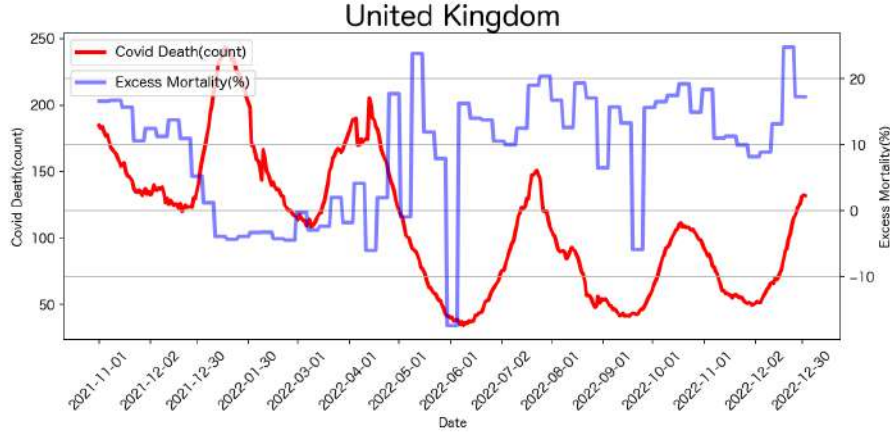


Figure 1. COVID death and excess mortality over time in UK.

those were not correctly diagnosed and reported. Therefore, in order to evaluate the total impact of the pandemic on deaths, excess mortality is considered to be a more comprehensive measure than the confirmed COVID-19 death count alone[21].

2.2 Our World In Data(OWID) dataset

OWID published their excess mortality rate data of 116 countries[21], which is the most comprehensive among all available datasets to the best of our knowledge. Excess deaths are defined as the difference of reported deaths and expected deaths, as in Eq.(1). The excess mortality rate is defined as the ratio of excess deaths to projected deaths, as in Eq.(2). The expected deaths are estimated from a regression model fitted by reported deaths of past years. In OWID's data, the model is fitted by the number of deaths data of 2015-2019 and used to project the number of deaths of since 2020[21].

$$\text{Excess Deaths} = \text{Reported Deaths} - \text{Expected Deaths} \quad (1)$$

$$\text{Excess MortalityRate} = \frac{\text{Reported Deaths} - \text{Expected Deaths}}{\text{Expected Deaths}} \quad (2)$$

OWID dataset also includes new confirmed COVID death data of 219 countries/regions extracted from "JHU CSSE COVID-19 Data"[22], and calculated the 7 day average. Another statistics included is the daily cumulative COVID vaccination rates for all countries and all dosages. This can be used to calculate that, how many vaccination amounts are actually at different post vaccination periods.

2.3 Abnormality in excess mortality in several countries

In England's recent COVID-19 vaccine surveillance report, it is shown that their COVID ever-infected rate has passed 80% since around the 40th week in 2022[23]. This means over 80% population in England should have the anti-COVID(Nucleocapsid) antibodies, which accordingly should lead to less new COVID infection cases and deaths. As a result, a declining excess mortality rate should be expected. We used the 7 day average of new confirmed COVID deaths and excess mortality data from OWID to verify this assumption, as plotted in Fig. 1. The time period is set to be from Nov. 2021 in order to observe the period after omicron variant first appeared[24]. Omicron variant is much more infectious than previous variants and leads to a rapidly increasing infection rate. As in Fig. 1, largely increased post-infection antibody cover rate caused COVID deaths to be declining after the first peak of the omicron-wave in Jan. 2022. However, the excess

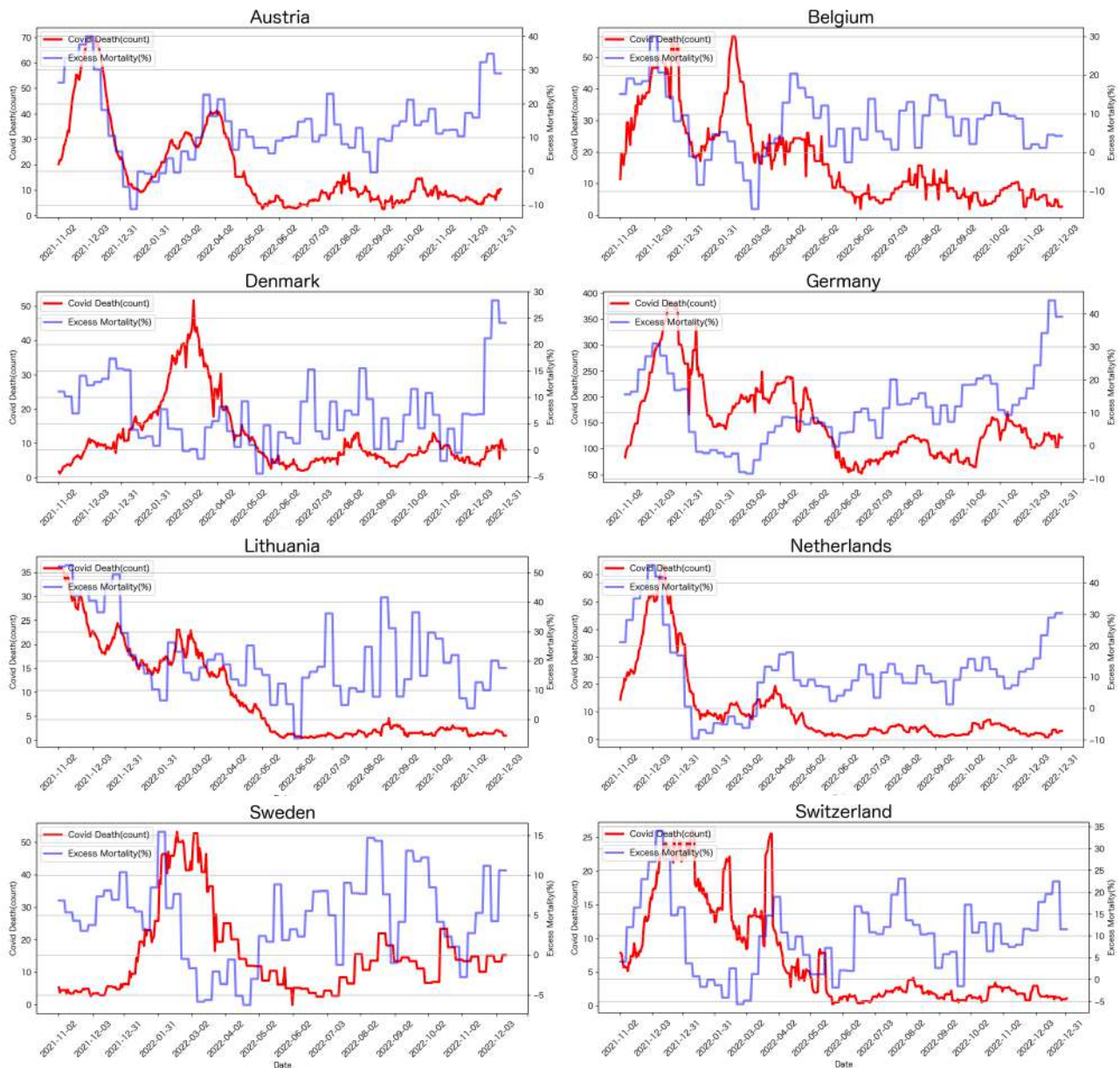


Figure 2. COVID death and excess mortality over time for 8 countries

mortality has been in an increasing trend. This means there are other reasons increasing excess mortality during this period. It is reasonable to suspect that COVID vaccines' long term side effects are causing increased excess mortality.

Similar phenomena are also found in other countries. COVID deaths and excess mortality rate of several other countries, such as Austria, Belgium, Denmark, Germany, Lithuania, Netherlands, Sweden and Switzerland are plotted, as in Fig. 2.

Data from the 8 countries clearly shows that while COVID deaths decline gradually during omicron wave, however the excess mortality data still stays at a high level. Therefore, it verifies again that there are other reasons that causing excess death since around 2022. Those countries are suffering an around 10% or higher excess mortality rate, which is at comparative or even higher level than that caused by the COVID pandemic.

For example, as in Fig. 3, UK is experiencing 10%~20% excess mortality rate in 2022 since May, which is even higher than the average value in 2021, which is about 10%. Whether this pandemic level excess

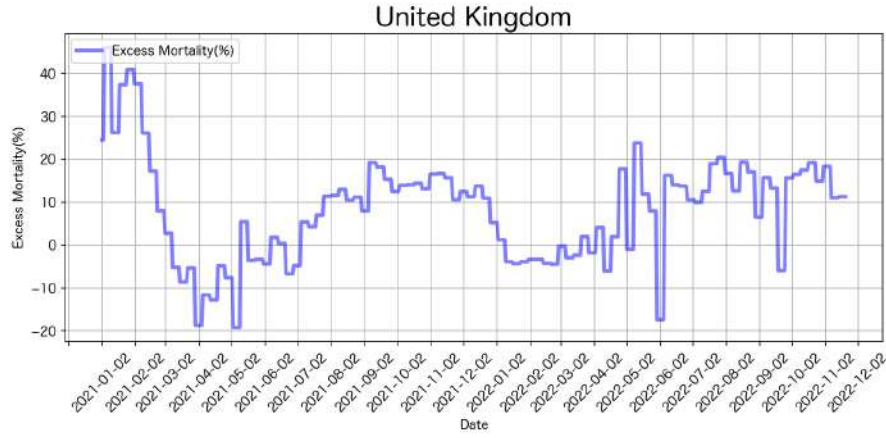


Figure 3. Excess Mortality in United Kingdom

mortality is caused by the massive vaccination campaign or other factors should be studied.

From what we observed in the above countries, the factors causing the current excess mortality should meet the following conditions.

- 1) Occurs in worldwide countries.
- 2) Positively correlates with excess mortality. And the correlation value could be in increasing trend.
- 3) Possible to cause pandemic level excess mortality.

3. Ever-infected rate related factor

3.1 Potential effect on excess mortality

To understand whether there is causal relationship between VA-PVP and excess mortality, other factors possibly related to excess mortality also need to be discussed. Since we are studying data from worldwide countries, only global factors should be considered. COVID death is obviously one possibility.

The other possibility could be fatal long-term post-COVID sequelae. According to US CDC, 3544 people died because of long COVID[25]. It seems to be a very small amount comparing to the whole population at the first glance. However, it is still possible that this number is underestimated, since it may take time to identify which death cases are caused by fatal long-term post-COVID sequelae. Under this assumption, the increasing ever-infected rate should lead to more people to suffer from fatal long-term post-COVID sequelae, and may finally lead to continuous positive excess mortality rate globally. Therefore, effect of ever-infected rate on excess mortality need to be studied and excluded from effect of VA-PVPs to make sure the latter one are only vaccination related.

3.2 Time Period after reference date(TP)

The ever-infected rate data itself is difficult to obtain, since only a few countries have been regularly collecting. However, since ever-infected rate positively correlates with the elapsed time since the pandemic started, we can study the elapsed time instead of ever-infected rate. In order to calculate how many time elapsed, a reference date needed to be decided beforehand. The new variable proposed to represent elapsed time is named as Time Period after reference date(TP). TP variables can be used to measure how the different time periods correlate with excess mortality rate. Therefore, if the abnormal trend of excess mortality

observed in 2.3 is caused by fatal long-term post-COVID sequelae, the positive correlation between TPs and excess mortality should be observed and in an increasing trend over time.

4. Pull-Forward Effect(PFE)

Pull-forward effect, or forward mortality displacement, is the temporary presence of deficit mortality following significant COVID-19 waves, as explained in [26] and observed in [27]. Therefore, the excess mortality should be expected to decrease or become negative after a huge COVID wave.

4.1 General Global PFE Represented by TP

Generally, the impact of a COVID wave is season and variant dependent. Since infectious respiratory diseases are more prevalent in winter, the highly infectious Omicron variant which became prevalent in winter of 2021, has caused a record level wave globally. The huge COVID death wave is expected to cause a worldwide PFE on excess mortality, or deficit mortality in the following months or years. Since TP is only representing all factors simply related to time, the general PFE caused by global simultaneous COVID wave(eg. Omicron) and shared by all countries, will also be represented by TP.

4.2 Non General PFE Variable

Besides, non season and variant independent PFE also exists. Before the emergence of Omicron variant, COVID waves among worldwide countries occurs at different times has caused different level PFE. Those PFEs in some countries have a clear negative effect on excess mortality on the Omicron wave period, during which high excess mortality should be expected. United Kingdom and Belgium are good examples. As in Fig. 4, time (a) in United Kingdom and Belgium, which are early Nov. and Dec. 2021, there were high COVID death and Excess mortality. Since COVID death is known to be observed 2~8 weeks after infection[28] and Omicron didn't become dominant until Dec. 2021, these COVID death waves in UK and Belgium were not caused by Omicron wave. However, in the following time (b), which is the Omicron wave, although both of the two countries still had high COVID death, their excess mortality were at low level as a result of PFE. Unlike the general PFE caused by the Omicron wave, which generally occurred at similar time period of Jan. 2022 ~ Mar. 2022, these PFEs can not be well represented by TP, because TP can only represent a general trend among all countries. As a result, we propose a new variable Country Dependent PFE(CD-PFE) to represent the specific PFE caused by COVID death for each country.

As shown in Fig. 4, in United Kingdom and Belgium's case, it seems COVID death in previous 3 months is causing PFE on the current excess mortality.

5. Modeling relationship between VA-PVPs and excess mortality

As the assumption in 1.2 and our previous result in [18], the effect of vaccination on excess mortality would change over time, and the effect would keep increasing. Since in this study, vaccination amount(or ratio) is taken into consideration, it should be assumed that the effect that any vaccination amount(or ratio) on the excess mortality of a country, could be positive and increasing along different post vaccination periods. Accordingly, it should be assumed that VA-PVP in a later period should have a larger positive correlation with excess mortality. In this session, this assumption is studied. We proposed using multiple linear regression(MLR) model for modeling the relationships between explanatory variables like averaged new COVID deaths, VA-PVPs, TPs, CD-PFE and the response variable excess mortality rate.

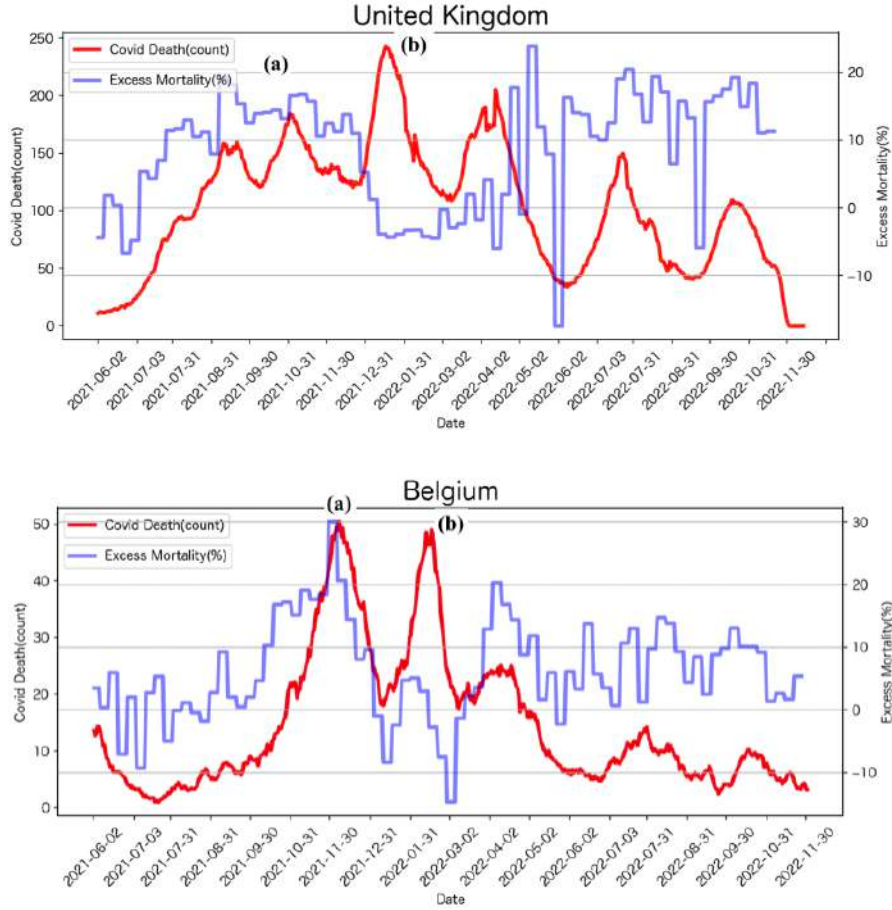


Figure 4. Country Dependent PFE in United Kingdom and Belgium

5.1 Linear Regression models

The concept of linear regression was first proposed by Sir Francis Galton in 1894[30]. It attempts to establish relationship between two types of variables, explanatory variable and response variable. In multiple linear regression(MLR), there are more than one explanatory variables and one response variable. The relationships are modeled by fitting a linear equation to the learning data as shown in Eq. (3).

$$y = \sum w_i x_i + b + \epsilon \quad (3)$$

In Eq.(3), y is the response variable, x_i ($i = 1, 2, \dots, k$) are the explanatory variables, ϵ is the residual error, b is the intercept on y axis while all explanatory variables $x_i = 0$. w_i ($i = 1, 2, \dots, k$) are the regression coefficients, which indicate the correlation between explanatory variables x_i and response y .

5.2 COVID deaths, VA-PVPs and TPs

5.2.1 COVID deaths

Since COVID deaths directly correlated to excess mortality, it is used as one explanatory variable to predict the response variable excess mortality rate. 7 day average of daily new COVID deaths is used in this study.

5.2.2 VA-PVPs

As in our assumption, a same vaccine amount in different post-vaccination periods should be contributing differently to the excess mortality. Therefore, we used the VA-PVP to represent how much vaccine amount are at a certain time period, after these vaccinations. The daily increased vaccination percentage against the

VP-PVP Variables	Definition
vax_per_1_3m	x% vaccination at 1-3 months period
vax_per_4_6m	x% vaccination at 4-6 months period
vax_per_7_9m	x% vaccination at 7-9 months period
vax_per_10_12m	x% vaccination at 10-12 months period
vax_per_13_15m	x% vaccination at 13-15 months period
vax_per_16_18m	x% vaccination at 16-18 months period
vax_per_19_21m	x% vaccination at 19-21 months period
vax_per_22_24m	x% vaccination at 22-24 months period
vax_per_25m+	x% vaccination at 25 months or longer period

Table 1 Definition of Vaccination Amount of Post-Vaccination Period(VA-PVP) variables

whole population is used for vaccination amount. Here, the vaccine types and number of dosages are not distinguished. We simplify the problem by assuming 1st, 2nd and 3rd(or boosters) dose of all types share the same side effect patterns on excess mortality.

Considering there is only limited data from OWID for modeling, we reduce the variables amount by using 3 months time period variables rather than 1 month. Since the entire length of time after vaccination initiation is also limited, periods later than 24 months are merged. The variables are as in Table 1.

5.2.3 TPs

Same as in our previous study[18], TPs are also designed to be one-hot categorical variables, which represent whether a date belongs to a time period or not. Before selecting the reference date, the selection of data period is discussed.

Data after Dec. 1st 2020 is selected for two reasons. Firstly, data in the early period is unreliable. At the beginning of the pandemic, shortage of resources like test kit would result in underestimated COVID deaths. Secondly, data from Dec. 2020 should be included, since massive COVID vaccination started at Dec. 15 2020. Therefore, data before Dec. 2020 are dropped. Therefore, the reference date need to be a date after Dec. 2020.

Since infectious respiratory diseases are seasonal[31], we also use 3 months time period variables for TP. The first season is the winter of 2020, which starts from Dec. 1st 2020. Considering this variable could represent season and variant dependent PFE caused by COVID death as discussed in 4.2, timing of large amount of COVID death should also be considered. According to the study[28], COVID death occurs 2-8 weeks after infection, COVID death from people get infected in this season should occur from after about 1 month, which is Jan. 1st 2021. Therefore, the reference date for TP is set to be Jan. 1st 2021. Since only about 3 years data is available, time periods later than 30 months are merged. The designed TP variables are as in table 2.

5.3 Feature normalization

Generally, statistics of COVID death and excess mortality are not reliable and biased in different countries.

TP Variables	Definition	TP Variables	Definition
tp_1_3m	After Jan. 1st 2021, 1-3 months	tp_19_21m	After Jan. 1st 2021, 19-21 months
tp_4_6m	After Jan. 1st 2021, 4-6 months	tp_22_24m	After Jan. 1st 2021, 22-24 months
tp_7_9m	After Jan. 1st 2021, 7-9 months	tp_25_27m	After Jan. 1st 2021, 25-27 months
tp_10_12m	After Jan. 1st 2021, 10-12 months	tp_28_30m	After Jan. 1st 2021, 28-30 months
tp_13_15m	After Jan. 1st 2021, 13-15 months	tp_31m+	After Jan. 1st 2021, 31 months and more
tp_16_18m	After Jan. 1st 2021, 16-18 months		

Table 2 Definition of Time Period after reference date(TP) variables

For COVID death, it is dependent on how thoroughly the death cases are tested for COVID in each country. And for both COVID death and excess mortality, it is dependent on the level of public health and medical care of each country. As a result, it may be difficult to model the correlation between COVID death and excess mortality with these biased raw data.

To solve this problem, we proposed to do normalization to both COVID death and excess mortality within each country. Since it is known that COVID death causes excess mortality, we assume the dates of maximum and minimum of COVID death always matches those of excess mortality. We proposed to normalize COVID death and excess mortality both to $[0,1]$ to fit this assumption.

Normalization of COVID deaths within each country is by dividing the maximum value of 7 day average COVID deaths in each country, as in Eq. (4). x_{cov_death} and $\hat{x}_{cov_death}$ stands for the original and normalized 7 day average COVID deaths, t stands for the date, c stands for a country, and T_c stands for all dates included in the country c 's data.

$$\hat{x}_{cov_death}(t, c) = \frac{x_{cov_death}(t, c)}{\max_{\forall t \in T_c} x_{cov_death}(t, c)} \quad (4)$$

Normalization of excess mortality within each country is by dividing the difference between current excess mortality and minimum excess mortality with the difference between maximum and minimum excess mortality, as in Eq. (5). $x_{ex_mortality}(t, c)$ and $\hat{x}_{ex_mortality}(t, c)$ stands for the original and normalized excess mortality.

$$\hat{x}_{ex_mortality}(t, c) = \frac{x_{ex_mortality}(t, c) - \min_{\forall t \in T_c} x_{ex_mortality}(t, c)}{\max_{\forall t \in T_c} x_{ex_mortality}(t, c) - \min_{\forall t \in T_c} x_{ex_mortality}(t, c)} \quad (5)$$

5.4 Proposed models

To study how the COVID death, VA-PVP, TP and CD-PFE variables could affect excess mortality, we proposed a MLR model to model the correlations. In the model, COVID death, VA-PVP, TP and CD-PFE are explanatory variables and excess mortality is response variable.

To evaluate the effectiveness of the proposed variables, 8 models are proposed. The model of COVID death is used as baseline. 3 models with addition of VA-PVP, TP and CD-PFE respectively to the baseline model

are also proposed to check the performance of the three variables. Then combination of 2 out of VA-PVP, TP and CD-PFE are added respectively to the baseline model. As a result, another 3 models are proposed. The final model is with addition of VA-PVP, TP and CD-PFE variables together to the baseline model.

5.5 Data processing

OWID dataset is updated Daily. The data version used in this study is downloaded on Feb. 18 2024. Data of the explanatory variables and response variable from OWID are processed in the following steps.

- 1) As discussed in 5.2.3, data before Dec. 2020 are dropped.
- 2) Weekly data are used. For countries only providing monthly excess mortality rates, monthly data is used to approximate weekly data.
- 3) Data from countries with less than 10 effective 7-day average COVID death data and less than 5 effective excess mortality rate data are dropped. This is because 7-day average COVID death and excess mortality rate data published in some countries are of too small amount that would be biased.
- 4) Data from countries with total vaccination rate greater than the median value among all countries are used. This is because we assume it might be difficult for low vaccination rate to show stable effect on excess mortality. Those data should be avoided.
- 5) Data from countries with less than 1 million population are dropped. It is observed that 7-day average COVID death numbers in those countries are too small (<1) and many are zeros. This shows their statistics of COVID death are not stable.
- 6) Data of countries with sudden jump in vaccination rate are dropped. This should be caused by errors in the statistical process and will result in error for the vaccination amount calculation of VA-PVPs.
- 7) Only data from north temperate zone and north frigid zone countries are used. This is because TP is supposed to represent seasonal factors. According to seasonal characteristics, there are 3 classes among all countries. Countries in the north temperate zone and north frigid zone have 4 seasons and shares the same season at the same time. Countries in south temperate zone also have 4 seasons, but those are opposite to that of the northern countries in time. And for countries in tropics, there is no seasonal difference throughout a year. The class of countries in north temperate zone and north frigid zone is chosen, for that it has the largest number of 29 countries among the 3 classes.
- 8) Data of Israel after Sep. 30, 2023 is dropped for the sharp increase of excess mortality after the attack by Hamas on Oct. 7, 2023.

In total, data of 29 countries, which represent 1.19 billion population are used for modeling.

5.6 Model evaluation metric

R-Square is used for performance evaluation metric of the proposed MLR model.

R-Square : Represents the proportion of the variance for the response variable that is explained by an explanatory variable or variables in a regression model. An effective model should have the value within (0,1]. Higher value indicates better model performance.

5.7 Models evaluation and analysis

5.7.1 R-Square result

5-fold cross-validation is used for evaluation. Since there could be huge bias among data from different countries, it is conducted in country-wise. The R-Square results of all models as in Table 3.

	Models	R-Square	P value[29] ($H_0 \neq H_1$)
H_0	COVID death	0.158 ± 0.134	—
H_1s	+ VA-PVP	0.282 ± 0.096	0.130
	+ TP	0.320 ± 0.137	0.096
	+ CD-PFE	0.235 ± 0.118	0.364
	+ VA-PVP + TP	0.364 ± 0.105	0.027
	+ VA-PVP + CD-PFE	0.318 ± 0.088	0.056
	+ TP + CD-PFE	0.340 ± 0.127	0.058
	+ VA-PVP + TP + CD-PFE	0.383 ± 0.098	0.016

Table 3. Performances of models with COVID death, VA-PVP, TP, CD-PFE variables

The baseline model only using COVID death for predicting excess mortality only achieved 0.158. The value is low, which fits our expectation as we have observed trends of COVID death and excess mortality from 2022 are not in accordance as in session 2.3.

Among the 3 models with addition of VA-PVP, TP or CD-PFE to COVID death, the R-Squares improved in average value, but the p-values are 0.130, 0.096 and 0.364, which are not small enough to be considered as statistically significant. However, the models with addition of VA-PVP and TP and with all 3 proposed VA-PVP, TP and CD-PFE, achieved statistically significant improvement with p-value of 0.027 and 0.016. The remaining 2 models with addition of VA-PVP and TP, and with TP and CD-PFE also achieved small p-values which are near statistically significant. The results indicate that the proposed variables VA-PVP, TP and CD-PFE all contribute to prediction of the excess mortality. And best model is the final model with COVID death, VA-PVP, TP and CD-PFE all together, which has the highest R-square of 0.383. Therefore, this model is used for further analysis.

5.7.2 Regression coefficients and analysis

The regression coefficients of each explanatory variables in the proposed model are as in Table 4, which show strength of correlations between explanatory variables and excess mortality rate. The reliable regression coefficients ($p < 0.05$) are in bold face. The coefficients of VA-PVPs and TPs are plotted as in Fig. 5(a,b). The coefficients which are statistically significant($p < 0.05$) are in solid dot, while the others ($p \geq 0.05$) are in dashed circle. Variable names of TPs are mapped into seasons.

There are several findings from results in Table 4 and Fig. 5.

5.7.2.1 Regression Coefficients of COVID death

As in Table 4, the regression coefficient of COVID death is 0.745, showing a high positive correlation with excess mortality rate. This is as expected that COVID will cause excess mortality.

5.7.2.2 Regression coefficients VA-PVPs

The regression coefficient of VA-PVPs stands for the amount of normalized excess mortality per 100% vaccination rate of population in each country.

Explanatory Variable(s)	Regression Coefficients	p value	Explanatory Variable(s)	Regression Coefficients	p value
7 days average COVID death	0.747	0.000	tp_4_6m(SP)	-0.027	0.123
vax_per_1_3m	0.081	0.000	tp_7_9m(SU)	-0.013	0.522
vax_per_4_6m	0.182	0.000	tp_10_12m(F)	-0.064	0.003
vax_per_7_9m	0.067	0.000	tp_13_15m(W)	-0.263	0.000
vax_per_10_12m	0.070	0.000	tp_16_18m(SP)	-0.179	0.000
vax_per_13_15m	0.228	0.000	tp_19_21m(SU)	-0.196	0.000
vax_per_16_18m	0.214	0.000	tp_22_24m(F)	-0.181	0.000
vax_per_19_21m	0.158	0.000	tp_25_27m(W)	-0.401	0.000
vax_per_22_24m	0.122	0.000	tp_28_30m(SP)	-0.339	0.000
vax_per_25m+	0.254	0.000	tp_31m+(SU)	-0.336	0.000
tp_1_3m(W)	-0.114	0.000	COVID_death_last_1_3m (CD-PFE)	-0.199	0.000

Table 4 Regression coefficients of COVID death + VA-PVPs + TPs + CD-PFE model

(W = winter, SP = spring, SU = summer, F = fall)

- 1) As in Table 4, all regression coefficients of VA-PVPs are reliable($p < 0.05$) and positive. This indicates during the whole period after vaccine rollout, every percentage of vaccination rate or each dose of vaccination positively correlates with excess mortality.
- 2) As in Fig. 5(a), although there are variations, the regression coefficients of VA-PVPs over time are generally in an increasing trend. This means the correlation between the vaccination rate and excess mortality is increasing. The reason of variations will be analyzed in 5.7.2.3. Besides, the vaccination rate is increasing, since people has been taking new vaccinations over time. As a result, the total correlation between total vaccination amount and excess mortality will also be in increasing trend, since it is the multiplication of vaccination amount(VA-PVPs) and the regression coefficients.
- 3) The largest regression coefficient is 0.254 of vax_per_25m+, which seems to be small comparing to 0.745 of COVID death at the first glance. However, to calculate the excess mortality, it need to be multiplied by value of vax_per_25m+, which has the range of [0%,309.6%] among the 29 countries. This means its maximum correlation with excess mortality should be 0.785. While the value of the normalized COVID death has the range of [0,1], the maximum correlation is 0.745. Therefore, the positive correlation with excess mortality from COVID death and VA-PVP should be considered to be of a same level.

The positive and increasing correlation between VA-PVPs and excess mortality is in accordance with the abnormal excess mortality occurred in the countries as observed 2.3.

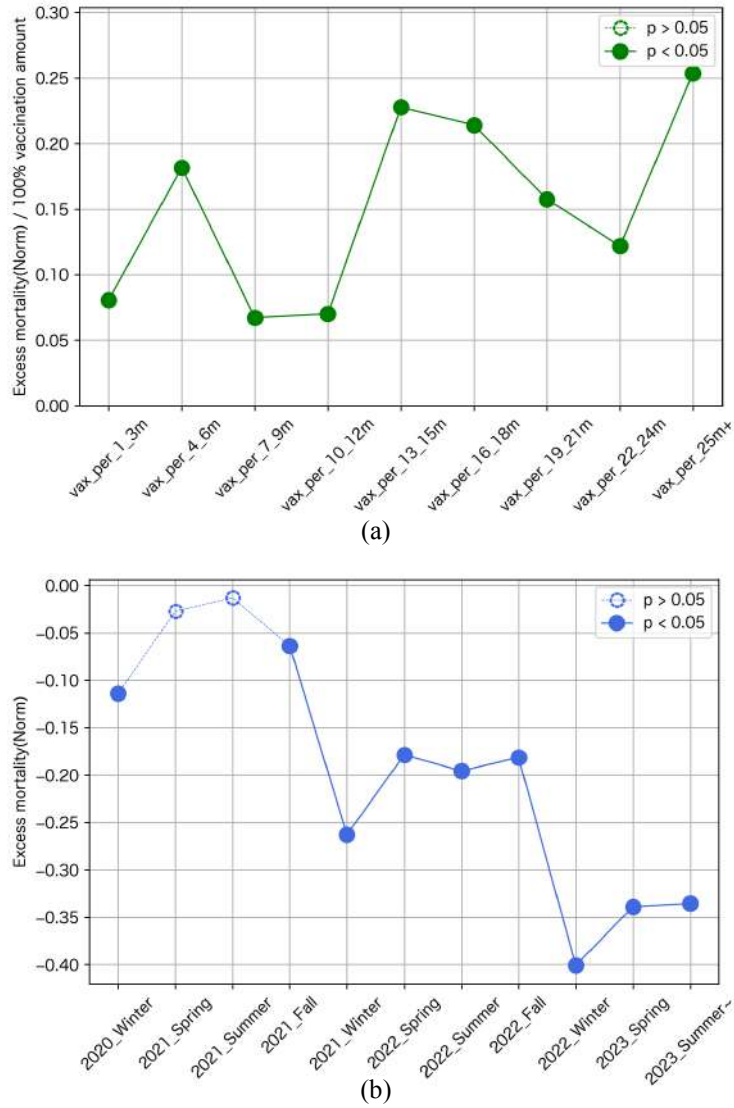


Figure 5. Regression coefficients of VA-PVPs(a), and TPs(Seasonal)(b)

5.7.2.3 Regression coefficients of TPs

- 1) As in Fig. 5(b), except those of 2021_Spring(tp_4_6m) and 2021_Summer(tp_7_9m), all regression coefficients of TPs are reliable values($p < 0.05$). And these values are all negative and in a descending trend annually. As in our assumption, if the abnormal excess mortality observed in 2.3 is caused by fatal long-term post-COVID sequelae, regression coefficients of TPs should be positive, continuing at high-level, or even in an increasing trend. However, the result shows the opposite. Therefore, this clearly shows the abnormal excess mortality is not caused by fatal long-term post-COVID sequelae.
- 2) A clear seasonal characteristic is shown in the descending trend of regression coefficients of TPs. A big decrease occurred at both 2021_winter and 2022_winter, when generally largest amount of COVID death occurred. When there is large amount of COVID death in winter, deficit mortality will occur on non-COVID mortality and this will be represented by coefficients of TPs. This can explain the big decrease at both 2021_winter and 2022_winter. And after the winter period, the large amount of COVID death will result in a deficit mortality in the following period, which is the PFE as explained in session 4. This phenomenon is also clearly represented by the descending trend of TPs' coefficients. After the huge decrease in 2021_winter and 2022_winter, the relative low values of TPs' coefficients continues, which

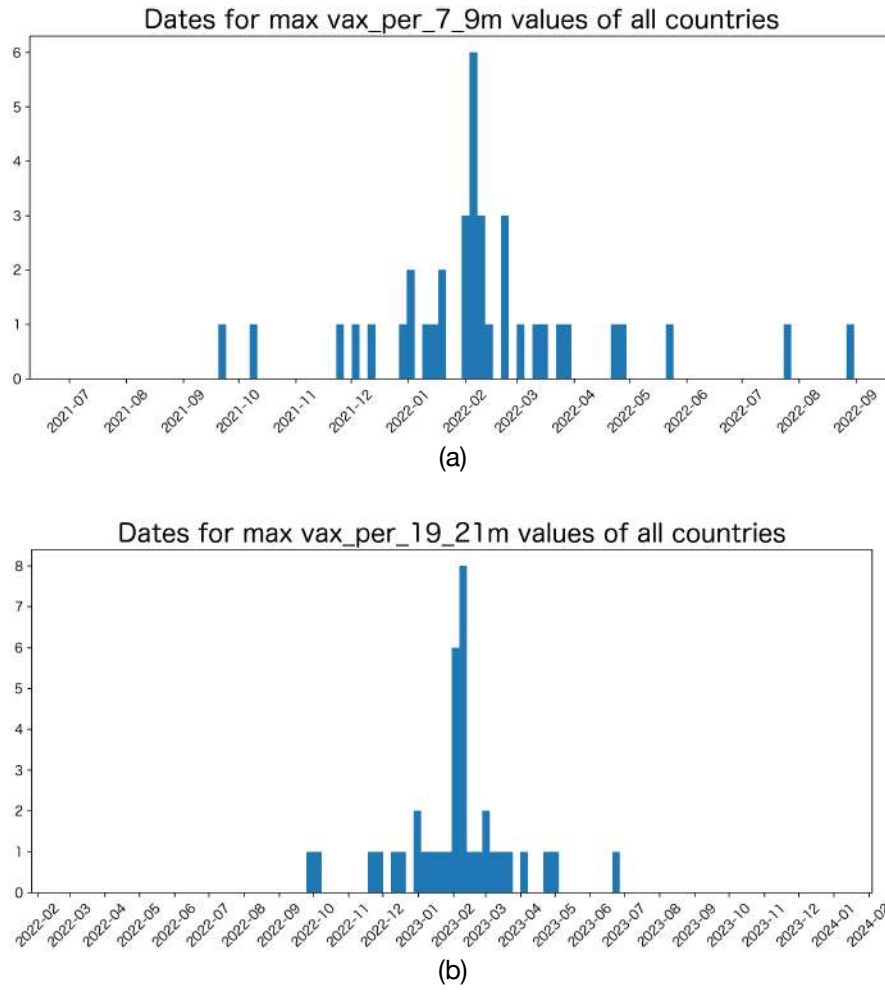


Figure 6. Dates for max_vax_per_7_9m(a), vax_per_19_21m(b) values of all countries

shows PFE(or mortality deficit) is taking place.

- 3) For the same reason as in TPs, the sudden decrease of VA-PVPs' coefficients are also caused by the large amount of COVID death in winter. For example, the coefficients of vax_per_7_9m and vax_per_19_21m. The distribution of dates when all counties reach the maximum vaccination amount of vax_per_7_9m, and vax_per_19_21m are plotted as in Fig. 6(a,b). As in Fig. 6(a,b), it is shown that for most countries, the period when the vaccination amount of vax_per_7_9m and vax_per_19_21m reached maximum from Jan. 2022 to Mar. 2022, and Jan. 2023 to Mar. 2023 respectively. These are winter periods when large amount of COVID death occurred, and will cause a deficit on non-COVID death like vaccination death. This should be the reason that vax_per_7_9m, vax_per_19_21m, and the adjacent vax_per_10_12m, vax_per_22_24m have relatively low coefficients.

5.7.2.4 Regression coefficient of CD-PFE

As in Table 4, the regression coefficient of CD-PFE is statistically significant and negatively correlated with excess mortality with the value -0.199. This fits our expectation that COVID death occurred in each country is causing country dependent PFE.

5.7.3 Summary

Positive and increasing correlation between vaccination amount(VA-PVPs) and excess mortality is observed from worldwide countries, which is in accordance of the abnormal excess mortality observed in 2.3.

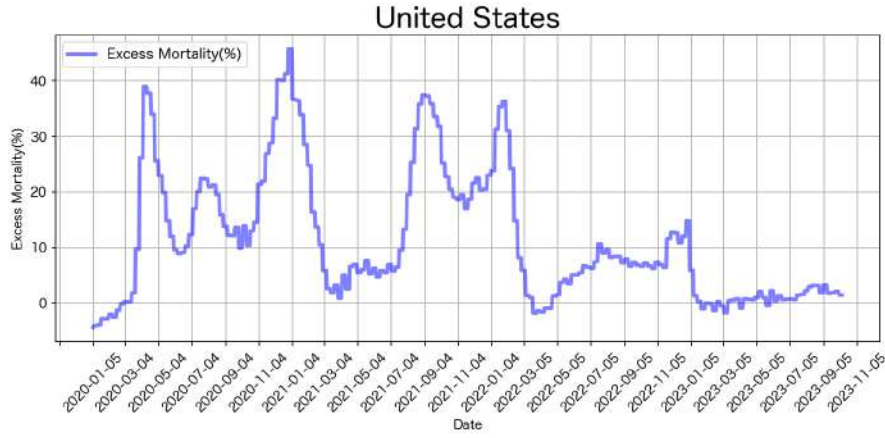


Figure 7. Excess mortality of United States

Furthermore, it is proven that the fatal long-term post-COVID sequelae is not the cause of this worldwide abnormal excess mortality. As far as we know, no other factors that can meet the conditions in 2.3 and result in an increasing effect as VA-PVPs, we can conclude the worldwide abnormal excess mortality is caused by the COVID vaccinations.

6. Discussion

6.1 Underestimated excess mortality

Excess mortality rate become relatively lower in many countries, and even around 0% in some countries in 2023. For example, Fig. 7 shows the excess mortality in US. This may lead to the conclusion that excess mortality is lower and about to end. However, lack of consideration of PFE or mortality displacement will lead to underestimation. Because of 3 years excess mortality caused by continuing COVID death and vaccination death, the actual baseline of mortality should be negative value and largely below 0% now. As a result, it should be noticed even if the current excess mortality rate is 0%, there is still actually large amount excess mortality. This means small amount of COVID deaths and large amount of vaccination deaths are still occurring. In our opinion, the regression coefficients of TPs shown in Fig. 5(b), which represent the non-COVID and non-vaccination death, could represent the real baseline of mortality better. The decreasing regression coefficients of TPs, clearly represents the mortality deficit as a result of the previous cumulating COVID deaths and vaccination deaths.

6.2 Compare impact on excess mortality by COVID deaths and vaccination

We want to evaluate how much the COVID vaccination has increased excess mortality. For this evaluation, the effect on excess mortality caused by the vaccination is compared with that caused by COVID death.

6.2.1 Excess mortality by COVID deaths

For COVID death, average daily effect on excess mortality is calculated as in the following steps. Firstly, the mean value of all daily 7 days average COVID deaths among all 29 countries used in this study is used as the average value of daily global COVID death. Then it is multiplied with coefficient value of 7 days average COVID death in Table 3. The result is used as average daily effect on excess mortality by COVID death. Here the 7 days average COVID death are in normalized values as in Eq.(4).

	Effect on excess mortality rate	Range of effects on excess mortality rate (by 95%CI regression coefficients)
COVID death (average)	0.132	(0.127, 0.137)
Vaccination / VA-PVPs (average)	0.226	(0.167, 0.285)
Vaccination / VA-PVPs (most current)	0.449	(0.330, 0.514)

Table 4 Effects on excess mortality by COVID deaths and vaccination

6.2.2 Excess mortality by vaccination deaths(Average)

For vaccination, the average daily effect on excess mortality is calculated as follows. Firstly, daily effect by VA-PVP in each country is calculated by doing dot product for VA-PVP values and corresponding regression coefficients. Then the effect is averaged to daily value, among the whole time period and all 29 countries.

6.2.3 Excess mortality by vaccination deaths(Most current)

Since the effect from vaccination has been increasing, the most current daily effect on excess mortality is calculated. The last day of each country among the calculated daily effect values in 6.2.2 are collected and the average among the countries is calculated.

For the 3 effects above, the 2.5% and 97.5% level of the 95%CI of regression coefficients is used to calculate the variation range. The results are as in table 4. The effect on excess mortality are in normalized value as in Eq.(5). Furthermore, The result shows that in the highly vaccinated 29 countries, the average daily excess mortality caused by COVID vaccinations(0.226) is about 1.7 times that of COVID itself(0.132). And as the effect keeps increasing along time, the most current effect rose up to 0.449, which is about 3.4 times that of COVID death. Since the increasing trend as in Fig. 5(a) doesn't seem to be ending, and new vaccines are still being taken gradually, this effect should be considered to keep increasing in the near future.

7. Conclusion

In our study, data of the highly vaccinated 29 countries was studied, which covers 14.7% (1.19 billion) of world population. It is clearly proven that COVID vaccination will cause excess mortality and the effect keeps increasing until the end of 2023, where our data ends. Furthermore, according to our model, during 2020.12~2023.12 period, the average excess mortality caused by COVID vaccination is of an higher level, about 1.7 times that of the COVID pandemic itself. And the most current effect is more than 3 times that of the COVID death. This means although the COVID pandemic will eventually end, the pandemic level excess mortality rate will be artificially perpetuated in time and increased in amount. The fact that a medical intervention that is causing much more death than the disease itself is shocking and doesn't make sense in any perspective. The massive vaccination campaign is proven to be an unacceptable failure and should be terminated immediately.

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