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# Estimate of the COVID-19 over-reporting bias as underlying cause of death in the USA

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## ABSTRACT

In this work we provide an estimate of the degree of over-reporting of COVID-19 as the underlying cause of death in the US. We calculate the over-reporting adjustment factor by comparing the ratios of reporting of COVID-19 as multiple cause of death to underlying cause of death, with the equivalent ratio for Influenza and Pneumonia (ICD-10 codes J09-J18).

Our results show that there is a systematic over-reporting of COVID-19 when reported as underlying cause of death, when compared to Influenza and Pneumonia during the same period. The average over-reporting factor is about 2.5 to 3 for all ages. We also observe that for ages 15 to 54 the over-reporting factor ranged from 2 to 3.5 between 2020 and 2022, which is higher than for younger and older individuals. For older individuals, the over-reporting factor ranged from 1.9 to 3, while for younger individuals the over-reporting factor ranged from 1.1 to 2.8.

The over-reporting factors we compute only account for the relative over-reporting of COVID-19 as the underlying cause of disease as opposed to as a contributing cause, when compared with influenza and pneumonia. This work therefore contributes to the ongoing discussion of death “with” COVID-19 versus “from” COVID-19.

**Keywords:** COVID-19 Over-reporting, Underlying cause of death, Comparative analysis

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## 1 INTRODUCTION

### 1.1 Background

At the start of the COVID-19 pandemic in 2020, the United States government passed a bill called the Coronavirus Aid, Relief, and Economic Security (CARES) Act which provided financial support to hospitals that were inundated with an influx of COVID-19 patients, with special provisions for Medicare recipients, patients without insurance, and regions with a high COVID-19 burden. Although widely considered a reasonable course of action, this funding was criticized for creating a perverse incentive for hospitals to inflate the importance of COVID-19 as a contributor to their patients' conditions. The official estimates of COVID-19 mortality during this time, originating mainly from hospitals, have been called into question as a result. Considering the negative effect of collective panic resulting from an inflation of these numbers (Weinberger, et al., 2020)[1] and (Kiang, et al., 2020)[2].

One of the aspects of the SARS-CoV-2 pandemic that is controversial is the actual counting and classification of deaths attributed to COVID-19 and the estimation of the respective case death rate<sup>1</sup>, as in most cases the disease manifested with mild symptoms as in a cold. To add to the problem of comparing the COVID-19 impact with other respiratory infections, the pandemic measures included isolation and quarantining of suspected infected individuals, new hospital protocols, mass COVID-19 testing, mass media showing of COVID-19 cases and deaths which led to an inherent bias towards finding COVID-19 infected people. If clinicians early on in the pandemic were likely to be under-counting COVID-19 deaths, later on in the pandemic the intensive testing, with PCR (Polymerase Chain Reaction) methods later criticized for high false positive rates, high sensitization and incentives for COVID-19 diagnosis were likely to have led to over-counting of COVID-19 deaths (Ioannidis, et al., 2021)[3].

The topic deserves scrutiny, not only to provide more accurate estimates on COVID-19 mortality for use in future studies, but also to provide historical context such that misleading data collection and reporting practices might be avoided in the future (Pashkevich, et al., 2022)[4].

In this study we attempt to address the problem of discerning between deaths “with” COVID-19 and deaths “from” COVID-19 by comparing the reporting of COVID-19 deaths with those by Influenza & Pneumonia during the pandemic. This estimate could be the basis for future studies that attempt to untangle the “true” rate of death “from” COVID-19 versus deaths of people “with” COVID-19 to adjust their results, leading to a more precise understanding of COVID-19 and the pandemic impacts.

### 1.2 Certification of COVID-19 Deaths

In order to better monitor and understand the impact of the COVID-19 pandemic, different health authorities updated their recommendations for accurately measuring COVID-19 related deaths. The World Health Organization (WHO) defines a death from COVID-19 as “*a death resulting from a clinically compatible illness in a probable or confirmed COVID-19 case, unless there is a clear alternative cause of death that cannot be related to COVID-19 disease, e.g., trauma.*” (Veeranna et al., 2020)[5].

COVID-19 Case Definitions for Global Surveillance as Prescribed by WHO (Veeranna et al., 2020)[5]:

**Confirmed case:** “*A confirmed case is a person with laboratory confirmation of infection with the COVID-19 virus, irrespective of clinical signs and symptoms.*”

**Suspected case:** “*A patient with acute respiratory illness (that is, fever and at least one sign or symptom of respiratory disease, for example, cough or shortness of breath) with no other etiology that fully explains the clinical presentation and a history of travel to or residence in a country, area, or territory that has reported local transmission of COVID-19 disease during the 14 days prior to symptom onset.*”

<sup>1</sup> <https://www.who.int/data/stories/the-true-death-toll-of-covid-19-estimating-global-excess-mortality>

OR

*“A patient with any acute respiratory illness and who has been a contact of a confirmed or probable case of COVID-19 disease during the 14 days prior to the onset of symptoms.”*

OR

*“A patient with severe acute respiratory infection (i.e., fever and at least one sign or symptom of respiratory disease, for example, cough or shortness of breath) and who requires hospitalization and who has no other etiology that fully explains the clinical presentation.”*

**Probable case:** *“A probable case is a suspected case for whom the report from laboratory testing for the COVID-19 virus is inconclusive.”*

The ICD-10 (International Classification of Diseases) coding of COVID-19 deaths are (World Health Organization (WHO), 2020)[6]:

- U07.1: COVID-19, virus identified.
- U07.2: COVID-19, virus not identified (Clinically epidemiologically diagnosed COVID-19; Probable COVID-19; Suspected COVID-19.)

Independently of international guidelines, different countries have been classifying COVID-19 deaths in slightly different manners. For example, in the UK, the country of Scotland *“has only been counting deaths within 28 days of a positive test so that deaths from COVID-19 beyond 28 days are not included”*<sup>2</sup>. The US attributes death to COVID-19 where this disease, or the coronavirus that causes it, appears as a cause or contributing cause of death on the death certificate (Vital Statistics Reporting Guidance (Centers for Disease Control (CDC)), 2020, updated 2023)[7].

The WHO methodology for identifying COVID-19-related deaths cast a wide net for potential classification of COVID-19 as either the underlying cause of death or a contributory cause of death, which could lead to over-reporting relative to other

diseases. This led to criticisms of suspected over-counting of COVID-19-related deaths during the pandemic. As an example, a CDC mortality report indicated that COVID-19 was the sole cause of only about 5% of listed COVID-19 deaths<sup>3</sup>.

To shed further light on whether COVID-19 deaths were over-reported during the pandemic, in this study we analyze the typical pattern of death classification for similar respiratory infectious diseases (pneumonia and influenza) prior to 2020 with the pattern after 2020, and then compare it with the pattern observed for the classification of COVID-19 deaths. We compute the ratio of influenza and pneumonia deaths that appear in multiple causes of deaths, with those are registered as the underlying cause, and then compare the equivalent ratio for COVID-19 deaths. We then assume that COVID-19 deaths should be classified similarly to influenza and pneumonia, in other words, that these conditions will exhibit a similar pattern in terms of contributing to deaths from another cause vs being the primary cause of death, compared to COVID-19. This allows us to estimate an over-reporting factor for the classification of COVID-19 underlying cause deaths. This study does not attempt to address the question of COVID-19 being over-reported on death certificates, but only addresses the over-reporting related to the classification of COVID-19 as the underlying cause of death.

## 2 DATA

### 2.1 Cause of Death Data

The data used in this analysis are the number of deaths that occurred in the US between 2010 and 2022, by underlying cause code (ICD-10), sex, and 10-year age groups, obtained using the CDC WONDER<sup>4</sup> system provided by the National Center for Health Statistics of the Centers for Disease Control and Prevention (CDC). The mortality data is final up to 2021 but provisional from 2022 onwards.

<sup>2</sup> <https://ukhsa.blog.gov.uk/2020/08/12/behind-the-headlines-counting-covid-19-deaths>

<sup>3</sup> [https://www.cdc.gov/nchs/nvss/vsrr/covid\\_weekly/index.htm#Comorbidities](https://www.cdc.gov/nchs/nvss/vsrr/covid_weekly/index.htm#Comorbidities)

<sup>4</sup> CDC Wonder

Additionally, for comparing multiple cause (MC) of death trends from Influenza & Pneumonia and COVID-19 with underlying cause (UC) of death trends, we downloaded data from both the multiple cause of death databases and underlying cause of death databases.

Query parameters:

For underlying cause of death data, select variable grouped by: 1. Ten-year-age-groups, 2. Gender, 3. Year, 4. UCD – ICD Chapter

[\(Link to the underlying cause of death databases\).](#)

For multiple cause of death data, select variable grouped by: 1. Ten-year-age-groups, 2. Gender, 3. Year, 4. MCD – ICD Chapter

[\(Link to the multiple cause of death databases\)](#)

## 2.2 Definition of MC of death and UC of death

The Centers for Disease Control and Prevention (CDC) classifies deaths based on cause into two primary categories: "Underlying Cause of Death" and "Multiple Causes of Death". These classifications are useful for epidemiological studies, public health, and understanding different mortality patterns. The definitions are:

**Underlying Cause (UC) of Death:** The underlying cause of death is defined as "the disease or injury which initiated the train of morbid events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury," according to the World Health Organization (WHO).

**Multiple Causes (MC) of Death:** Multiple causes of death include all causes and conditions reported on the death certificate that contributed to death, not just the underlying cause. This includes the underlying cause, immediate cause, and any other significant conditions contributing to death. Each death certificate contains a single underlying cause of death, and up to twenty additional multiple causes.

## 2.3 Data Use Restrictions

In this research paper we abide by the CDC's restrictions on data use which are:<sup>5</sup>:

*"The Public Health Service Act (42 U.S.C. 242m(d)) provides that the data collected by the National Center for Health Statistics (NCHS) may be used only for the purpose for which they were obtained; any effort to determine the identity of any reported cases, or to use the information for any purpose other than for health statistical reporting and analysis, is against the law. Therefore, users will:*

- *Use these data for health statistical reporting and analysis only.*
- *Do not present or publish death counts of 9 or fewer or death rates based on counts of nine or fewer (in figures, graphs, maps, tables, etc.).*
- *Make no attempt to learn the identity of any person or establishment included in these data.*
- *Make no disclosure or other use of the identity of any person or establishment discovered inadvertently and advise the NCHS Confidentiality Officer of any such discovery."*

## 2.4 Population data

The source for the population data that are used for computing death rates (deaths per 100,000) are the data retrieved from the CDC queries. We opted to utilize CDC population data instead of data from the US Census Bureau to maintain consistency with analyses conducted by other researchers.

## 2.5 ICD-10 Code List of Selected Causes of Death for: Influenza & Pneumonia

For this analysis we selected the ICD-10 codes from the CDC code-range: J09 to J18 which refer to the different types of Influenza & Pneumonia, within the respiratory system.

The US CDC only uses the U07.1 ICD-10 code for all COVID-19 underlying-cause deaths. Post-COVID condition (ICD-10 code U09) may be

<sup>5</sup> CDC Wonder - Data Use Restrictions



recorded as a multiple cause of death, however we have omitted this code from our analysis as post-COVID is not comparable to the acute infections of influenza and pneumonia.

Additionally, J12.82 (Pneumonia due to COVID-19) is also recorded by the CDC as a multiple cause classification. J12.82 must be used only as an MC code because the COVID code U07.1 is a “code first” code for J12.82<sup>6</sup>.

The CDC WONDER system, however, does not provide deaths with a lower granularity than J12.8 (Other viral pneumonia). We downloaded both the MC and UC deaths for code J12.8 and observed that the recorded yearly deaths for 2018 to 2023 were negligible when compared to Influenza & Pneumonia deaths (less than 1%), and in many age groups and years, were suppressed due to very low numbers being recorded.

Consequently, using the full range of Influenza and Pneumonia codes (J09 to J18) is a good approximation that should not include significant contamination from the COVID-19-related code J12.81.

### 3 STUDY OUTLINE

In this study, we analyze the ratios of MC to UC deaths for Influenza & Pneumonia (ICD-10 codes: J09-J18) and for COVID-19 (code: U07.1).

We then use the ratio of MC/UC deaths from Influenza & Pneumonia as what we would expect to be the baseline ratio for COVID-19 disease. This comparison makes sense as COVID-19 is a predominantly respiratory infectious disease, which has many similar potential complications as those seen in influenza, including sepsis, heart attack, stroke, multi-organ failure, and secondary bacterial or fungal infections<sup>7</sup>. One could make the assumption that the ratio of COVID-19 deaths appearing in the multiple-cause of deaths fields of the death certificate by the COVID-19 deaths as underlying cause

should be similar to the equivalent ratio for Influenza & Pneumonia. We can then adjust COVID-19 deaths to compensate for systematic under/over estimation of COVID-19 deaths that result from the pandemic measures that we discussed in the introduction.

We first need to investigate the reported death rates from or with COVID-19, as well as the trends in death rates from and with Influenza & Pneumonia. For this purpose, we first perform an extended analysis of a particular age group (35-44-year-olds) and later generalize the analysis for all age groups.

Our study is organized as follows:

In section 4 we perform the different steps for estimating the over-reporting factor for COVID-19 deaths for the particular case of ages 35 to 44:

4.1 – Analysis and comparison of UC death rates from Influenza & Pneumonia (from 2010 to 2022) and UC COVID-19 death rates from 2020 to 2022, for ages 35 to 44.

4.2 – Analysis and comparison of MC death rates from Influenza & Pneumonia (from 2010 to 2022) and MC COVID-19 death rates from 2020 to 2022, for ages 35 to 44.

4.3 – Comparison of ratio of MC/UC death rates from Influenza & Pneumonia with COVID-19 MC/UC death rates, for ages 35 to 44. By comparing these ratios (for Influenza & Pneumonia and COVID-19) we obtain an estimation for the over-reporting adjustment factor for COVID-19 as the underlying cause of death.

After showing the process for estimating the over-reporting factor for COVID-19 deaths for the particular case of ages 35 to 44, we generalize our analysis for all ages in Section 5.

### 4 ANALYSIS OF DEATH RATES FROM INFLUENZA & PNEUMONIA (J09-J18) AND COVID-19

In this section we perform a yearly analysis of the death rates for individuals aged 35 to 44 in the US,

<sup>6</sup> <https://www.icd10data.com/ICD10CM/Codes/J00-J99/J09-J18/J12-J12.82>

<sup>7</sup> <https://www.cdc.gov/flu/symptoms/flu-vs-covid19.htm>

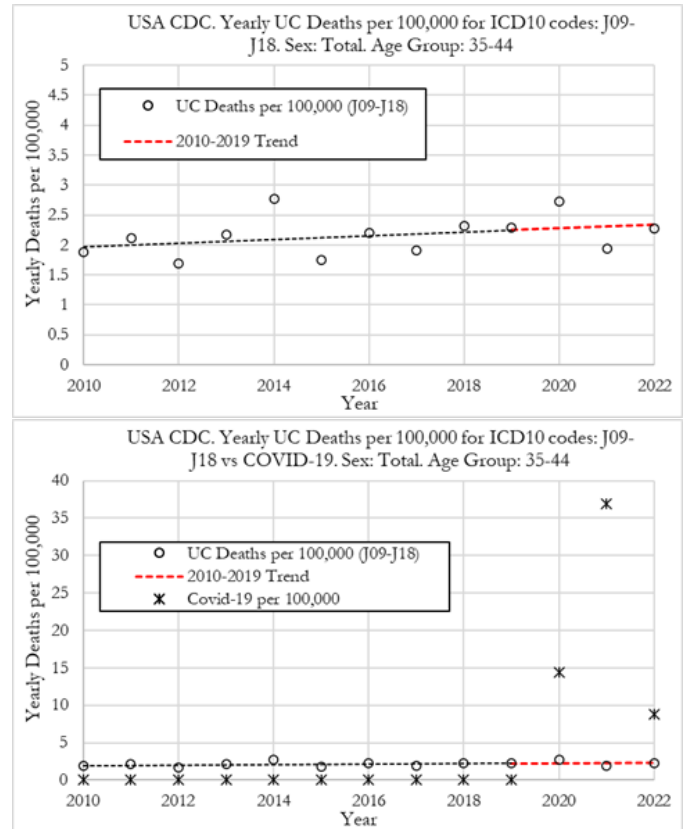
using the data from CDC WONDER. We first compute the ratio of MC/UC deaths for both COVID-19 and Influenza & Pneumonia and then calculate the respective adjustment factors which are applied to the UC COVID-19 death rates. The analysis of the 35 to 44 age group is a case study that is then generalized to the whole population in the next chapter.

#### 4.1 UC Death Rates from Influenza & Pneumonia (J09-J18) and COVID-19

We investigate death rates from Influenza & Pneumonia (J09-J18) and COVID-19 (U07.1 code) from 2010 to 2022 where these diseases were the underlying cause of death, as recorded on the death certificate (Figure 1). The death rates are computed as the number of deaths for a given year divided by the population cohort for the 35-44 age group. The death rates are shown as deaths per 100,000 population.

In Figure 1-top we can observe that the UC death rates from Influenza & Pneumonia were very stable from 2010 to 2022, with a slight upward trend. The death rate was 1.88 per 100,000 in 2010 and 2.28 per 100,000 in 2022. In 2020, the death rate from influenza and pneumonia was slightly above trend, at a value of 2.72 per 100,000 and in 2021 and 2022 the death rate was close to the 2010-2019 trendline.

From Figure 1-bottom we can observe that the UC death rates from COVID-19 in 35 to 44 year-olds were much higher than for Influenza & Pneumonia in 2020 and 2021. In 2020 the COVID-19 death rate was 14.4 per 100,000, double the rate for Influenza & Pneumonia, and in 2021 it was 36.9 per 100,000, around 19 times higher than Influenza & Pneumonia. In 2022, with the milder Omicron variant in circulation and the rollout of the COVID-19 vaccinations, the UC death rate from COVID-19 dropped to its lowest level since the start of the pandemic but was still 8.9 per 100,000 (3.9 times higher than death rates from Influenza and Pneumonia).



**Figure 1.** US CDC underlying cause deaths per 100,000 for individuals aged 35 to 44 for COVID-19 deaths and Influenza and Pneumonia (J09-J18). The red dashed line shows the trend from 2010 to 2019. Top: Influenza & Pneumonia (J09-J18). Bottom: Influenza & Pneumonia vs COVID-19.

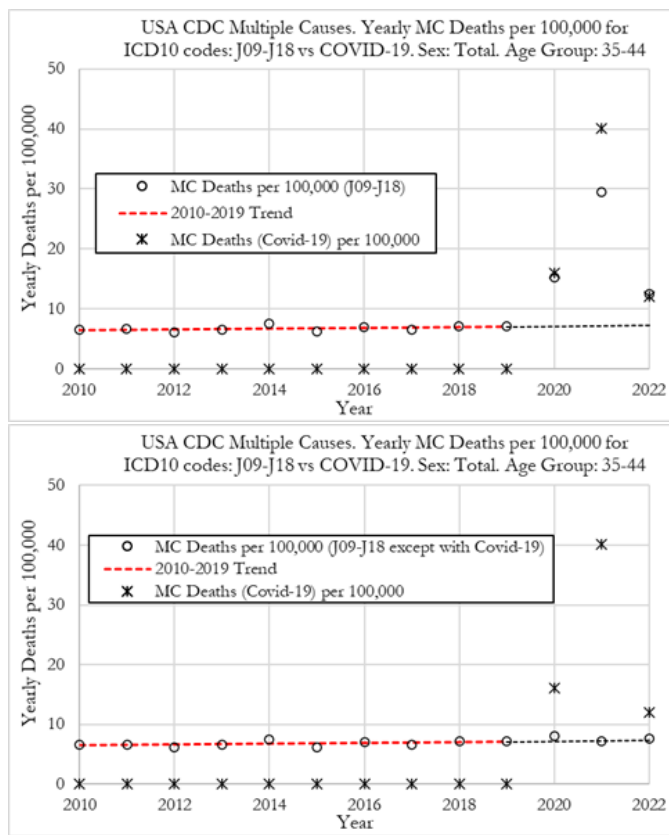
#### 4.2 MC Death Rates from Influenza & Pneumonia (J09-J18) and COVID-19

In this section, we investigate death rates from Influenza & Pneumonia (J09-J18) and COVID-19 (U07.1 code) from 2010 to 2022 where these diseases were among the multiple cause of death (MC) i.e. recorded on the death certificate either as underlying cause or a contributing cause of death (Figure 2). The death rates are computed as the number of deaths for a given year divided by the population cohort for the 35-44 age group. The death rates are shown as MC deaths per 100,000 population.

In the Figure 2-top we can observe that the MC death rates from Influenza & Pneumonia were very stable from 2010 to 2019, with a slight upward trend. The death rate was 6.6 per 100,000 in 2010 and 7.2

per 100,000 in 2019. In 2020, the MC death rate from Influenza & Pneumonia rose substantially, to a value of 15.2 per 100,000 and in 2021, and to 29.4 per 100,000. In 2022 the death rate from Influenza & Pneumonia was 12.6 per 100,000.

From Figure 2-top we can also observe that the MC death rate from COVID-19 was higher than for Influenza & Pneumonia in 2020 and 2021, but slightly lower in 2022. In 2020 the COVID-19 MC death rate was 16.0 per 100,000 in 2020, 40.1 per 100,000 in 2021, and 12.0 per 100,000 in 2022.



**Figure 2.** US CDC multiple cause deaths per 100,000 for individuals aged 35 to 44 for COVID-19-related deaths and Influenza and Pneumonia (J09-J18). The red dashed line shows the trend from 2010 to 2019. Top: MC death rates J00-J98. Bottom: MC death rates J09-J18 except where COVID-19 is mentioned.

In 2020, 2021 and 2022, MC death rates from Influenza & Pneumonia were of similar magnitude to those for COVID-19 which is the opposite of our previous findings when comparing UC death

rates. However, the increase in MC Influenza & Pneumonia during the pandemic is likely explained by people with another respiratory illness, for viral or bacterial pneumonia, dying from COVID-19 as the underlying cause.

Consequently, a fair comparison of MC Influenza & Pneumonia death rates with MC COVID-19 death rates should be done by removing all deaths where both Influenza & Pneumonia and COVID-19 appeared in the death certificates. This is done in Figure 2-bottom that compares MC death rates from Influenza & Pneumonia except where COVID-19 also appeared in the death certificates, with MC COVID-19 death rates.

After performing the adjustment, we can observe that MC death rates from Influenza & Pneumonia do not deviate from the 2010-2019 trend. We also notice that MC death rates from COVID-19 in 2020 and 2021 were substantially higher than MC death rates for Influenza & Pneumonia. In 2022 however, after the adjustment, even though MC death rates from COVID-19 were still higher than MC death rates from Influenza & Pneumonia, they were of comparable magnitude.

### 4.3 Comparison of Ratio of MC/UC Death Rates from Influenza & Pneumonia (J09-J18) with COVID-19

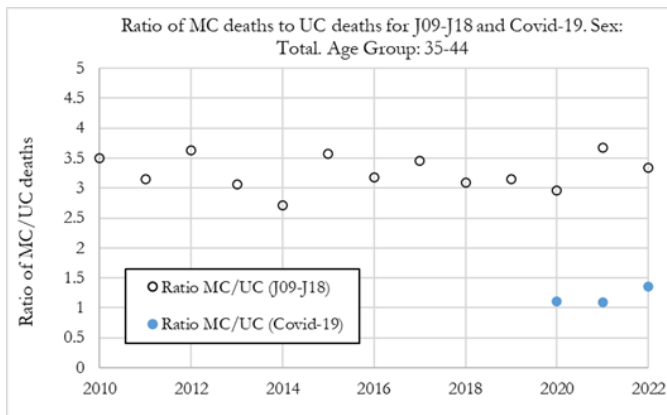
In this section, we compute the ratio of  $R_{J09-J18}^* = MC_{J09-J18}^*/UC_{J09-J18}$  death rates from Influenza & Pneumonia (J09-J18) and compare them with the equivalent ratio  $R_{C19} = MC_{C19}/UC_{C19}$  for COVID-19 (U07.1 code), from 2010 to 2022 (see Figure 3). The ratio  $R_{J09-J18}^* = MC_{J09-J18}^*/UC_{J09-J18}$  death rates for Influenza & Pneumonia was computed using the adjusted MC\* death rates, which is the MC death rates from Influenza & Pneumonia except where COVID-19 is mentioned in the death certificate, as shown in Figure 2-bottom.

The results in Figure 3 show that the ratio of  $MC_{J09-J18}^*/UC_{J09-J18}$  death rates are stable both before the pandemic years, from 2010 to 2019, and also during 2020, 2021 and 2022, within the



range of 2.5 to 4. The 2010 to 2015 average was about 3.3. These values mean that deaths from Influenza & Pneumonia as the underlying cause of death were 30.3% of those that appeared as multiple causes (which includes those recorded as underlying cause).

For COVID-19 deaths, Figure 3 shows that the ratio of MC C19/UC C19 death rates was 1.11 in 2020, 1.09 in 2021, and 1.36 in 2022. These values mean that about 90% of deaths from COVID-19 were registered as the underlying cause of death on the death certificate in 2020 and 2021. In 2022, even though a higher proportion of deaths relating to COVID-19 were classified with COVID-19 as a secondary cause of death, 73% of COVID-19 deaths still had COVID-19 classified as being the underlying cause.



**Figure 3.** Ratio of  $MC/UC$  deaths for Influenza and Pneumonia (J09-J18) and COVID-19. The ratio of  $MC/UC$  death rates for Influenza and Pneumonia (J09-J18) excludes MC deaths where COVID-19 is mentioned.

As previously mentioned, a possible criterion for estimating the over/under-classification factor in attributing COVID-19 deaths as the underlying cause of death is to make the assumption that the ratio of COVID-19 deaths appearing in the multiple-cause of deaths fields of the death certificate by the COVID-19 deaths as underlying cause should be similar to the equivalent ratio for Influenza & Pneumonia. We can then adjust COVID-19 deaths to

compensate for systematic under/over-estimation of COVID-19 deaths.

The formula for the adjustment factor,  $F$ , is simply:

$$F = \frac{R_{J09-J18}^*}{R_{C19}} = \frac{MC_{J09-J18}^*/UC_{J09-J18}}{MC_{C19}/UC_{C19}} \quad (1)$$

Where  $R_{J09-J18}^*$  refers to the ratio of death rates for Influenza & Pneumonia that was computed using the adjusted  $MC_{J09-J18}^*$  death rates, which is the MC death rates from Influenza & Pneumonia except where COVID-19 is mentioned on the death certificate.

Consequently, by using the values shown in Figure 3 we estimate that the over-reporting factor for UC deaths from COVID-19 in 35 to 44 year-olds is 2.7 in 2020, 3.4 in 2021 and 2.5 in 2022. We can then divide the computed UC death rates from COVID-19 by the adjustment factor and obtain the death rate from COVID-19 that one would expect if the ratio of COVID-19  $MC/UC$  ratio were similar to the equivalent ratio for Influenza & Pneumonia.

In the next chapter we compute, for all age groups, the adjustment factor and adjusted COVID-19 UC death rates, using the same process as described previously for the 35-44 age group.

## 5 ANALYSIS OF INFLUENZA & PNEUMONIA AND COVID-19 FOR ALL AGES

In this chapter we generalize the previous analysis for all age groups. We first compute the ratio of  $MC/UC$  deaths for both COVID-19 and Influenza & Pneumonia for each age group and then calculate the respective adjustment factors which are applied to the UC COVID-19 death rates for that age group.

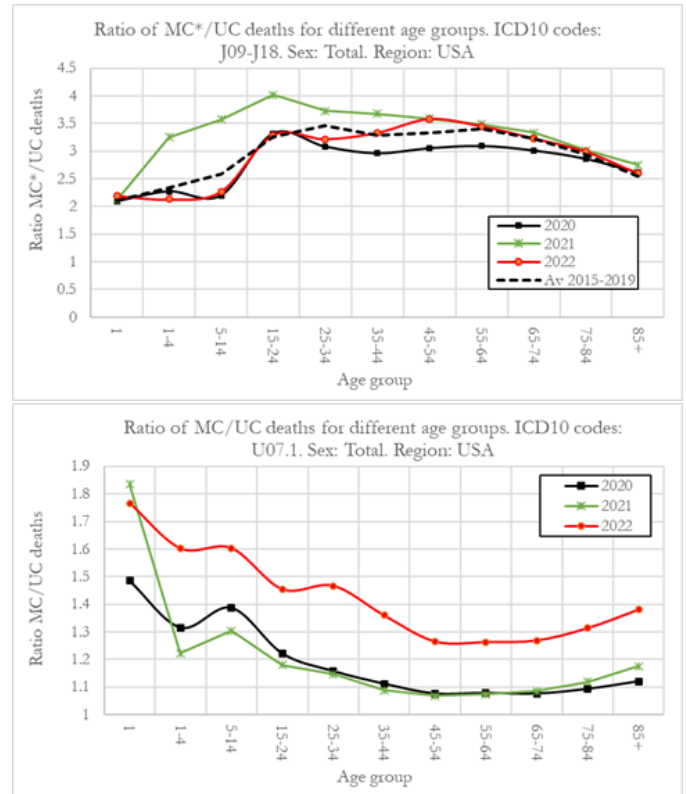
### 5.1 Ratio of MC/UC Death Rates from Influenza & Pneumonia versus COVID-19

In this section, we compute, for each age group, for 2020, 2021 and 2022, the ratio of  $R_{J09-J18}^* = MC_{J09-J18}^*/UC_{J09-J18}$  death rates from Influenza & Pneumonia (J09-J18), and for COVID-19 (U07.1), (see Figure 4). The ratio  $R_{J09-J18}^* = MC_{J09-J18}^*/UC_{J09-J18}$  death rates for Influenza & Pneumonia was computed using the adjusted MC\* death rates, which is the MC death rates from Influenza & Pneumonia except where COVID-19 is mentioned on the death certificate. For Influenza & Pneumonia, for comparison, we also plot the average ratio from 2015 to 2019.

When analyzing Figure 4-top we can observe that the ratio of MC\*/UC death rates from Influenza & Pneumonia in 2020 and 2022 are in line with the historical average for 2015 to 2019. In 2021 the ratio increases, particularly for younger individuals aged 45 or less. We can also observe that the ratio is particularly high for ages 5 to 54 ranging between about 3.5 and 4. The ratio is lower for individuals aged 75 or older, ranging between about 2.5 and 3.

Figure 4-bottom we can observe that the ratio of MC/UC death rates for COVID-19 in 2020, 2021 and 2022 tend to follow a similar pattern where the ratio is higher for younger individuals and lower for older individuals. In 2020 and 2021 the ratio was close to 1.1 for ages 34 and higher, which means that almost all COVID-19-related deaths were classified as death from COVID-19 (it was the underlying cause of death). For 2022 we can notice that the ratio increased for all age groups, which can be explained by COVID-19 becoming milder over time. Yet, for ages 35 and above the ratio still ranged between 1.25 and 1.4 which means that COVID-19 was still mostly classified as the underlying cause of death. This was the case even for younger individuals where the ratio was always below 2.

When computing the ratios, shown in Figure 4 for all ages, we estimate that for Influenza & Pneumonia, in 2020 the ratio was 2.84, in 2021 was 3.09



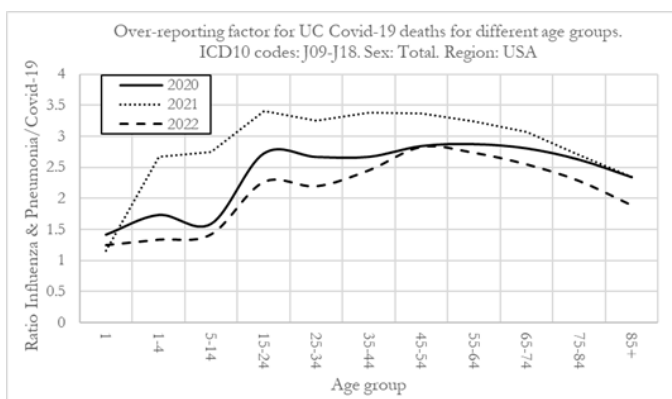
**Figure 4.** Ratio of MC/UC deaths for all age groups in the US. Top: Influenza & Pneumonia (J09-J18). Bottom: COVID-19. The ratio of MC/UC death rates for Influenza & Pneumonia (J09-J18) excludes MC deaths where COVID-19 is mentioned.

and 2022 it was 2.99. These values are equivalent to saying that the percentage of MC Influenza & Pneumonia reported as underlying cause of death was 35.2%, 32.3% and 33.5% for 2020, 2021 and 2022, respectively. For COVID-19, the equivalent ratio for all ages was 1.10 in 2020, 1.11 in 2021 and 1.32 in 2022, corresponding to a percentage of MC COVID-19 reports with COVID-19 as the underlying cause of death of 91.2%, 90.2% and 75.9% for 2020, 2021 and 2022, respectively. We can notice that the ratio of MC/UC deaths for Influenza & Pneumonia was very stable with about 1/3 of these deaths being reported as the underlying cause. For COVID-19 however, around 90% of deaths were recorded as the underlying cause in 2020 and 2021, and a lower level of 75.9% in 2022. COVID-19 deaths as the underlying cause are over-reported when compared to Influenza & Pneumonia.

## 5.2 COVID-19 over-reporting factor

We now compute the adjustment factor for the over/under classification in attributing COVID-19 deaths as the underlying cause of death, using the formula shown in Equation 1.

Figure 5 shows the adjustment factor for 2020, 2021 and 2022, for the different age groups in the US. It can be observed that there is a systematic over-reporting of COVID-19 as the underlying cause of death compared to Influenza & Pneumonia. The average over-reporting factor is between 1.2 and 3.5 for all ages. However, one can notice that for ages 15 to 74 the over-reporting factor is higher than for younger and older individuals. For individuals aged 15 to 74 the over-reporting factor ranged from 2.3 to 3.5 between 2020 and 2022. For younger individuals aged 1-4 and 5-14, the over-reporting factor was low, with the exception of 2021. For individuals with less than 1 year old, the over-reporting factor was consistent from 2020 to 2022 at around 1.3. The over-reporting factor is also lower for older individuals (aged 75 and over) ranging between 1.8 and 2.8. The over-reporting factors for each age group in 2020, 2021 and 2022 can be found in Table 1, shown in Appendix.



**Figure 5.** 2020, 2021 and 2022 over-reporting adjustment factor for COVID-19 deaths as underlying cause when compared to Influenza & Pneumonia (J09-J18), for all age groups in the US.

Overall, we also notice that there appears to be a systematic over-reporting of COVID-19 deaths as the underlying cause, which is consistent across all

ages. To be clear, the adjustment factors above refer to the multiple by which COVID-19 underlying cause deaths are over-reported relative to Influenza & Pneumonia (J09-J18). An adjustment factor of 2 signifies that COVID-19 underlying cause deaths should be 50% of the reported values.

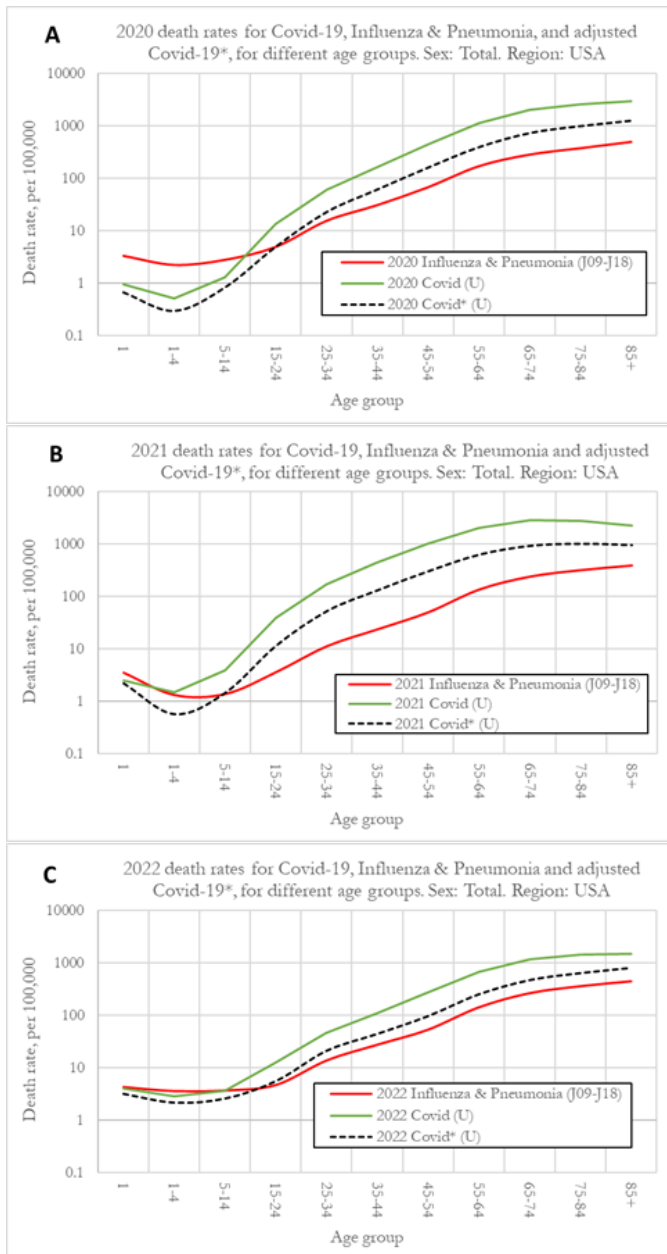
## 5.3 Comparison of Adjusted UC Death Rates from Influenza & Pneumonia and COVID-19

Once the over-reporting factors are computed, we now calculate the adjusted UC death rates from COVID-19\* and compare them with the un-adjusted death rates from COVID-19 and death rates from Influenza & Pneumonia, as shown in Figure 6. All the death rates refer to the respective diseases as the underlying cause of death. Panel A shows the death rates for 2020, Panel B for 2021 and Panel C for 2022. The dashed lines refer to adjusted death rates for COVID-19\*, where the adjustment is performed using the adjustment factors computed in the previous section 5.2. The full results for the death rates and adjustment factors can be found in Table 1, in Appendix.

The results for 2020 (Figure 6-A), show UC death rates from COVID-19 were higher than death rates for Influenza for age groups 15-24 and older. For younger individuals, death rates from COVID-19 were substantially lower than equivalent death rates from Influenza & Pneumonia. We also observe that death rates from COVID-19 for individuals 55 and older were roughly 10x the death rates Influenza & Pneumonia.

After the adjustment for over-reporting, UC COVID-19\* death rates were still higher than those from Influenza & Pneumonia. For individuals aged 15-24 UC death rates from COVID-19\* were similar to those for Influenza and Pneumonia and for age group 25-34 and older they were higher.

When looking at Table 1 we can observe, for example, that for individuals aged 75-84, the death rate from COVID-19 before the adjustment was 2598 per 100,000, while after the adjustment it was 992 per 100,000. By comparison, the death rate



**Figure 6.** Comparison of underlying cause of death rates from Influenza & Pneumonia (J09-J18), COVID-19 and adjusted COVID-19\* for different age groups in the US. Panel A – 2020. Panel B – 2021. Panel C – 2022.

from Influenza & Pneumonia was 370 per 100,000. In another example, for the 15-24 age group, the un-adjusted UC death rate from COVID-19 was 13.4 per 100,000, while after the adjustment it was 4.9 per 100,000. For comparison, for Influenza & Pneumonia the rate was 4.9 per 100,000 for this age group.

The results for 2021 (Figure 6-B), show UC death rates from COVID-19 were generally higher than in 2020. Additionally, we observe that death rates from Influenza & Pneumonia were lower for age groups 1-4, 5-14 and 15-24 in 2021. We should note that in general, death rates from Influenza & Pneumonia were stable during 2020, 2021 and 2022 with the exception of the previously stated drop in death rates for younger individuals in 2021 and a rise in death rates for these same age groups in 2022.

Before applying the over-reporting adjustment factors, in 2021 COVID-19 death rates were higher than death rates from Influenza & Pneumonia for age groups older than 5-14. For the younger age groups under 1 and 1-4, death rates from Influenza & Pneumonia and COVID-19 were similar. After applying the adjustment factors for 2021, we can observe that UC COVID-19\* death rates were much lower due to the higher over-reporting adjustment factors (Figure 5). However, even after the adjustment, UC COVID-19\* death rates were still much higher than death rates from Influenza & Pneumonia for age groups 15-24 and older, but lower for the younger age groups.

The results for 2022 (Figure 6-C), show that UC death rates from COVID-19 dropped significantly but were still substantially higher than those for Influenza & Pneumonia. After adjusting for over-reporting using the adjustment factor, UC death rates from COVID-19\* were of similar magnitude to those from Influenza & Pneumonia. For all age groups from 15-24 and older, UC death rates from COVID-19\* were slightly higher than those from Influenza & Pneumonia, while for younger individuals aged 5-14 or less, they were slightly lower.

We also make the observation that UC death rates from COVID-19\* for younger individuals aged 5-14 and lower were at their lowest in 2020, then rose in 2021 and in 2022 were at their highest level, which is strange to reconcile for our understanding that the

different SARS-CoV-2 virus variants were successively milder (and more contagious) over time, with the milder Omicron variant being prevalent in 2022.

## 6 SUMMARY AND CONCLUSION

In our study we estimate the degree to which COVID-19 is over-reported as the underlying cause of death in the US. We calculate the over-reporting adjustment factor by comparing the ratios of reporting of COVID-19 as a multiple cause of death with underlying cause of death, with the equivalent ratio for Influenza & Pneumonia (ICD-10 codes J09-J18). We operate under the assumption that Influenza & Pneumonia diseases are comparable (of similar nature) to COVID-19.

We conclude that there appears to be a systematic over-reporting of COVID-19 when reported as the underlying cause of death compared to Influenza & Pneumonia. The over-reporting factor is higher for age groups 15-24 and older ranging from 1.89 to 3.4 between 2020 and 2022, and lower for younger individuals. The highest over-reporting factors were observed in 2021 while over-reporting factors in 2020 and 2022 were similar to each other. The detailed estimates for the over-reporting factor for all age groups in 2020, 2021 and 2022 can be found in Table 1.

When comparing underlying cause death rates for different age groups for COVID-19 with death rates from Influenza & Pneumonia, we observe that UC COVID-19 death rates were higher than those for Influenza and Pneumonia from age group 15-24 and older. After performing the adjustment for the estimated over-reporting factor, we observe that UC COVID-19\* death rates are still higher than for Influenza and Pneumonia for ages 25-34 and older and the equivalent for age group 15-24. We also observe that the death rate from UC COVID-19 was higher in 2021.

We believe that the estimates computed above represent a first order approximation towards understanding the mortality patterns associated with COVID-19 and other diseases during the post 2020

period (pandemic and post pandemic). It should be noted that the over-reporting factors we compute only account for the relative over-reporting of COVID-19 as the underlying cause of death as opposed to as a contributing cause, when compared with Influenza and Pneumonia, therefore they contribute to the ongoing discussion of death “with” COVID-19 versus “from” COVID-19.

### *Future work*

The overall over(under)-reporting of COVID-19 deaths (either as UC or MC) relative to Influenza and Pneumonia are not estimated in this work. As noted by (Ioannidis, et al., 2021)[3], due to the incentives for recording positive SARS-CoV-2 tests, developed countries are likely to also have an over-reporting bias in the number of deaths attributed to COVID-19, when compared to other diseases. Further work is needed to understand the extent to which this occurred (or not).

Finally, during our research, we also observed several effects that are beyond the scope of this paper that we believe healthcare professionals would find of interest to investigate further. In particular, a detailed analysis for each age group, with particular focus on individuals aged 14 and lower would be of interest.

## CONFLICT OF INTEREST STATEMENT

None that the authors are aware of.

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APPENDIX

Summary table with adjusted death rates for UC COVID-19.

2020 Age Group	UC Death Rate per 100,000			Adjustment Factor (over-reporting factor)	COVID-19* / (J09-J18)
	Influenza & Pneumonia (J09-J18)	COVID-19	COVID-19*		
1	3.35	0.94	0.66	1.41	0.20
1-4	2.25	0.51	0.29	1.73	0.13
5-14	2.81	1.31	0.83	1.59	0.29
15-24	4.95	13.41	4.94	2.72	1.00
25-34	15.48	60.35	22.67	2.66	1.46
35-44	30.74	162.76	61.11	2.66	1.99
45-54	67.23	454.19	160.11	2.84	2.38
55-64	168.54	1126.90	392.94	2.87	2.33
65-74	208.05	2042.22	729.47	2.80	2.60
75-84	370.33	2597.85	992.26	2.62	2.68
85+	487.79	2932.50	1255.20	2.34	2.57

2021 Age Group	UC Death Rate per 100,000			Adjustment Factor (over-reporting factor)	COVID-19* / (J09-J18)
	Influenza & Pneumonia (J09-J18)	COVID-19	COVID-19*		
1	3.51	2.55	2.21	1.16	0.63
1-4	1.32	1.51	0.57	2.66	0.43
5-14	1.37	3.98	1.45	2.74	1.06
15-24	3.59	39.30	11.54	3.41	3.21
25-34	11.22	172.06	52.97	3.25	4.72
35-44	23.62	449.04	132.85	3.38	5.62
45-54	50.02	1034.68	307.73	3.36	6.15
55-64	135.92	2068.32	637.63	3.24	4.69
65-74	238.97	2881.64	937.33	3.07	3.92
75-84	317.77	2771.98	1029.01	2.69	3.24
85+	388.61	2270.56	969.98	2.34	2.50

2022 Age Group	UC Death Rate per 100,000			Adjustment Factor (over-reporting factor)	COVID-19* / (J09-J18)
	Influenza & Pneumonia (J09-J18)	COVID-19	COVID-19*		
1	4.35	3.96	3.18	1.24	0.73
1-4	3.65	2.89	2.17	1.33	0.60
5-14	3.73	3.68	2.59	1.42	0.70
15-24	4.74	12.54	5.54	2.26	1.17
25-34	13.89	46.04	20.98	2.19	1.51
35-44	27.63	107.81	43.99	2.45	1.59
45-54	53.47	271.43	95.90	2.83	1.79
55-64	142.10	680.38	248.87	2.73	1.75
65-74	263.96	1179.92	463.17	2.55	1.75
75-84	358.09	1436.11	629.84	2.28	1.76
85+	444.16	1488.94	789.52	1.89	1.78

**Table 1.** Adjustment of death rates for COVID-19 as underlying cause of death. Comparison with UC death rates for Influenza and Pneumonia. US, 2020, 2021 and 2022, all ages, both sexes. \*Refers to adjusted COVID-19 UC death rates. The last column refers to the ratio of COVID-19\* to Influenza and Pneumonia death rates.