Validation of the *International Classification of Diseases* Code for COVID-19 among Critically Ill Patients

To the Editor:

The coronavirus disease (COVID-19) pandemic has strained intensive care unit (ICU) resources across the world. One of several public health challenges during the COVID-19 pandemic has been the accurate counting of COVID-19 cases (1). *International Classification of Diseases, Tenth Revision* (ICD-10) (2) codes are widely used to track the epidemiology of diseases. However, ICD codes may not accurately reflect disease status (3, 4). In April 2020, the U.S. Centers for Disease Control and Prevention updated ICD-10 codes to include the code *U07.1, COVID-19* for clinicians to document the presence of COVID-19 (5). Kadri and colleagues (6) identified the rapid uptake and high diagnostic accuracy of the COVID-19 ICD-10 code among hospitalized patients in the early pandemic. However, the degree to which the COVID-19 ICD-10 code reflects COVID-19 infection in critically ill patients and its accuracy over time are unclear. In this study, we sought to assess the accuracy of the COVID-19 ICD-10 code among adult patients admitted to U.S. ICUs and stepdown units in 2020.

We used the Premier Inc. database, an enhanced multicenter U.S. claims-based database with laboratory values available for a patient subset (7), to identify patients for study inclusion. Included patients were *1*) adults (≥18 yr) with a *2*) hospital encounter that included a general or medical ICU or stepdown unit admission, who were *3*) discharged between April 2020 and December 2020, and who had *4*) at least one severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) ribonucleic acid polymerase chain reaction (PCR) laboratory test result (positive or negative) during the hospitalization. For each patient, we extracted results from all SARS-CoV-2 PCR tests and use of the ICD-10 code U07.1. COVID-19 positivity (gold standard) was defined as a positive result from any SARS-CoV-2 PCR test during the hospitalization. The SARS-CoV-2 antigen test was not used as gold standard owing to its rare use (3,464 tests performed in the database; 393 were positive).

We evaluated performance characteristics of the ICD-10 discharge code U07.1 for COVID-19 status based on the gold-standard SARS-CoV-2 PCR laboratory test result: *1*) sensitivity, *2*) specificity, *3*) positive predictive value (PPV), *4*), negative predictive value, and *5*) c-statistic. In stratified analyses, we calculated performance statistics by *1*) age, *2*) sex, *3*) race, *4*) acute respiratory distress syndrome (ARDS) or acute respiratory failure (ARF) diagnoses, *5*) use of mechanical ventilation, *6*) admission to the ICU, and *7*) discharge month. We stratified by month to assess for changes in performance due to changes in COVID-19 prevalence and changes in coding strategies over time. Lastly, we conducted a sensitivity analysis excluding patients admitted as transfers from outside healthcare facilities to account for patients who might have previously positive testing and thus might not receive a second SARS-CoV-2 test. This study was designated not Human Subjects Research by Boston University's Institutional Review Board (#H-41991).

Among 274,392 adult ICU and stepdown patients, 180,426 (65.8%) from 214 hospitals had a SARS-CoV-2 PCR test and were thus included in the study. SARS-CoV-2 laboratory tests were positive in 22,700 (12.4%) of tested patients (8.3% of all ICU and stepdown patients). Compared with patients with negative tests, patients with positive SARS-CoV-2 tests had higher rates of ARDS or ARF diagnoses (70.9%), mechanical ventilation (25.0%), and death (20.5%) (Table 1).

The overall sensitivity and specificity of the COVID-19 ICD-10 code was 0.98 (95% confidence interval [CI], 0.98–0.98) and 0.99 (0.99–0.99), respectively. The overall PPV was 0.92 (0.92–0.92), negative predictive value was 1.00 (1.00–1.00), and the c-statistic was 0.98 (0.98–0.99). Excluding patients admitted from other healthcare facilities (n = 151,509) resulted in marginal increases in performance (c-statistic, 0.99 [0.98–0.99]). Stratified analyses were similar to the primary analysis, showing high performance of the U07.1 ICD-10 code across subgroups with *1*) the lowest sensitivity (0.96 [0.95–0.96]) among patients without a diagnosis of ARDS or ARF, *2*) the lowest specificity (0.97 [0.97–0.97]) among patients who received mechanical ventilation, and the lowest c-statistic (0.98 [95% CI, 0.97–0.98]) among patients without a diagnosis of ARDS or ARF. Performance was similar in patients admitted to ICUs (sensitivity, 0.98 [0.98–0.98]; specificity, 0.99 [0.99–0.99]) and in patients admitted only to stepdown units (sensitivity, 0.98 [0.98–0.98]; specificity, 0.99 [0.99–0.99]). Performance characteristics were largely stable by month of discharge (Figure 1).

We used a large U.S. multicenter enhanced claims database to examine the accuracy of the COVID-19 ICD-10 code for patients admitted to ICUs and stepdown units. More than 8% of ICU and stepdown unit admissions across more than 200 U.S. hospitals had a positive COVID-19 test in 2020. The ICD-10 code U07.1 was highly accurate for identifying critically ill patients with COVID-19; accuracy remained high across subgroups and over time. These results provide confidence in the use of claims data for COVID-19 surveillance among critically ill patients.

The performance of the COVID-19 ICD-10 U07.1 code in our study was similar to its performance among all hospitalized patients in the early pandemic (6). Building on this prior study, our study found that the performance of U07.1 was high among critically ill patients and persisted throughout the 2020 COVID-19 pandemic. We speculate that the accurate coding of COVID-19—compared with other viral respiratory diseases (8)—may reflect increased scrutiny by hospitals to accurately document COVID-19 in the setting of reimbursement programs (9, 10). In addition, our results provide reassurance that media reports (11) suggesting hospitals overcount COVID-19 cases for reimbursement reasons are unfounded.

Author Contributions: N.A.B. takes responsibility for the integrity of the letter. All authors substantially contributed to the conception and design of this study. N.A.B. acquired the data. All authors were involved in the interpretation of data. N.A.B. drafted the manuscript and all authors revised it critically for important intellectual content. All authors read and approved the final manuscript.

Table 1. Characteristics of ICU patients with SARS-CoV-2 testing

	SARS-CoV-2 Positive (*n* = *22,700*)	SARS-CoV-2 Negative (*n* = *157,726*)	Overall (*N* = *180,426*)
Age, yr			
<65	10,097 (44.5)	71,026 (45.0)	81,123 (45.0)
⩾65	12,603 (55.5)	86,700 (55.0)	99,303 (55.0)
Sex*			
Female	9,913 (43.7)	73,845 (46.8)	83,758 (46.4)
Male	12,786 (56.3)	83,875 (53.2)	96,661 (53.6)
Race			
Asian	513 (2.3)	3,034 (1.9)	3,547 (2.0)
Black	4,642 (20.4)	25,090 (15.9)	29,732 (16.5)
Other	2,224 (9.8)	7,585 (4.8)	9,809 (5.4)
Unknown	997 (4.4)	4,352 (2.8)	5,349 (3.0)
White	14,324 (63.1)	117,665 (74.6)	131,989 (73.2)
Mechanical ventilation	5,665 (25.0)	23,963 (15.2)	29,628 (16.4)
ARDS or ARF diagnosis	16,091 (70.9)	49,737 (31.5)	65,828 (36.5)
Hospital mortality	4,644 (20.5)	10,571 (6.7)	15,215 (8.4)
Admission to the ICU	11,496 (50.6)	79,496 (50.4)	90,992 (50.4)

Definition of abbreviations: ARDS = acute respiratory distress syndrome; ARF = acute respiratory failure; ICU = intensive care unit; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2.
Data are shown as *n* (%).
*Sex was unknown for seven patients.

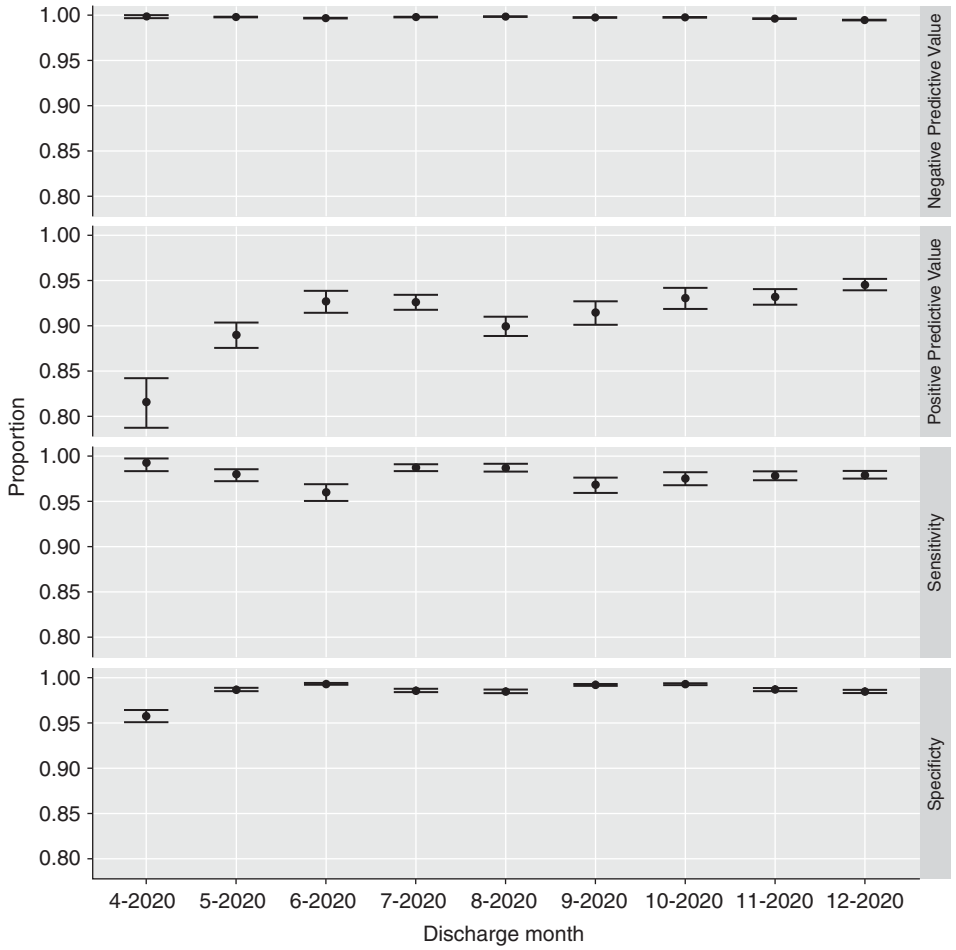

Figure 1. Performance of the *International Classification of Diseases, Tenth Revision* code U07.1 for the diagnosis of coronavirus disease (COVID-19) from April 2020 to December 2020. Shown are point estimates and 95% confidence intervals for negative predictive value, positive predictive value, sensitivity, and specificity for each month.

Strengths of our study include the large multicenter cohort, examination of performance characteristics over time to account for changes in prevalence and documentation practices, and similar results from the sensitivity and subgroup analyses. Our study also has limitations. First, although our study found that U07.1 correlates well with a positive SARS-CoV-2 test, neither the ICD-10 code nor a positive test necessarily indicates symptomatic COVID-19. In addition, long turnaround times of the PCR test early in the pandemic may have led to more frequent "empiric" coding for COVID-19 while tests were processing, thus decreasing the initial PPV of the ICD-10 code.

In conclusion, ICD-10 code U07.1 is highly specific and sensitive for SARS-CoV-2 infection and thus should be an accurate marker of disease activity in claims-based databases. ■

Author disclosures are available with the text of this letter at www.atsjournals.org.

Nicholas A. Bosch, M.D., M.Sc.*
Anica C. Law, M.D., M.S.
Daniel Peterson, M.S.
Allan J. Walkey, M.D., M.Sc.
Boston University School of Medicine
Boston, Massachusetts

ORCID IDs: 0000-0001-7161-5254 (N.A.B.); 0000-0003-3616-0316 (A.C.L.); 0000-0003-4685-6894 (A.J.W.).

*Corresponding author (e-mail: nabosch@bu.edu).

References

1 Mahase E. Covid-19: the problems with case counting. *BMJ* 2020;370: m3374.
2 CDC. International Classification of Diseases, Tenth Revision (ICD-10). 2020 [2021 Oct 14]. Available from: https://www.cdc.gov/nchs/icd/icd10.htm.
3 Ku JH, Henkle EM, Aksamit TR, Winthrop KL. Limited validity of diagnosis code-based claims to identify *Pseudomonas aeruginosa* in patients with bronchiectasis in Medicare data. *Ann Am Thorac Soc* 2021;18:1246–1249.
4 Ley B, Urbania T, Husson G, Vittinghoff E, Brush DR, Eisner MD, *et al.* Code-based diagnostic algorithms for idiopathic pulmonary fibrosis. Case validation and improvement. *Ann Am Thorac Soc* 2017;14: 880–887.
5 CDC. ICD-10-CM Official Coding and Reporting Guidelines April 1, 2020 through September 30, 2020. 2020 [2021 Oct 14]. Available from: https://www.cdc.gov/nchs/data/icd/COVID-19-guidelines-final.pdf.
6 Kadri SS, Gundrum J, Warner S, Cao Z, Babiker A, Klompas M, *et al.* Uptake and accuracy of the diagnosis code for COVID-19 among US hospitalizations. *JAMA* 2020;324:2553–2554.
7 Premier. White Paper: PINC AI™ Healthcare Data. 2020 [2021 Oct 14]. Available from: https://offers.premierinc.com/WC_PAS_WP_2019_10_24_Landing-Page.html.
8 Hamilton MA, Calzavara A, Emerson SD, Djebli M, Sundaram ME, Chan AK, *et al.* Validating International Classification of Disease 10th Revision algorithms for identifying influenza and respiratory syncytial virus hospitalizations. *PLoS One* 2021;16:e0244746.
9 Health Resources & Services Administration. About the Provider Relief Fund and Other Programs. 2021 [2021 Oct 14]. Available from: https://www.hrsa.gov/provider-relief/about.
10 Courtney J. Text - H.R.748–116th Congress (2019–2020): CARES Act. 2020 [2021 Oct 14]. Available from: https://www.congress.gov/bill/116th-congress/house-bill/748/text.
11 The Spectator. Hospitals Get Paid More to List Patients as COVID-19 and Three Times as Much if the Patient Goes on Ventilator (VIDEO). 2020 [2021 Oct 14]. Available from: https://thespectator.info/2020/04/09/hospitals-get-paid-more-to-list-patients-as-covid-19-and-three-times-as-much-if-the-patient-goes-on-ventilator-video/.

Prescribing Patterns and Tolerability of Mycophenolate and Azathioprine in Patients with Nonidiopathic Pulmonary Fibrosis Fibrotic Interstitial Lung Disease

To the Editor:

Mycophenolate mofetil (MMF) and azathioprine (AZA) are immunosuppressive medications commonly used to treat fibrotic interstitial lung diseases (ILDs) other than idiopathic pulmonary fibrosis (IPF). MMF and AZA may stabilize lung function in this population (1–7); however, no randomized trial has directly compared their efficacy. Adverse drug reactions associated with MMF and AZA are different and may inform therapeutic decisions (8). We sought to characterize prescribing patterns and tolerability of MMF and AZA in patients with non-IPF fibrotic ILD.

Methods

Patients with connective tissue disease–associated ILD (CTD-ILD), fibrotic hypersensitivity pneumonitis (HP), and unclassifiable ILD (uILD) were identified from the Canadian Registry for Pulmonary Fibrosis. Diagnosis was determined by multidisciplinary review at experienced ILD centers, including with rheumatologist input for patients with CTD-ILD, following current standard of care and diagnostic guidelines where available. Patients treated with MMF or AZA after ILD diagnosis were included. There were no exclusion criteria. All available medical records from the time of ILD diagnosis were reviewed in a standardized fashion to obtain medication data, adverse drug reactions, and actions taken (i.e., continuation at original or reduced dose, cessation, or change to an alternative) within the first 6 months after initiation of AZA and/or MMF. If a patient received MMF and AZA at different

Supported by Boehringer Ingelheim, grant number 20R23666 (CARE-PF). The sponsor did not have input on any aspect of this work. Also supported by a Royal Australasian College of Physicians Research Establishment Fellowship and the Austin Medical Research Foundation Bernie Sweet Clinical Research Fellowship (Y.H.K.).

Author Contributions: A.W.W. and C.J.R. were responsible for trial conception and development of the study protocol. A.W.W., Y.H.K., K.D., A.C., V.M., J.H.F., K.A.J., D.A., N.K., H.M., M.K., L.R., and C.J.R. were responsible for data acquisition. A.W.W. was responsible for data analysis. A.W.W. drafted the manuscript. All authors contributed to data interpretation, revised the manuscript, and approved the final version for publication. A.W.W. is the guarantor of the content of the manuscript, including the data and analysis.