



# Assessing the quality of cause-of-death reporting before and during the COVID-19 pandemic

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## Abstract

This study assessed the quality of cause-of-death reporting in the United States before and during the COVID-19 pandemic. We used the selection rate and the adjusted odds ratio (aOR) to analyze each cause identified by the National Center for Health Statistics as unsuitable for the underlying cause of death (UCOD). The selection rate was defined as the proportion of deaths with mention of a particular unsuitable UCOD on the death certificate where that cause was ultimately selected as the UCOD. Out of 36 unsuitable UCODs, 33 exhibited a significant decline in selection rates from 2019 to 2021. However, when deaths with mention of COVID-19 on the death certificate were excluded, only 19 causes revealed a significant decline. In analyses that controlled for the age of decedents, aORs in 2021 were significantly lower compared with 2019 for 26 causes, and this number decreased to 17 causes in analyses that excluded COVID-19-related deaths. In conclusion, the overall quality of COD reporting improved during the COVID-19 pandemic, attributable mainly to the fact that over one-tenth of the deaths were related to COVID-19. Yet, for deaths that did not involve COVID-19, improvements in the quality of COD reporting were less prominent for certain causes.

**Key words:** quality of cause-of-death reporting; underlying cause of death; COVID-19.

## Introduction

High quality cause-of-death (COD) reporting is the cornerstone of reliable COD data, which are crucial for monitoring the impact of the coronavirus disease 2019 (COVID-19) pandemic on a population's health.<sup>1–4</sup> To rapidly respond to the growing need for accurate, comprehensive, and timely data on deaths attributed to COVID-19, the US National Center for Health Statistics (NCHS) issued preliminary certification guidance on March 4, 2020, and comprehensive guidance on April 2, 2020. Moreover, the NCHS modified their internal data processing systems and established a surveillance system to provide daily updates on COVID-19 deaths and to monitor closely the impact of the COVID-19 pandemic on mortality in the United States.<sup>5–7</sup> However, whether the quality of COD reporting in the United States improved during the COVID-19 pandemic remains unclear. Before the assessment, we performed a brief review of the literature regarding measures used to evaluate the quality of COD reporting in a country or across countries. Our review excluded studies that examined COD reporting quality in hospital settings.

## A review of measures used to evaluate the quality of COD reporting

The World Health Organization (WHO) introduced a measure in the World Health Statistics Annual of 1988 to assess the quality of COD reporting, which considers the proportion of deaths attributed to the chapter "Symptoms, Signs, and Ill-Defined Con-

ditions" in the International Statistical Classification of Diseases and Related Health Problems, Ninth and Tenth Revision, codes (ICD-9 codes 780–799 and ICD-10 codes R00–R99).<sup>8,9</sup> A higher proportion indicates a lower quality of COD reporting. In a 2003 study assessing the quality of COD reporting among 105 WHO member countries, certain ill-defined codes were included, such as injuries where the intent is undetermined, cardiovascular disease categories lacking diagnostic meaning, and cancer deaths coded to categories for secondary or unspecified sites; the median proportion among these 105 countries was 4%.<sup>10</sup> However, this measure has been criticized due to its exclusion of numerous ill-defined causes.<sup>11</sup>

A more inclusive measure, used by Murray and Lopez in the Global Burden of Disease (GBD) Study in 1996, is the proportion of all deaths assigned to "garbage codes," which hold little value for public health analysis of COD data. Garbage codes can be categorized into 4 types: (1) causes that cannot or should not be considered as the underlying COD (UCOD), such as essential hypertension (which is a risk factor rather than UCOD), long-term disease sequelae, and all codes in Chapter 18 of the ICD-10; (2) intermediate causes, such as heart failure and septicemia; (3) immediate causes that are part of the final step in the disease pathway leading to death, including cardiac arrest and respiratory failure; and (4) unspecified causes within a broader cause grouping, exemplified by a neoplasm of an unspecified site.<sup>12–15</sup>

A sophisticated data quality assessment tool, known as Analysis of Causes of National Deaths for Action (ANACONDA), has been developed and utilized under the Bloomberg Data for Health

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Initiative at the University of Melbourne.<sup>16-18</sup> ANACONDA ranks garbage codes into 4 levels based on their policy impact. Level 1 (very high) comprises codes with severe policy implications, representing causes for which the true UCOD can belong to more than one broad cause group, such as septicemia. Level 2 (high) comprises codes with substantial implications, representing causes for which the true UCOD is likely to belong to only one or 2 of the 3 broad groups, such as essential hypertension. Level 3 (medium) comprises codes with crucial implications, representing causes for which the true UCOD is likely to be within the same ICD chapter, such as unspecified cancer. Level 4 (low) comprises codes with limited implications, representing diagnoses for which the true UCOD is likely confined to a single disease or injury category, such as unspecified stroke, which remains within the stroke category. Quality assessment further involves analyzing death distributions across the 3 broad GBD disease groups: communicable diseases, noncommunicable diseases, and external causes. This evaluation determines whether death pattern align with expectations based on the country's epidemiologic transition.

In 2021, the NCHS compiled a condensed list of unsuitable UCODs (aligned with the GBD categorization), dividing them into 3 subtypes with 36 subcategories: (1) the "unknown and ill-defined causes" subtype, which comprises 4 subcategories such as cardiac arrest and respiratory failure; (2) the "immediate and intermediate causes" subtype, which comprises 17 subcategories such as heart failure, chronic kidney disease, atrial fibrillation and flutter, sepsis, and pneumonia; and (3) the "nonspecific causes" subtype, which comprises 15 subcategories such as unspecified diabetes mellitus, unspecified dementia, atherosclerotic heart disease, malignant neoplasm without a specified site, and strokes not specified as hemorrhage or infarction.<sup>19</sup>

The NCHS list is superior to aforementioned lists in 2 respects. First, the list's categorization into 3 subtypes with a manageable number of causes (4, 17, and 15, respectively) offers a more practical approach compared with the garbage codes defined in the 2019 GBD study (146 for level 1, 76 for level 2, 199 for level 3, and 42 for level 4).<sup>20</sup> This simplified list allows for all causes to be captured in a single table for comparison. Such arrangement aids in the identification of causes that demand intervention due to their effect on quality of mortality data. Second, the nomenclature for the subtypes in the NCHS list (eg, unknown and ill-defined causes, immediate and intermediate causes, and nonspecific causes) provides clearer insight into the nature of COD reporting problems than the generic labels (eg, type 1 to 4 or level 1 to 4) used in previous lists, which emphasize the influence on policy decisions without adequately clarifying the underlying quality problems. The terminology used for 3 subtypes in NCHS list can help readers grasp both the format and effects of the problems related to COD reporting quality.

## Limitation and proposed solution

The measure of quality for COD reporting requires more refined comparative analyses. The NCHS reported that in 2018, among 2 846 305 deaths in the United States, 34.7% had an unsuitable UCOD. Specifically, 2.2% were attributed to unknown or ill-defined causes, 12.7% were attributed to immediate or intermediate causes, and 19.8% were attributed to nonspecific causes. The proportion of total unsuitable UCODs declined by 0.6% annually from 2013 to 2018.<sup>19</sup> The comparisons of proportions between causes and across years are inadequate because the variations in proportions of particular causes (eg, cancer of an unspecified site) might result from shifts in other causes (eg, unspecified diabetes mellitus or unspecified dementia) instead of actual changes in

certification behaviors for a particular cause (eg, cancer with specific site).

We proposed the "selection rate" as a measure of COD reporting quality, which is defined as proportion of deaths with mention of particular unsuitable UCODs on the death certificate that was ultimately selected as the UCOD. For example, although sepsis can be appropriately cited as an immediate or intermediate cause on a death certificate, it is not appropriate as a UCOD. The denominator of the selection rate is the number of deaths attributed to a particular unsuitable UCOD, akin to the population at risk in the calculation of an incidence rate. Table 1 illustrates 9 sepsis-related COD reporting patterns. The numerator of the selection rate is the number of deaths where the particular cause is selected as the UCOD, akin to the occurrence of events in an incidence rate. In 5 COD reporting patterns (scenarios 5 to 9 in Table 1), sepsis was selected as the UCOD, for a selection rate of 0.56 (5/9).

The concept of the selection rate is inspired by 2 quality measures assessing the accuracy of reported cancer sites reported on death certificates: (1) the "detection rate," which is defined as proportion of hospital diagnoses of a particular cancer site that is accurately reflected as the UCOD on death certificates, and (2) the "confirmation rate" which is defined as proportion of UCOD for a particular cancer site confirmed by hospital diagnoses.<sup>21-24</sup> Furthermore, several researchers have used selection rates to assess the COD reporting quality for deaths related to diabetes,<sup>25</sup> stroke,<sup>26</sup> and injury,<sup>27</sup> where the numerator is the number of deaths with an unspecified code as the UCOD, and the denominator is the total number of deaths attributed to diabetes, stroke, or injury.

## Aim of this study

The aim of our study was to determine whether the quality of COD reporting in the United States has improved following the year 2019, a period during which numerous interventions were launched by the NCHS in response to the COVID-19 outbreak that began in the United States in March 2020. Our analysis aimed to assess the changes in the quality of COD reporting before (2019) and throughout (2020 and 2021) the pandemic. We calculated the "selection rate" for each unsuitable UCOD as a measure to assess the quality of COD reporting across the 3 years under study.

The NCHS guidance, issued in March and April 2020, was primarily directed at accurately certifying COVID-19-related deaths. The effect of these guidelines on the reduction of unsuitable UCODs when COVID-19 was mentioned on the death certificate remains uncertain. Consequently, to assess improvements in COD reporting quality for non-COVID-19-related deaths, we further examined the selection rates of 36 unsuitable UCODs for deaths that did not mention COVID-19 on the death certificate in 2020 and 2021.

## Methods

For our analysis, we utilized the Mortality Multiple Cause-of-Death Public Use Record files for the years 2019, 2020, and 2021.<sup>28</sup> We identified unsuitable UCODs based on the data item "underlying cause." Furthermore, we determined the mention of unsuitable UCODs and COVID-19 on death certificates using the S

First, we presented the proportion of each unsuitable UCOD among all deaths for the years 2019, 2020, and 2021. Second, we calculated the selection rate for each unsuitable UCOD in these years. The denominator of the selection rate is the number of deaths with mention of an unsuitable UCOD on the death certificate. The numerator of the selection rate is the number of deaths

**Table 1.** Examples of cause-of-death reporting with a mention of sepsis on the death certificate.

| <b>Scenario 1</b>                  | <b>Scenario 2</b>        | <b>Scenario 3</b>  |
|------------------------------------|--------------------------|--|
| Part I                             | Part I                   | Part I   |
| a) Renal failure                   | a) Sepsis                | a) Sepsis  |
| b) Sepsis                          | b) Pulmonary embolism    | b) Skin abscess  |
| c) Peritonitis                     | c) COVID-19 <sup>a</sup> | c) Psychoactive substance abuse <sup>a</sup>                           |
| d) Colon cancer <sup>a</sup>       | d)                       | d)   |
| Part II Hypertension, diabetes     | Part II Stroke           | Part II  |
| <b>Scenario 4</b>                  | <b>Scenario 5</b>        | <b>Scenario 6</b>  |
| Part I                             | Part I                   | Part I   |
| a) Hypovolemic shock               | a) Sepsis <sup>a</sup>   | a) Heart failure   |
| b) Sepsis                          | b) Bacterial infection   | b) Respiratory failure   |
| c) Acute pancreatitis <sup>a</sup> | c)                       | c) Sepsis <sup>a</sup>   |
| d)                                 | d)                       | d)   |
| Part II Alcoholism                 | Part II Dementia         | Part II  |
| <b>Scenario 7</b>                  | <b>Scenario 8</b>        | <b>Scenario 9</b>  |
| Part I                             | Part I                   | Part I   |
| a) Cardiac arrest                  | a) Hypovolemic shock     | a) Sepsis <sup>a</sup> , skin abscess,<br>psychoactive substance abuse |
| b) Hypotension                     | b) Acute pancreatitis    | b)   |
| c) Acidosis                        | c) Sepsis <sup>a</sup>   | c)   |
| d) Sepsis <sup>a</sup>             | d)                       | Part II  |
| Part II                            | Part II Alcoholism       |  |

Abbreviation: COVID-19, coronavirus disease 2019.

<sup>a</sup>As the underlying cause of death.

in which the unsuitable UCOD in question was ultimately selected as the UCOD. Third, we recalculated the selection rates after excluding deaths mentioning COVID-19 on the death certificate to assess the changes in quality of COD reporting among non-COVID-19-related deaths. We used the Cochran-Armitage trend test to examine whether changes in the proportions and selection rates from 2019 through 2021, were statistically significant. Fourth, we estimated the adjusted odds ratio (aOR) and the 95% CI for the selection of each unsuitable UCOD as the UCOD. Specifically, we used the odds of the subcategory "26. Atherosclerotic heart disease" (the cause with the largest number of deaths) in 2019 as reference. We controlled for the age of decedents in the multivariate logistic regression model, given that the proportions and selection rates of unsuitable UCODs increased with the age of the decedents.<sup>19</sup>

Because publicly available mortality data were used in the analysis, patient consent was not required. This study was approved by the Institutional Review Board of National Cheng Kung University Hospital (A-EX-112-019).

## Results

In the United States, out of 2 861 523 deaths in 2019, 3 390 278 in 2020, and 3 472 120 in 2021, the proportions of all unsuitable UCODs were 34.4%, 30.7%, and 29.3%, respectively. This was a 5.1% decline from 2019 to 2021. According to Table 2, the subcategory with largest proportion was "26. Atherosclerotic heart disease" (5.7% in 2019 and 4.8% in 2021) followed by "24. Unspecified dementia" (3.4% in 2019 and 2.5% in 2021) and "15. Heart failure" (2.3% in 2019 and 4.8% in 2021).

The selection rate for each unsuitable UCOD across the 3 study years, both including and excluding deaths that mentioned COVID-19 on the death certificate, is illustrated in Table 3, with corresponding number of deaths in Table S1. The selection rate was low for unknown and ill-defined causes (6.2% in 2019 and 5.3% in 2021), moderate for immediate and intermediate causes (29.0% in 2019 and 22.0% in 2021), and high for nonspecific causes (56.2% in 2019 and 49.5% in 2021). The selection rate was highest

for "34. Unspecified fall" (73.0% in 2019 and 71.4% in 2021) followed by "25. Atherosclerotic cardiovascular disease, so described" (70.1% in 2019 and 67.2% in 2021) and "27. Chronic ischemic heart disease, unspecified" (53.4% in 2019 and 47.8% in 2021).

The Cochran-Armitage trend test revealed a significant decline in selection rates for 33 causes from 2019 to 2021. However, only 19 causes exhibited a significant decline after the exclusion of deaths with mention of COVID-19 on the death certificate. The magnitude of decline in selection rate was most prominent for "16. Pneumonia, organism unspecified," from 25.3% in 2019 to 12.8% in 2020 and 9.1% in 2021 among deaths including COVID-19-related deaths. Nevertheless, the selection rate remained relatively unchanged among non-COVID-19-related deaths, at 26.5% in 2020 and 26.4% in 2021.

Table 4 presents the aOR for each unsuitable UCOD being selected as the UCOD, with the age of decedents controlled for; the odds of "26. Atherosclerotic heart disease" was used as a reference, and the aORs when COVID-19-related deaths were included and excluded are presented for comparison. In 2021, the aORs were significantly lower than those in 2019 for 26 causes among all deaths, and for 17 causes among deaths that did not mention COVID-19 on the death certificate. Similar to the change in selection rates, the decline of aOR was most prominent for "16. Pneumonia, organism unspecified," which was 0.33 (95% CI, 0.33-0.34) in 2019, 0.15 (95% CI, 0.14-0.15) in 2020, and 0.10 (95% CI, 0.10-0.10) in 2021 among all deaths. However, the aOR was 0.35 (95% CI, 0.35-0.36) in 2020, and 0.35 (95% CI, 0.35-0.36) in 2021 among all deaths excluding COVID-19-related deaths.

## Discussion

The findings of this study indicate that the overall quality of COD reporting improved during the COVID-19 pandemic. This improvement is attributed to the reduction in deaths attributed to 3 immediate and intermediate causes (heart failure, kidney failure, and pneumonia) and 3 nonspecific causes (atherosclerotic heart disease, unspecified dementia, and unspecified stroke).

**Table 2.** Number of deaths and proportion of 36 unsuitable causes being selected as the underlying cause of death among all deaths in the United States for the years 2019, 2020, and 2021.

|  | Proportion, % |       |       | Difference <sup>a</sup> | P value <sup>b</sup> | No. of deaths as UCOD |           |           |
|--|---------------|-------|-------|-------------------------|----------------------|-----------------------|-----------|-----------|
|  | 2019          | 2020  | 2021  |                         |                      | 2019                  | 2020      | 2021      |
| All deaths   | 100.0         | 100.0 | 100.0 |                         |                      | 2 861 523             | 3 390 278 | 3 472 120 |
| Total unsuitable causes  | 34.4          | 30.7  | 29.3  | -5.1                    | <0.001               | 985 625               | 1 040 521 | 1 018 179 |
| Unknown and ill-defined causes   | 2.1           | 1.9   | 2.0   | -0.1                    | <0.001               | 61 129                | 65 617    | 70 683    |
| 1. Cardiac arrest  | 0.6           | 0.5   | 0.6   | 0.0                     | 0.0235               | 17 031                | 17 958    | 20 975    |
| 2. Respiratory failure, not elsewhere classified   | 0.4           | 0.4   | 0.4   | 0.0                     | 0.0020               | 12 690                | 14 706    | 14 831    |
| 3. Respiratory failure of newborn  | 0.0           | 0.0   | 0.0   | 0.0                     | 0.0202               | 33                    | 34        | 21        |
| 4. Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified | 1.1           | 1.0   | 1.0   | -0.1                    | <0.001               | 31 375                | 32 919    | 34 856    |
| Immediate and intermediate causes  | 12.5          | 10.9  | 10.4  | -2.1                    | <0.001               | 358 746               | 368 956   | 362 671   |
| 5. Sepsis, unspecified   | 1.3           | 1.1   | 1.1   | -0.1                    | <0.001               | 36 334                | 37 827    | 39 711    |
| 6. Secondary malignant neoplasm of respiratory and digestive organs                        | 0.1           | 0.1   | 0.1   | 0.0                     | <0.001               | 3342                  | 3311      | 3581      |
| 7. Secondary malignant neoplasm of other sites   | 0.1           | 0.1   | 0.1   | 0.0                     | <0.001               | 4066                  | 4053      | 4101      |
| 8. Other disorders of fluid, electrolyte and acid-base balance                             | 0.2           | 0.2   | 0.2   | 0.0                     | 0.0008               | 5962                  | 6519      | 6797      |
| 9. Anoxic brain damage, not elsewhere classified   | 0.2           | 0.2   | 0.2   | 0.0                     | <0.001               | 7111                  | 6992      | 7076      |
| 10. Pulmonary embolism   | 0.3           | 0.3   | 0.3   | 0.0                     | <0.001               | 8653                  | 9412      | 8902      |
| 11. Other secondary pulmonary hypertension   | 0.3           | 0.2   | 0.3   | 0.0                     | <0.001               | 8241                  | 8380      | 8700      |
| 12. Cardiomyopathy, unspecified  | 0.5           | 0.4   | 0.4   | -0.1                    | <0.001               | 15 172                | 14 879    | 13 916    |
| 13. Atrial fibrillation and flutter  | 0.9           | 0.8   | 0.8   | -0.1                    | <0.001               | 26 562                | 26 637    | 27 138    |
| 14. Other cardiac arrhythmias  | 0.3           | 0.3   | 0.3   | -0.1                    | <0.001               | 9514                  | 10 151    | 9806      |
| 15. Heart failure  | 3.0           | 2.5   | 2.3   | -0.7                    | <0.001               | 86 237                | 85 917    | 80 202    |
| 16. Pneumonia, organism unspecified  | 1.4           | 1.2   | 1.0   | -0.4                    | <0.001               | 39 197                | 40 971    | 35 098    |
| 17. Hepatic failure, not elsewhere classified  | 0.2           | 0.1   | 0.1   | 0.0                     | <0.001               | 4620                  | 4748      | 5128      |
| 18. Gastrointestinal hemorrhage, unspecified   | 0.3           | 0.3   | 0.3   | 0.0                     | <0.001               | 9434                  | 10 318    | 10 712    |
| 19. Acute renal failure, chronic kidney disease, and unspecified kidney failure            | 1.8           | 1.5   | 1.5   | -0.3                    | <0.001               | 50 591                | 51 531    | 51 329    |
| 20. Urinary tract infection, site not specified  | 0.4           | 0.4   | 0.4   | 0.0                     | 0.2974               | 11 204                | 12 470    | 13 369    |
| 21. Other immediate and intermediate causes  | 1.1           | 1.0   | 1.1   | -0.1                    | <0.001               | 32 506                | 34 840    | 37 105    |
| Nonspecific causes   | 19.8          | 17.9  | 16.8  | -2.9                    | <0.001               | 565 750               | 605 948   | 584 825   |
| 22. Malignant neoplasm, without specification of site                                      | 1.0           | 0.9   | 0.9   | -0.1                    | <0.001               | 28 550                | 28 885    | 29 800    |
| 23. Unspecified diabetes mellitus  | 1.8           | 1.7   | 1.6   | -0.1                    | <0.001               | 50 610                | 57 606    | 56 722    |
| 24. Unspecified dementia   | 3.4           | 3.1   | 2.5   | -0.9                    | <0.001               | 97 518                | 104 968   | 86 755    |
| 25. Atherosclerotic cardiovascular disease, so described                                   | 2.3           | 2.3   | 2.4   | 0.1                     | <0.001               | 66 486                | 77 528    | 83 268    |
| 26. Atherosclerotic heart disease  | 5.7           | 5.0   | 4.8   | -1.0                    | <0.001               | 163 787               | 170 048   | 165 238   |
| 27. Chronic ischemic heart disease, unspecified  | 0.3           | 0.3   | 0.2   | -0.1                    | <0.001               | 9112                  | 8795      | 8419      |
| 28. Cardiovascular disease, unspecified  | 0.3           | 0.3   | 0.2   | -0.1                    | <0.001               | 8959                  | 10 107    | 8555      |
| 29. Heart disease, unspecified   | 0.3           | 0.2   | 0.2   | 0.0                     | <0.001               | 7453                  | 7812      | 7603      |
| 30. Stroke, not specified as hemorrhage or infarction                                      | 1.9           | 1.6   | 1.5   | -0.4                    | <0.001               | 53 825                | 53 758    | 51 484    |
| 31. Cerebrovascular disease, unspecified   | 0.4           | 0.4   | 0.3   | -0.1                    | <0.001               | 10 344                | 11 966    | 10 795    |
| 32. Sequelae of stroke, not specified as hemorrhage or infarction                          | 0.4           | 0.3   | 0.3   | -0.1                    | <0.001               | 11 176                | 11 669    | 10 881    |
| 33. Liver disease, unspecified   | 0.1           | 0.1   | 0.1   | 0.0                     | <0.001               | 3718                  | 3747      | 3972      |
| 34. Unspecified fall   | 0.6           | 0.6   | 0.6   | 0.0                     | <0.001               | 17 611                | 18 968    | 19 642    |
| 35. Exposure to unspecified factor   | 0.2           | 0.2   | 0.2   | 0.0                     | <0.001               | 6385                  | 6269      | 6231      |
| 36. Other nonspecific underlying causes of death   | 1.1           | 1.0   | 1.0   | 0.0                     | <0.001               | 30 216                | 33 822    | 35 460    |

Abbreviation: UCOD, underlying cause of death.

<sup>a</sup>Difference = 2021-2019.<sup>b</sup>P value was based on Cochran-Armitage trend test.

**Table 3.** Selection rates (%) for 36 unsuitable causes being selected as the underlying causes of death including and excluding deaths with mention of COVID-19 on the death certificate in the United States for the years 2019, 2020, and 2021

|  | SR, % including COVID-19 |      |      | Difference <sup>a</sup> | P value <sup>b</sup> | SR, % excluding COVID-19 |      | Difference <sup>a</sup> | P value <sup>b</sup> |
|--|--------------------------|------|------|-------------------------|----------------------|--------------------------|------|-------------------------|----------------------|
|  | 2019                     | 2020 | 2021 |                         |                      | 2020                     | 2021 |                         |                      |
| Total unsuitable causes  | 47.4                     | 41.3 | 39.2 | -8.2                    | <0.0001              | 47.2                     | 46.1 | -1.3                    | <0.0001              |
| Unknown and ill-defined causes   | 6.2                      | 5.3  | 5.3  | -0.9                    | <0.0001              | 6.3                      | 6.6  | 0.4                     | <0.0001              |
| 1. Cardiac arrest  | 4.7                      | 4.2  | 4.1  | -0.6                    | <0.0001              | 4.6                      | 5.1  | 0.4                     | <0.0001              |
| 2. Respiratory failure, not elsewhere classified   | 3.9                      | 3.1  | 2.7  | -1.2                    | <0.0001              | 4.4                      | 4.2  | 0.3                     | 0.0115               |
| 3. Respiratory failure of newborn  | 1.6                      | 1.6  | 0.9  | -0.7                    | 0.0966               | 1.6                      | 1.0  | -0.6                    | 0.0471               |
| 4. Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified | 6.5                      | 5.7  | 5.6  | -0.9                    | <0.0001              | 6.4                      | 6.5  | 0.0                     | 0.1268               |
| Immediate and intermediate causes  | 29.0                     | 24.0 | 22.2 | -6.8                    | <0.0001              | 28.4                     | 27.7 | -1.3                    | <0.0001              |
| 5. Sepsis, unspecified   | 18.5                     | 16.0 | 15.3 | -3.2                    | <0.0001              | 18.8                     | 19.1 | 0.6                     | 0.0067               |
| 6. Secondary malignant neoplasm of respiratory and digestive organs                        | 5.3                      | 4.9  | 5.0  | -0.3                    | 0.0164               | 4.9                      | 5.0  | -0.3                    | 0.3705               |
| 7. Secondary malignant neoplasm of other sites   | 7.3                      | 6.9  | 6.6  | -0.7                    | <0.0001              | 7.0                      | 6.7  | -0.6                    | 0.0696               |
| 8. Other disorders of fluid, electrolyte and acid-base balance                             | 14.1                     | 12.3 | 11.2 | -2.9                    | <0.0001              | 14.0                     | 13.2 | -0.9                    | 0.0003               |
| 9. Anoxic brain damage, not elsewhere classified   | 24.2                     | 23.0 | 22.4 | -1.8                    | <0.0001              | 24.4                     | 24.8 | 0.6                     | 0.3270               |
| 10. Pulmonary embolism   | 22.9                     | 19.9 | 16.0 | -6.9                    | <0.0001              | 22.4                     | 20.5 | -2.4                    | <0.0001              |
| 11. Other secondary pulmonary hypertension   | 30.3                     | 28.0 | 26.9 | -3.4                    | <0.0001              | 29.3                     | 28.7 | -1.6                    | 0.0831               |
| 12. Cardiomyopathy, unspecified  | 45.5                     | 41.6 | 39.6 | -5.9                    | <0.0001              | 43.9                     | 42.4 | -3.1                    | <0.0001              |
| 13. Atrial fibrillation and flutter  | 14.5                     | 12.2 | 11.6 | -2.9                    | <0.0001              | 13.5                     | 13.1 | -1.4                    | <0.0001              |
| 14. Other cardiac arrhythmias  | 17.1                     | 16.3 | 15.3 | -1.8                    | <0.0001              | 16.9                     | 16.1 | -1.0                    | 0.0002               |
| 15. Heart failure  | 21.9                     | 19.6 | 18.2 | -3.7                    | <0.0001              | 20.9                     | 19.5 | -2.4                    | <0.0001              |
| 16. Pneumonia, organism unspecified  | 25.3                     | 12.8 | 9.1  | -16.2                   | <0.0001              | 26.5                     | 26.4 | 1.1                     | 0.8244               |
| 17. Hepatic failure, not elsewhere classified  | 15.1                     | 14.3 | 14.5 | -0.6                    | 0.0288               | 14.8                     | 15.2 | 0.1                     | 0.1499               |
| 18. Gastrointestinal hemorrhage, unspecified   | 24.3                     | 22.5 | 21.1 | -3.2                    | <0.0001              | 24.2                     | 23.5 | -0.8                    | 0.0169               |
| 19. Acute renal failure, chronic kidney disease, and unspecified kidney failure            | 16.2                     | 13.3 | 12.1 | -4.1                    | <0.0001              | 15.2                     | 14.3 | -1.9                    | <0.0001              |
| 20. Urinary tract infection, site not specified  | 27.0                     | 25.3 | 25.8 | -1.2                    | <0.0001              | 27.3                     | 27.9 | 0.9                     | 0.0506               |
| 21. Other immediate and intermediate causes  | 14.9                     | 12.1 | 11.4 | -3.5                    | <0.0001              | 15.0                     | 15.0 | 0.1                     | 0.9600               |
| Nonspecific causes   | 56.2                     | 50.8 | 49.5 | -6.7                    | <0.0001              | 55.5                     | 54.0 | -2.2                    | <0.0001              |
| 22. Malignant neoplasm, without specification of site                                      | 51.1                     | 50.2 | 51.8 | 0.7                     | <0.0001              | 50.8                     | 52.6 | 1.5                     | <0.0001              |
| 23. Unspecified diabetes mellitus  | 30.3                     | 25.3 | 24.2 | -6.1                    | <0.0001              | 30.0                     | 28.5 | -1.8                    | <0.0001              |
| 24. Unspecified dementia   | 49.1                     | 41.7 | 40.3 | -8.8                    | <0.0001              | 48.0                     | 43.7 | -5.4                    | <0.0001              |
| 25. Atherosclerotic cardiovascular disease, so described                                   | 70.1                     | 67.4 | 67.2 | -2.9                    | <0.0001              | 70.7                     | 69.3 | -0.8                    | <0.0001              |
| 26. Atherosclerotic heart disease  | 50.8                     | 46.8 | 45.9 | -4.9                    | <0.0001              | 49.7                     | 48.9 | -1.9                    | <0.0001              |
| 27. Chronic ischemic heart disease, unspecified  | 53.4                     | 47.9 | 47.8 | -5.6                    | <0.0001              | 49.8                     | 49.8 | -3.6                    | 0.9699               |
| 28. Cardiovascular disease, unspecified  | 52.2                     | 50.5 | 46.5 | -5.7                    | <0.0001              | 52.0                     | 48.0 | -4.2                    | <0.0001              |
| 29. Heart disease, unspecified   | 27.1                     | 25.6 | 25.6 | -1.5                    | <0.0001              | 26.7                     | 26.9 | -0.2                    | 0.5988               |
| 30. Stroke, not specified as hemorrhage or infarction                                      | 49.6                     | 45.0 | 44.2 | -5.4                    | <0.0001              | 48.2                     | 47.5 | -2.1                    | 0.0027               |
| 31. Cerebrovascular disease, unspecified   | 42.5                     | 39.4 | 38.4 | -4.1                    | <0.0001              | 42.0                     | 40.1 | -2.4                    | <0.0001              |
| 32. Sequelae of stroke, not specified as hemorrhage or infarction                          | 42.3                     | 37.2 | 36.4 | -5.9                    | <0.0001              | 40.3                     | 39.5 | -2.8                    | 0.0614               |
| 33. Liver disease, unspecified   | 26.5                     | 24.0 | 23.7 | -2.8                    | <0.0001              | 24.7                     | 24.7 | -1.8                    | 0.9409               |
| 34. Unspecified fall   | 73.0                     | 70.9 | 71.4 | -1.6                    | <0.0001              | 72.7                     | 72.9 | -0.1                    | 0.5968               |
| 35. Exposure to unspecified factor   | 39.2                     | 36.3 | 35.0 | -4.2                    | <0.0001              | 38.6                     | 37.9 | -1.3                    | 0.1812               |
| 36. Other nonspecific underlying causes of death   | 28.7                     | 25.9 | 23.7 | -5.0                    | <0.0001              | 28.5                     | 27.7 | -1.0                    | <0.0001              |

Abbreviations: COVID-19, coronavirus disease 2019; SR, selection rate.

<sup>a</sup>Difference = 2021-2019.<sup>b</sup>P value was based on Cochran-Armitage trend test.

**Table 4.** Adjusted odds ratios of each unsuitable cause being selected as the underlying cause of death using "Atherosclerotic Heart Disease" as reference including and excluding deaths with mention of COVID-19 on the death certificate in the United States for the years 2019, 2020, and 2021

|  | aORs <sup>a</sup> including COVID-19 |           |                   |           |                   |           | aORs <sup>a</sup> excluding COVID-19 |           |                   |           |
|--|--------------------------------------|-----------|-------------------|-----------|-------------------|-----------|--------------------------------------|-----------|-------------------|-----------|
|  | 2019                                 | 95% CI    | 2020              | 95% CI    | 2021              | 95% CI    | 2020                                 | 95% CI    | 2021              | 95% CI    |
| All deaths   |                                      |           |                   |           |                   |           |                                      |           |                   |           |
| Total unsuitable causes  | 0.89                                 | 0.88-0.89 | <sup>b</sup> 0.69 | 0.68-0.69 | <sup>b</sup> 0.64 | 0.64-0.65 | 0.88                                 | 0.87-0.88 | <sup>b</sup> 0.84 | 0.84-0.85 |
| Unknown and ill-defined causes   | 0.06                                 | 0.06-0.07 | 0.06              | 0.05-0.06 | 0.06              | 0.06-0.06 | 0.07                                 | 0.07-0.07 | 0.07              | 0.07-0.07 |
| 1. Cardiac arrest  | 0.05                                 | 0.05-0.05 | 0.04              | 0.04-0.04 | 0.05              | 0.05-0.05 | 0.05                                 | 0.05-0.05 | 0.05              | 0.05-0.05 |
| 2. Respiratory failure, not elsewhere classified   | 0.04                                 | 0.04-0.04 | 0.03              | 0.03-0.03 | 0.03              | 0.03-0.03 | <sup>c</sup> 0.05                    | 0.05-0.05 | 0.04              | 0.04-0.05 |
| 3. Respiratory failure of newborn  | 0.01                                 | 0.01-0.02 | 0.01              | 0.01-0.02 | 0.01              | 0.00-0.01 | 0.01                                 | 0.01-0.02 | 0.01              | 0.01-0.01 |
| 4. Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified | 0.07                                 | 0.07-0.07 | 0.06              | 0.06-0.06 | 0.06              | 0.06-0.06 | 0.07                                 | 0.07-0.07 | 0.07              | 0.07-0.07 |
| Immediate and intermediate causes  | 0.40                                 | 0.40-0.40 | <sup>b</sup> 0.31 | 0.31-0.31 | <sup>b</sup> 0.28 | 0.28-0.29 | <sup>b</sup> 0.39                    | 0.39-0.39 | <sup>b</sup> 0.38 | 0.37-0.38 |
| 5. Sepsis, unspecified   | 0.23                                 | 0.23-0.23 | <sup>b</sup> 0.19 | 0.19-0.19 | <sup>b</sup> 0.19 | 0.18-0.19 | 0.23                                 | 0.23-0.24 | <sup>c</sup> 0.24 | 0.24-0.24 |
| 6. Secondary malignant neoplasm of respiratory and digestive organs                        | 0.06                                 | 0.06-0.06 | 0.05              | 0.05-0.06 | 0.06              | 0.05-0.06 | 0.05                                 | 0.05-0.06 | 0.06              | 0.05-0.06 |
| 7. Secondary malignant neoplasm of other sites   | 0.08                                 | 0.08-0.09 | 0.08              | 0.07-0.08 | 0.08              | 0.07-0.08 | 0.08                                 | 0.08-0.08 | 0.07              | 0.07-0.08 |
| 8. Other disorders of fluid, electrolyte and acid-base balance                             | 0.17                                 | 0.16-0.17 | <sup>b</sup> 0.14 | 0.14-0.14 | <sup>b</sup> 0.13 | 0.13-0.13 | 0.16                                 | 0.16-0.17 | <sup>b</sup> 0.15 | 0.15-0.16 |
| 9. Anoxic brain damage, not elsewhere classified   | 0.34                                 | 0.33-0.35 | <sup>b</sup> 0.31 | 0.30-0.32 | 0.32              | 0.31-0.33 | 0.34                                 | 0.33-0.35 | 0.35              | 0.34-0.36 |
| 10. Pulmonary embolism   | 0.31                                 | 0.30-0.32 | <sup>b</sup> 0.25 | 0.25-0.26 | <sup>b</sup> 0.20 | 0.20-0.21 | 0.30                                 | 0.29-0.30 | <sup>b</sup> 0.26 | 0.26-0.27 |
| 11. Other secondary pulmonary hypertension   | 0.42                                 | 0.41-0.44 | <sup>b</sup> 0.38 | 0.37-0.39 | <sup>b</sup> 0.36 | 0.35-0.37 | 0.40                                 | 0.39-0.41 | <sup>b</sup> 0.39 | 0.38-0.40 |
| 12. Cardiomyopathy, unspecified  | 0.84                                 | 0.82-0.86 | <sup>b</sup> 0.71 | 0.70-0.73 | <sup>b</sup> 0.67 | 0.65-0.68 | <sup>b</sup> 0.78                    | 0.77-0.80 | <sup>b</sup> 0.74 | 0.72-0.75 |
| 13. Atrial fibrillation and flutter  | 0.16                                 | 0.15-0.16 | <sup>b</sup> 0.13 | 0.13-0.13 | <sup>b</sup> 0.12 | 0.12-0.12 | 0.15                                 | 0.14-0.15 | <sup>b</sup> 0.14 | 0.14-0.14 |
| 14. Other cardiac arrhythmias  | 0.21                                 | 0.20-0.21 | 0.19              | 0.19-0.20 | <sup>b</sup> 0.18 | 0.18-0.19 | 0.20                                 | 0.20-0.21 | 0.19              | 0.19-0.20 |
| 15. Heart failure  | 0.26                                 | 0.26-0.26 | <sup>b</sup> 0.23 | 0.23-0.23 | <sup>b</sup> 0.21 | 0.21-0.21 | <sup>b</sup> 0.25                    | 0.25-0.25 | <sup>b</sup> 0.23 | 0.23-0.23 |
| 16. Pneumonia, organism unspecified  | 0.33                                 | 0.33-0.34 | <sup>b</sup> 0.15 | 0.14-0.15 | <sup>b</sup> 0.10 | 0.10-0.10 | <sup>c</sup> 0.35                    | 0.35-0.36 | <sup>c</sup> 0.35 | 0.35-0.36 |
| 17. Hepatic failure, not elsewhere classified  | 0.19                                 | 0.19-0.20 | <sup>b</sup> 0.18 | 0.17-0.18 | 0.19              | 0.18-0.20 | 0.19                                 | 0.18-0.19 | 0.19              | 0.18-0.20 |
| 18. Gastrointestinal hemorrhage, unspecified   | 0.32                                 | 0.31-0.33 | <sup>b</sup> 0.29 | 0.28-0.30 | <sup>b</sup> 0.27 | 0.27-0.28 | 0.32                                 | 0.31-0.33 | 0.31              | 0.30-0.31 |
| 19. Acute renal failure, chronic kidney disease, and unspecified kidney failure            | 0.19                                 | 0.19-0.19 | <sup>b</sup> 0.15 | 0.15-0.15 | <sup>b</sup> 0.14 | 0.14-0.14 | <sup>b</sup> 0.18                    | 0.17-0.18 | <sup>b</sup> 0.16 | 0.16-0.17 |
| 20. Urinary tract infection, site not specified  | 0.35                                 | 0.34-0.36 | <sup>b</sup> 0.32 | 0.31-0.33 | 0.33              | 0.33-0.34 | 0.36                                 | 0.35-0.36 | 0.37              | 0.36-0.38 |
| 21. Other immediate and intermediate causes  | 0.18                                 | 0.17-0.18 | <sup>b</sup> 0.14 | 0.13-0.14 | <sup>b</sup> 0.13 | 0.13-0.13 | 0.18                                 | 0.17-0.18 | 0.18              | 0.17-0.18 |
| Nonspecific causes   | 1.25                                 | 1.24-1.26 | <sup>b</sup> 1.00 | 0.99-1.01 | <sup>b</sup> 0.97 | 0.96-0.98 | <sup>b</sup> 1.21                    | 1.20-1.22 | <sup>b</sup> 1.15 | 1.14-1.16 |
| 22. Malignant neoplasm, without specification of site                                      | 1.08                                 | 1.06-1.10 | <sup>b</sup> 1.03 | 1.01-1.05 | 1.12              | 1.10-1.14 | 1.06                                 | 1.04-1.08 | <sup>c</sup> 1.13 | 1.11-1.15 |
| 23. Unspecified diabetes mellitus  | 0.44                                 | 0.44-0.45 | <sup>b</sup> 0.34 | 0.34-0.35 | <sup>b</sup> 0.33 | 0.33-0.34 | 0.44                                 | 0.43-0.44 | <sup>b</sup> 0.40 | 0.40-0.41 |
| 24. Unspecified dementia   | 0.86                                 | 0.85-0.87 | <sup>b</sup> 0.65 | 0.64-0.65 | <sup>b</sup> 0.60 | 0.59-0.60 | <sup>b</sup> 0.83                    | 0.82-0.84 | <sup>b</sup> 0.71 | 0.70-0.72 |
| 25. Atherosclerotic cardiovascular disease, so described                                   | 2.39                                 | 2.35-2.42 | <sup>b</sup> 2.09 | 2.06-2.12 | <sup>b</sup> 2.15 | 2.12-2.17 | <sup>c</sup> 2.46                    | 2.43-2.50 | <sup>b</sup> 2.29 | 2.26-2.32 |
| 26. Atherosclerotic heart disease  | 1.00                                 |           | <sup>b</sup> 0.85 | 0.84-0.86 | <sup>b</sup> 0.83 | 0.82-0.84 | <sup>b</sup> 0.96                    | 0.95-0.97 | <sup>b</sup> 0.93 | 0.92-0.94 |
| 27. Chronic ischemic heart disease, unspecified  | 1.11                                 | 1.08-1.15 | <sup>b</sup> 0.89 | 0.86-0.92 | <sup>b</sup> 0.90 | 0.87-0.92 | <sup>b</sup> 0.96                    | 0.93-0.99 | <sup>b</sup> 0.96 | 0.93-1.00 |
| 28. Cardiovascular disease, unspecified  | 1.08                                 | 1.05-1.12 | <sup>b</sup> 1.01 | 0.98-1.04 | <sup>b</sup> 0.87 | 0.85-0.90 | 1.08                                 | 1.05-1.11 | <sup>b</sup> 0.91 | 0.89-0.94 |
| 29. Heart disease, unspecified   | 0.36                                 | 0.35-0.37 | <sup>b</sup> 0.33 | 0.32-0.34 | <sup>b</sup> 0.33 | 0.32-0.34 | 0.35                                 | 0.34-0.36 | 0.35              | 0.35-0.36 |
| 30. Stroke, not specified as hemorrhage or infarction                                      | 0.95                                 | 0.93-0.96 | <sup>b</sup> 0.79 | 0.78-0.80 | <sup>b</sup> 0.77 | 0.76-0.78 | <sup>b</sup> 0.90                    | 0.89-0.91 | <sup>b</sup> 0.88 | 0.87-0.89 |
| 31. Cerebrovascular disease, unspecified   | 0.68                                 | 0.67-0.70 | <sup>b</sup> 0.61 | 0.59-0.62 | <sup>b</sup> 0.57 | 0.56-0.59 | 0.67                                 | 0.66-0.69 | <sup>b</sup> 0.63 | 0.61-0.64 |
| 32. Sequelae of stroke, not specified as hemorrhage or infarction                          | 0.70                                 | 0.68-0.71 | <sup>b</sup> 0.57 | 0.55-0.58 | <sup>b</sup> 0.55 | 0.54-0.56 | <sup>b</sup> 0.64                    | 0.63-0.66 | <sup>b</sup> 0.63 | 0.61-0.65 |
| 33. Liver disease, unspecified   | 0.39                                 | 0.38-0.41 | <sup>b</sup> 0.33 | 0.32-0.35 | <sup>b</sup> 0.35 | 0.33-0.36 | <sup>b</sup> 0.35                    | 0.34-0.36 | <sup>b</sup> 0.35 | 0.33-0.36 |
| 34. Unspecified fall   | 2.54                                 | 2.46-2.61 | <sup>b</sup> 2.29 | 2.23-2.35 | <sup>b</sup> 2.34 | 2.28-2.40 | 2.50                                 | 2.43-2.57 | 2.54              | 2.47-2.61 |
| 35. Exposure to unspecified factor   | 0.61                                 | 0.59-0.63 | <sup>b</sup> 0.54 | 0.52-0.56 | <sup>b</sup> 0.52 | 0.50-0.53 | 0.60                                 | 0.58-0.62 | 0.59              | 0.57-0.60 |
| 36. Other nonspecific underlying causes of death   | 0.40                                 | 0.40-0.41 | <sup>b</sup> 0.34 | 0.34-0.35 | <sup>b</sup> 0.31 | 0.31-0.32 | 0.40                                 | 0.39-0.40 | <sup>b</sup> 0.38 | 0.37-0.38 |

Abbreviations: aOR, adjusted odd ratio; COVID-19, coronavirus disease 2019.

<sup>a</sup>Based on multivariate logistic regression controlling the age of decedents.<sup>b</sup>Significantly lower than reference in 2019.<sup>c</sup>Significantly higher than reference in 2019.

These reductions are likely because COVID-19 was often the assigned UCOD when it was a concurrent condition. However, the quality of COD reporting for deaths that did not mention COVID-19 on the death certificate did not exhibit similar improvements. Specifically, 4 immediate and intermediate causes (sepsis, anoxic brain damage, pneumonia, and urinary tract infection) and 3 nonspecific causes (malignant neoplasm without specification of site, unspecified heart disease, and unspecified fall) revealed the least improvement during the pandemic.

The NCHS list, comprising 36 causes, makes analyses more manageable to display proportions, selection rates, and aORs for these 36 causes and allows for comparison across different causes and years. Using three indicators, we noted that causes with high proportions (atherosclerotic heart disease, unspecified dementia, and heart failure) were different from those with high selection rates (unspecified fall, atherosclerotic cardiovascular disease, and unspecified chronic ischemic heart disease).

For practitioners aiming to enhance COD reporting quality, the primary focus should be on unsuitable UCODs that have both high proportions and high selection rates. The findings of this study indicate that atherosclerotic heart disease, atherosclerotic cardiovascular disease, unspecified dementia, stroke not specified as hemorrhage or infarction, and malignant neoplasm without specification of site were the causes with both high proportions and high selection rates. Most of these causes are identified as "priority level 1" for intervention, necessitating that state health departments proactively request clarification or additional information from the medical certifier to ensure accuracy in the coding of the COD.<sup>29</sup> The 6 priority levels for querying suggested by the NCHS are presented in Appendix S1.

We observed large variations in selection rates among 3 sub-categories of unsuitable UCOD: low for unknown and ill-defined causes (6% in 2019), moderate for immediate and intermediate causes (29% in 2019), and high for nonspecific causes (56% in 2019). This suggests that medical certifiers often record specific diagnoses on the death certificate alongside ill-defined or immediate and intermediate causes in Part 1, as scenarios 1 to 4 in Table 1 illustrate, typically precluding these causes from being selected as the UCOD. Conversely, in cases where only ill-defined or immediate and intermediate causes are documented, as in scenarios 5 to 7 in Table 1, these tend to be selected as the UCOD. In some instances, a more specific diagnosis was recorded in Part 1 of the death certificate; nevertheless, the position recorded was not justified for being selected as the UCOD, exemplified by scenarios 8 and 9 in Table 1, highlighting the necessity for enhanced guidance for medical certifiers. We suggest that the guidance should include additional examples of nonstandard recording patterns, such as multiple diagnoses per line in Part 1 of the death certificate, improper causal sequences, and specific selection rules, to ensure that the intended UCOD of the medical certifiers aligns with the officially selected UCODs for mortality tabulation.

With regard to unspecified causes, medical certifiers may consider recording diagnoses such as atherosclerotic heart disease, diabetes mellitus, dementia, chronic ischemic heart disease, or falls as being adequately specific. However, as indicated by the ANACONDA initiative, these unsuitable UCODs have limited impact on health policy due to their lack of specificity, often sharing 3-digit codes with more precise options.<sup>16-18</sup> Queries to medical certifiers for more detailed information may not yield additional specificity, especially if the medical records lack detail or if the death did not occur in a hospital. We should consider the

feasibility and purpose of getting more specific information for unspecified causes.

The improvement in COD reporting quality during the COVID-19 pandemic primarily resulted from the inclusion of deaths related to COVID-19 (384 536 in 2020 and 462 193 in 2021 with mention of COVID-19 on the death certificate). COVID-19 was selected as the UCOD in the majority of these cases (350 831 in 2020 and 416 893 in 2021). This increased specificity led to a lower proportion of unsuitable UCODs being selected. A key strength of this study was the analysis of selection rates for deaths in which the death certificate did not mention COVID-19, revealing that the selection rates for some unsuitable UCODs did not decline during 2020 and 2021. This approach assists in the identification of causes with high selection rates that warrant prioritization for future interventions.

Several limitations should be noted in interpreting the findings of this study. First, we did not analyze various improper COD reporting patterns such as mechanisms of death only, multiple diagnoses per line, and improbable causal sequences.<sup>30,31</sup> Second, for reasons of space, we could not analyze selection rates by characteristics of decedents, state, or place of death, as detailed in the original report.<sup>19</sup> Third, we lacked information on the characteristics of medical certifiers (eg, whether they were medical examiners, coroners, or physicians of a different specialty).

In conclusion, the overall quality of COD reporting in the United States improved during the COVID-19 pandemic. This improvement is mainly because in more than one-tenth of the deaths where COVID-19 was mentioned, COVID-19 was assigned as the UCOD, which resulted in a reduced selection of unsuitable UCODs. However, for deaths without a mention of COVID-19, the quality of COD reporting for some unsuitable UCODs did not improve considerably. We recommend the use of COD querying for unsuitable UCOD causes to improve the specificity and utility of COD mortality data.

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## Supplementary material

Supplementary material is available at *American Journal of Epidemiology* online.

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## Conflict of interest

None declared.

## Data availability

Available upon request to corresponding author.

## References

- Gill JR, ME DJ. The importance of proper death certification during the COVID-19 pandemic. *JAMA*. 2020;324(1):27-28. <https://doi.org/10.1001/jama.2020.9536>

2. Kiang MV, Irizarry RA, Buckee CO, et al. Every body counts: measuring mortality from the COVID-19 pandemic. *Ann Intern Med.* 2020;173(12):1004-1007. <https://doi.org/10.7326/M20-3100>
3. Gerberding JL. Measuring pandemic impact: vital signs from vital statistics. *Ann Intern Med.* 2020;173(12):1022-1023. <https://doi.org/10.7326/M20-6348>
4. Cochran SD, Mays VM. To save lives, we need to improve the measurement of death. *Am J Public Health.* 2021;111(S2):S45. <https://doi.org/10.2105/AJPH.2021.306440>
5. National Center for Health Statistics. Guidance for certifying COVID-19 deaths. March 4, 2020. Accessed July 28, 2023. <https://www.cdc.gov/nchs/data/nvss/coronavirus/Alert-1-Guidance-for-Certifying-COVID-19-Deaths.pdf>
6. National Center for Health Statistics. Guidance for certifying deaths due to COVID-19. April 2020. Accessed July 28, 2023. <https://www.cdc.gov/nchs/data/nvss/vsrg/vsrg03-508.pdf>
7. Ahmad FB, Anderson RN, Knight K, et al. Advancements in the National Vital Statistics System to meet the real-time data needs of a pandemic. *Am J Public Health.* 2021;111(12):2133-2140. <https://doi.org/10.2105/AJPH.2021.306519>
8. World Health Organization. *World Health Statistics Annual.* World Health Organization; 1988.
9. Ruzicka LT, Lopez AD. The use of cause-of-death statistics for health situation assessment: national and international experiences. *World Health Stat Q.* 1990;43(4):249-258.
10. Mathers CD, Ma Fat D, Inoue M, et al. Counting the dead and what they died from: an assessment of the global status of cause of death data. *Bull World Health Organ.* 2005;83(3):171-177.
11. Johansson LA, Pavillon G, Anderson R, et al. Counting the dead and what they died of. *Bull World Health Organ.* 2006;84(3):254-255.
12. CJL M, Lopez AD. *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020.* Harvard School of Public Health; 1996.
13. Naghavi M, Makela S, Foreman K, et al. Algorithms for enhancing public health utility of national causes-of-death data. *Popul Health Metr.* 2010;8(1):9. <https://doi.org/10.1186/1478-7954-8-9>
14. Phillips DE, Lozano R, Naghavi M, et al. A composite metric for assessing data on mortality and causes of death: the vital statistics performance index. *Popul Health Metr.* 2014;(1):12, 14. <https://doi.org/10.1186/1478-7954-12-14>
15. Mikkelsen L, Phillips DE, Abouzahr C, et al. A global assessment of civil registration and vital statistics systems: monitoring data quality and progress. *Lancet.* 2015;386(10001):1395-1406. [https://doi.org/10.1016/S0140-6736\(15\)60171-4](https://doi.org/10.1016/S0140-6736(15)60171-4)
16. Abouzahr C, Mikkelsen L, Rampatige R, Lopez A. Mortality statistics: a tool to enhance understanding and improve quality. *Pac Health Dialog.* 2012;18(1):247-270. PMID: 23240364.
17. Mikkelsen L, Moesgaard K, Hegnauer M, et al. ANACONDA: a new tool to improve mortality and cause of death data. *BMC Med.* 2020;18(1):61. <https://doi.org/10.1186/s12916-020-01521-0>
18. Mikkelsen L, Iburg KM, Adair T, et al. Assessing the quality of cause of death data in six high-income countries: Australia, Canada, Denmark, Germany, Japan and Switzerland. *Int J Public Health.* 2020;65(1):17-28. <https://doi.org/10.1007/s00038-019-01325-x>
19. Flagg LA, Anderson RN. Unsuitable underlying causes of death for assessing the quality of cause-of-death reporting. *National Vital Statistics Reports; Vol 69 No 14.* Hyattsville, MD: National Center for Health Statistics; 2021. Accessed April 21, 2023. <https://stacks.cdc.gov/view/cdc/100414>
20. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet.* 2020;396(10258):1204-1222. [https://doi.org/10.1016/S0140-6736\(20\)30925-9](https://doi.org/10.1016/S0140-6736(20)30925-9)
21. Percy C, Stanek E, Gloeckler L. Accuracy of cancer death certificates and its effect on cancer mortality statistics. *Am J Public Health.* 1981;71(3):242-250. <https://doi.org/10.2105/AJPH.71.3.242>
22. Percy C, Ries LG, Van Holten VD. The accuracy of liver cancer as the underlying cause of death on death certificates. *Public Health Rep.* 1990;105(4):361-367.
23. Hoel DG, Ron E, Carter R, et al. Influence of death certificate errors on cancer mortality trends. *J Natl Cancer Inst.* 1993;85(13):1063-1068. <https://doi.org/10.1093/jnci/85.13.1063>
24. German RR, Fink AK, Heron M, et al. The accuracy of cancer mortality statistics based on death certificates in the United States. *Can Epidemiol.* 2011;35(2):126-131. <https://doi.org/10.1016/j.caep.2010.09.005>
25. Cheng TJ, Lu TH, Kawachi I. State differences in the reporting of diabetes-related incorrect cause-of-death causal sequences on death certificates. *Diabetes Care.* 2012;35(7):1572-1574. <https://doi.org/10.2337/dc11-2156>
26. Cheng TJ, Chang CY, Lin CY, et al. State differences in the reporting of "unspecified stroke" on death certificates: implications for improvement. *Stroke.* 2012;43(12):3336-3342. <https://doi.org/10.1161/STROKEAHA.112.670877>
27. Lu TH, Lunetta P, Walker S. Quality of cause-of-death reporting using ICD-10 drowning codes: a descriptive study of 69 countries. *BMC Med Res Methodol.* 2010;10(1):30. <https://doi.org/10.1186/1471-2288-10-30>
28. National Center for Health Statistics. Mortality multiple cause-of-death public use record. Accessed April 21, 2023. [https://www.cdc.gov/nchs/nvss/mortality\\_public\\_use\\_data.htm](https://www.cdc.gov/nchs/nvss/mortality_public_use_data.htm)
29. National Center for Health Statistics. Instruction manual part 20, ICD-10 causes of death querying, 2013. Accessed April 21, 2023. [https://www.cdc.gov/nchs/data/dvs/Instruction\\_Manual\\_revise20\\_2013.pdf](https://www.cdc.gov/nchs/data/dvs/Instruction_Manual_revise20_2013.pdf)
30. Lu TH, Anderson RN, Kawachi I. Trends in frequency of reporting improper diabetes-related cause-of-death statements on death certificates, 1985–2005: an algorithm to identify incorrect causal sequences. *Am J Epidemiol.* 2010;171(10):1069-1078. <https://doi.org/10.1093/aje/kwq057>
31. Falci L, Lee Argov EJ, Van Wye G, et al. Examination of cause-of-death data quality among New York city deaths due to cancer, pneumonia, or diabetes from 2010 to 2014. *Am J Epidemiol.* 2018;187(1):144-152. <https://doi.org/10.1093/aje/kwx207>