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Methods Article

A novel method for handling pre-existing conditions in multivariate prediction model development for COVID-19 death in the Department of Veterans Affairs

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Abstract

Many mathematical models have been proposed to predict death following the Coronavirus Disease 2019 (COVID-19); all started with comorbidity subsets for this still-little understood disease. Thus, we derived a novel predicted probability of death model (PDeathDx) upon all diagnostic codes documented in the Department of Veterans Affairs. We present the conceptual underpinnings and analytic approach in estimating the independent contribution of pre-existing conditions. This is the largest study to-date following patients with COVID-19 to predict mortality. Cases were identified with at least one positive nucleic acid amplification test. Starting in 1997, we use diagnoses from the first time a patient sought care until 14 days before a positive nucleic acid amplification test. We demonstrate the clear advantage of using an unrestricted set of pre-existing conditions to model COVID-19 mortality, as models using conventional comorbidity indices often assign little weight or usually do not include some of the highest risk conditions; the same is true of conditions associated with COVID-19 severity. Our findings suggest that it is risky to pick comorbidities for analysis without a systematic review of all those experienced by the cohort. Unlike conventional approaches, our comprehensive methodology provides the flexibility that has been advocated for comorbidity indices since 1993; such an approach can be readily adapted for other diseases and outcomes. With our comorbidity risk adjustment approach outperforming conventional indices for predicting COVID-19 mortality, it shows promise for predicting outcomes for other conditions of interest.

Keywords: COVID-19; risk adjustment; prognosis; big data; veterans

Introduction

The Coronavirus Disease 2019 (COVID-2019) has changed lives worldwide. In the USA, COVID-19 is estimated to have 17.2–163.4 times higher mortality rate compared to seasonal influenza; the difference in numbers is based on whether deaths due to pneumonia among those infected with influenza were included [1, 2]. In the Department of Veterans Affairs (VA), COVID-19 has been associated with 4.0-, 2.9-, and 1.3 times higher risk of death, mechanical ventilation, and admission to intensive care, respectively [3].

Several mathematical models have been proposed for predicting death from COVID-19 [4–8]. Since they are very helpful for patient management and resource allocation, their use has proliferated. One of the most important components of these models is the set of pre-existing conditions. Many diseases increase the mortality rate because they diminish the host response to infection, cause end-organ dysfunction that is further compromised by COVID-19, or severely limit life expectancy and functional status. One method for handling these conditions is to gather them under broad categories (e.g. "malignancy") and derive a regression coefficient for each grouping [6, 7]. Another approach is to use a comorbidity scoring system such as the Charlson comorbidity index (CCI) or Elixhauser comorbidity index [4, 5, 8–13]. With this approach, the groupings are assigned weights, and the weights are added to generate a summary score. The summary score is then used as a covariate in the model. CCI and Elixhauser have been extensively validated and applied to many conditions [14]. Moreover, mathematical modeling has shown that they provide all that is necessary to handle confounding from the underlying diagnoses [15]. Having said this, their development was based on solely inpatient data [16, 17]. Also, neither method handles protective conditions. Lastly, rare diseases are not well represented. As a result, a person with a common disease of limited impact could be given a poorer prognosis than another with a rare but lethal condition.

A more sophisticated approach is to do a systematic survey of all pre-existing conditions, determine which have an impact on outcomes, and generate a predicted probability of death that represents the aggregate risk posed by those that are statistically

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significant. Like a propensity score, this predicted probability of death (PDeathDx) can be used as a variable in the model. Fortunately, advanced computer methods have made it possible to generate these estimates. The purpose of this study is to describe a novel approach to handling comorbidities in COVID-19 prediction models and compare the performance of PDeathDx with conventional comorbidity measures in distinguishing fatal from nonfatal cases.

Materials and methods

Cases were defined as VA patients who had at least one positive nucleic acid amplification test (NAAT) at the VA or elsewhere, identified in the VA's COVID-19 Shared Data Resource (CSDR). We defined death within 60 days of the NAAT as the primary outcome. The outcome was retrieved from the post-index conditions file of the CSDR, which assigns a 1 to those who died and 0 otherwise. Likewise, the 2-year CCI score (Charl2Yrs), lifetime CCI score (CharlEver), 2-year Elixhauser score (Elix2Yrs), and lifetime Elixhauser score (ElixEver) were retrieved from the CSDR for each patient.

Pre-existing conditions were identified by reviewing all diagnoses entered into the electronic medical record for outpatient visits, on patient problem lists, or at the time of hospital discharge. "Pre-existing" refers to entries made at least 14 days prior to the diagnosis of COVID-19. This precaution excludes any entries that may have been made during the pre-symptomatic phases of COVID-19. International Classification of Diseases, Ninth Revision (ICD-9) codes were converted to ICD-10 using a crosswalk provided by the Centers for Medicare & Medicaid Services (CMS). A "category condition" was defined as all characters preceding the decimal point for ICD-10 codes or the ICD-9 equivalent. A patient was considered to have or not have each category condition prior to the COVID-19 diagnosis.

A computer program was used to identify all patients with a given condition who died or survived as well as all patients without the condition who died or survived. For a visual depiction of workflow, see Figure 1. The software used these cell frequencies to derive the relative risk (RR) of death associated with the condition and its confidence interval (CI). CIs were adjusted for multiple comparisons by the Bonferroni procedure [18]. A category condition was considered to have a significant effect on the outcome if there were at least 100 cases and if the lower limit for the CI was $\geq$1.5 or the upper limit was $\leq$0.80, denoting risk or protective conditions, respectively.

Another software program was used to create a diagnostic grid in which each patient was assigned a value for all significant category conditions. Since a relative risk of 1 has no effect the scale for relative risk was centered on 1, then that value was entered for the corresponding category condition, if present. Those without the condition were treated as if they had a condition with no prognostic significance and assigned a value of 0. The diagnostic grid was exported to a statistical program (StataMP 17, StataCorp LP, College Station, TX, USA). Stepwise logistic regression was used to identify those that were independently predictive of death. This procedure adjusted the contribution of each condition for the presence of the others, assigned a predicted probability of death to each patient (PDeathDx), and used PDeathDx to generate an area under a receiver operating characteristic curve (AUROC). The product of coefficient $\times$ (RR $-$ 1) is the contribution of each condition to the logit function if present. It was therefore used to rank order the importance of the category conditions.

Differences in categorical variables were tested by chi-square analysis; differences in continuous variables were analyzed by the unpaired Student's *t*-test or rank sum test. Separate logistic models were used to examine the effect of age, Charl2Yrs, CharlEver, Elix2Yrs, and ElixEver as single predictors of death; the AUROC for each was compared to the AUROC for PDeathDx.

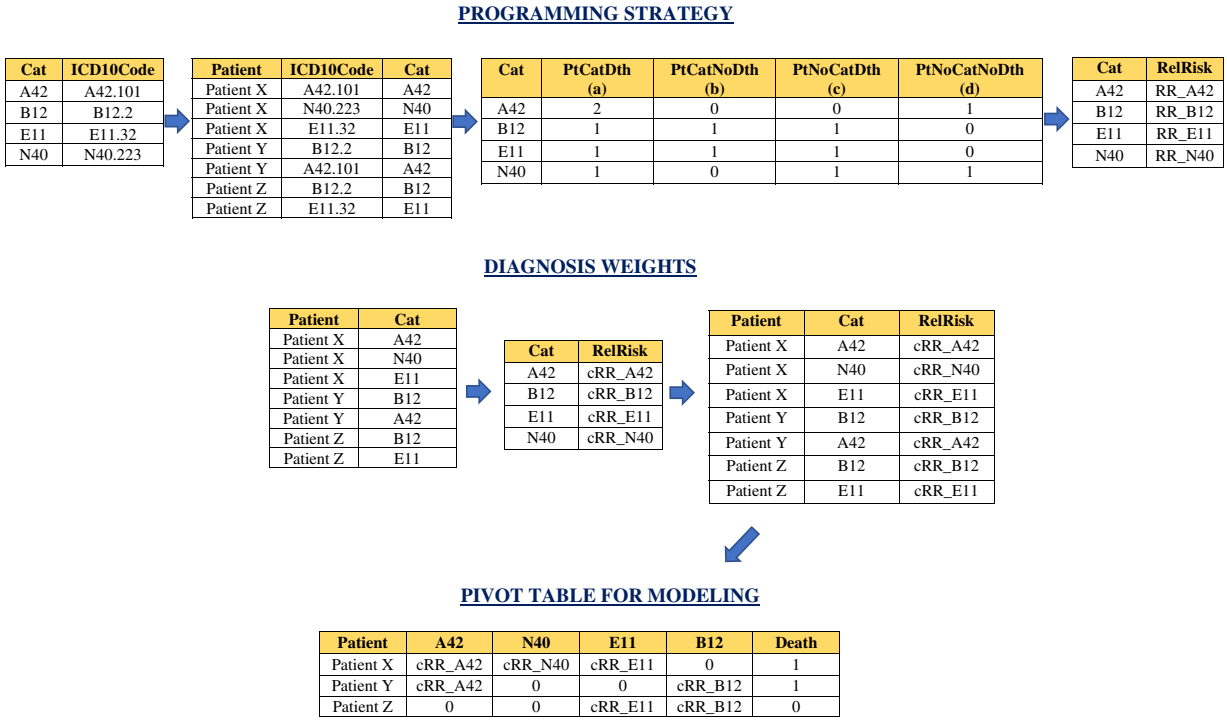
This study followed the Transparent Reporting of a multivariate prediction model for Individual Prognosis or Diagnosis guidelines specific to development. The New Mexico VA Health Care System Institutional Review Board approved this study, granting a waiver of informed consent.

Results

As of 30 September 2021, there were 347 220 COVID-19 patients in the CSDR. Of these, 339 772 (97.9%) had at least one pre-existing condition, forming the basis of this study. The mean age at the time of diagnosis was 58.6 $\pm$ 16.7 years, 84.1% were male, 22.9% were members of a racial minority, 9.0% were Hispanic, 0.7% were on supplemental oxygen, 11.8% were current smokers, and 9.1% had been fully vaccinated at least 14 days before testing positive. Presumed to have the delta variant, 21.5% acquired their infections after 1 July 2021. Overall, 18 120 patients (5.33%) died within 60 days of their NAAT.

For the study cohort, 82 578 233 ICD-9 codes had been entered into the electronic record before the VA converted to ICD-10 codes in 2015. Of these, 81 671 483 (98.9%) were successfully converted to an ICD-10 equivalent using the CMS crosswalk. Additionally, 78 976 269 ICD-10 codes were entered at least 14 days before testing positive. After consolidation, 29 162 710 separate diagnoses were given to patients representing 41 341 ICD-10 codes. The sample size was insufficient to test each ICD-10 code for its prognostic significance. Therefore, using ICD hierarchy, individual codes were aggregated to 1890 category conditions which were assigned to the group for the first time on 19 184 437 occasions.

Of the 1890 category conditions, 425 involved $\geq$100 subjects and had a lower boundary for the CI $\geq$ 1.50 or upper boundary $\leq$ 0.80 (Table 1). One diagnosis [Z11 (screening for other viral diseases)] was given to 120 308 subjects and had a high RR for death; it was removed because it may have been used for COVID-19 testing before there was a suitable ICD-10 code. Preliminary regressions indicated that an additional 25 provided a perfect prediction of the outcome when present A56 (Other sexually transmitted chlamydial diseases), A60 (Anogenital herpesviral [herpes simplex] infections), A63 (Other predominantly sexually transmitted diseases, not elsewhere classified), A64 (Unspecified sexually transmitted disease), A74 (Other diseases caused by Chlamydiae), F12 (Cannabis-related disorders), F15 (Vestibular Assessment), F90 (Attention-deficit hyperactivity disorders), G43 (Migraine), J03 (Acute tonsillitis), K58 (Irritable bowel syndrome), L70 (Acne), N76 (Other inflammation of vagina and vulva), N83 (Noninflammatory disorders of ovary, fallopian tube and broad ligament), N84 (Polyp of female genital tract), N87 (Dysplasia of cervix uteri), N93 (Other abnormal uterine and vaginal bleeding), R51 (Headache), R87 (Abnormal findings in specimens from female genital organs), R92 (Abnormal and inconclusive findings on diagnostic imaging of breast), X50 (Overexertion and strenuous or repetitive movements), Z30 (Encounter for contraceptive management), Z32 (Encounter for pregnancy test and childbirth and childcare instruction), Z33 (Pregnant state), and Z60 (Problems related to social environment). Another 20 were affected by collinearity. A diagnostic grid was therefore assembled



Cat	ICD10Code
A42	A42.101
B12	B12.2
E11	E11.32
N40	N40.223

Patient	ICD10Code	Cat
Patient X	A42.101	A42
Patient X	N40.223	N40
Patient X	E11.32	E11
Patient Y	B12.2	B12
Patient Y	A42.101	A42
Patient Z	B12.2	B12
Patient Z	E11.32	E11

Cat	PtCatDth (a)	PtCatNoDth (b)	PtNoCatDth (c)	PtNoCatNoDth (d)
A42	2	0	0	1
B12	1	1	1	0
E11	1	1	1	0
N40	1	0	1	1

Cat	RelRisk
A42	RR_A42
B12	RR_B12
E11	RR_E11
N40	RR_N40

Patient	Cat
Patient X	A42
Patient X	N40
Patient X	E11
Patient Y	B12
Patient Y	A42
Patient Z	B12
Patient Z	E11

Cat	RelRisk
A42	cRR_A42
B12	cRR_B12
E11	cRR_E11
N40	cRR_N40

Patient	Cat	RelRisk
Patient X	A42	cRR_A42
Patient X	N40	cRR_N40
Patient X	E11	cRR_E11
Patient Y	B12	cRR_B12
Patient Y	A42	cRR_A42
Patient Z	B12	cRR_B12
Patient Z	E11	cRR_E11

Patient	A42	N40	E11	B12	Death
Patient X	cRR_A42	cRR_N40	cRR_E11	0	1
Patient Y	cRR_A42	0	0	cRR_B12	1
Patient Z	0	0	cRR_E11	cRR_B12	0

Figure 1: Diagnosis grid overview.
Cat: category condition; Pt: patient; Dth: death; RelRisk: relative risk.

where each patient was assigned a value for each of the remaining 378 category conditions. If the diagnosis was present, (RR − 1) was assigned as its value and 0 otherwise. Stepwise logistic regression showed that 153 were statistically significant, independent predictors of death (Table 2). PDeathDx was derived for each patient; AUROC = 0.811 ± 0.002. Single variable logistic models were constructed for age at diagnosis, Charl2Yrs, CharlEver, Elix2Yrs, and ElixEver, and AUROCs determined for their predicted probabilities. PDeathDx was less powerful than age as a discriminator (AUROC = 0.812 ± 0.001; $P < 0.001$) but was superior to the Charl2Yr (AUROC = 0.727 ± 0.002; $P < 0.001$), CharlEver (AUROC = 0.753 ± 0.002; $P < 0.001$), Elix2Yr (AUROC = 0.694 ± 0.002; $P < 0.001$); and ElixEver (AUROC = 0.731 ± 0.002; $P < 0.001$). As can be seen from Figure 2, PDeathDx has the best performance each of the models among patients who have lower probability of death, which is relevant to the majority of patients.

Table 1 ranks the category conditions by their RR on univariate analysis. Degenerative neurologic disease and severe functional disability are represented in multiple category conditions within the 20 highest risk conditions while only one solid tumor (malignant neoplasm of other and unspecified parts of biliary tract) appears. In terms of reduced risk of death, several functional diagnoses, gynecologic disorders, and sexually transmitted diseases are present. Table 2 shows the ICD-10 codes that were independently predictive of death rank ordered by their contribution to the logit when present. Many high-risk conditions found upon univariate analysis became less so, to the point of some becoming protective, when adjusted for the effects of others. Hypertension was the most important independent risk factor for death and represented a greater threat than coronary artery disease. Degenerative neurologic diseases were prominently represented at the top of the list, while malignancies comprised the bulk of high-risk conditions.

Discussion

We present a novel method for handling pre-existing conditions in COVID-19 prediction models, currently available to VA clinicians that has several theoretical advantages over conventional comorbidity indices. (Individuals interested in the model should contact the corresponding author for more information.) Tables 1 and 2 show that this approach provides more clinical information than Charlson or Elixhauser comorbidity indices, handling rare and protective conditions. Table 3 compares the attributes of these indices with PDeathDx. Unlike conventional indices, our methodology can create a different model for every disease state and outcome, flexibilities that have been advocated in comorbidity indices since 1993 [19]. Whereas the Charlson and Elixhauser indices have static conditions in their models, PDeathDx's methodology starts with all documented diagnostic codes, permitting flexibility of conditions to be included in the model for each disease state and outcome based on their corresponding RRs and CIs. Following this line of thought, probabilities, analogous to condition weights in the conventional comorbidity indices, will change across diseases and outcomes of interest. Furthermore, since a part of the output also includes a probability for each pattern of conditions, it can detect circumstances where disease combinations are problematic. Finally, the model can be used to return actionable information to providers. Instead of total or condition scores, this information includes the predicted probability of the outcome, the specific diagnoses contributing to the prediction, and their rank order of importance. Such information may prompt the provider to explore a mechanism of injury or an intervention to mitigate the risk.

PDeathDx provided powerful discrimination between COVID-19 patients who died and survived; outperforming the other comorbidity indices, it is the second most powerful predictor of

Table 1: ICD-10 category conditions predictive of death on univariate analysis

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
G30	G30.9	Alzheimer's disease	4348 (1.2797)	0.2672	0.0506	5.2861	4.7347–5.9017
F03	F03.90	Unspecified dementia	13 895 (4.0895)	0.2340	0.0456	5.1278	4.7678–5.5150
F02	F02.80	Dementia in other diseases classified elsewhere	8684 (2.5558)	0.2379	0.0485	4.9065	4.4977–5.3524
I10	I10.	Essential (primary) hypertension	208 817 (61.4580)	0.0768	0.0159	4.8387	4.3920–5.3309
F01	F01.50	Vascular dementia	6033 (1.7756)	0.2342	0.0501	4.6786	4.2212–5.1856
Z66	Z66.	Do not resuscitate	6448 (1.8977)	0.2244	0.0500	4.4864	4.0498–4.9700
R62	R62.7	Lack of expected normal physiological development in childhood and adults	3414 (1.0048)	0.2209	0.0516	4.2777	3.7238–4.9140
R54	R54.	Age-related physical debility	11 357 (3.3425)	0.1983	0.0483	4.1040	3.7668–4.4714
C93	C93.10	Monocyte leukemia	122 (0.0359)	0.2131	0.0533	4.0005	1.9240–8.3180
D46	D46.9	Myelodysplastic syndromes	755 (0.2222)	0.2106	0.0530	3.9750	2.9513–5.3539
L89	L89.90	Pressure ulcer	8092 (2.3816)	0.1908	0.0500	3.8180	3.4499–4.2253
I13	I13.0	Hypertensive heart and chronic kidney disease	9823 (2.8911)	0.1844	0.0494	3.7299	3.3925–4.1008
J64	J64.	Unspecified pneumoconiosis	107 (0.0315)	0.1963	0.0533	3.6833	1.6173–8.3882
C95	C95.90	Leukemia of unspecified cell type	609 (0.1792)	0.1938	0.0531	3.6505	2.5754–5.1743
R64	R64.	Cachexia	797 (0.2346)	0.1932	0.0530	3.6457	2.6851–4.9499
E43	E43.	Unspecified severe protein-calorie malnutrition	1597 (0.4700)	0.1904	0.0527	3.6133	2.9023–4.4984
Z74	Z74.09	Problems related to care provider dependency	17 940 (5.2800)	0.1681	0.0469	3.5822	3.3154–3.8704
D63	D63.1	Anemia in chronic diseases classified elsewhere	14 823 (4.3626)	0.1703	0.0480	3.5494	3.2667–3.8565
C24	C24.1	Malignant neoplasm of other and unspecified parts of biliary tract	122 (0.0359)	0.1885	0.0533	3.5383	1.6054–7.7983
F05	F05.	Delirium due to known physiological condition	3612 (1.0631)	0.1822	0.0519	3.5070	3.0142–4.0803
Y95	Y95.	Nosocomial condition	355 (0.1045)	0.1859	0.0532	3.4952	2.1891–5.5806
W06	W06.XXXA	Fall from bed	2167 (0.6378)	0.1832	0.0525	3.4898	2.8768–4.2334
C78	C78.7	Secondary malignant neoplasm of respiratory and digestive organs	1305 (0.3841)	0.1839	0.0528	3.4814	2.7193–4.4570
J90	J90.	Pleural effusion, not elsewhere classified	5673 (1.6696)	0.1754	0.0513	3.4218	3.0197–3.8774
J69	J69.0	Pneumonitis due to solids and liquids	2896 (0.8523)	0.1785	0.0523	3.4165	2.8812–4.0511
I50	I50.9	Heart failure	36 427 (10.7210)	0.1447	0.0424	3.4162	3.2021–3.6445
N18	N18.9	Chronic kidney disease	48 428 (14.2531)	0.1352	0.0397	3.4042	3.2006–3.6206
I75	I75.029	Atheroembolism	138 (0.0406)	0.1812	0.0533	3.4003	1.5879–7.2814
J81	J81.0	Pulmonary edema	2462 (0.7246)	0.1767	0.0524	3.3700	2.7995–4.0567
G20	G20.	Parkinson's disease	5105 (1.5025)	0.1732	0.0515	3.3623	2.9456–3.8379
N25	N25.81	Disorders resulting from impaired renal tubular function	6475 (1.9057)	0.1699	0.0511	3.3268	2.9515–3.7497
J96	J96.01	Respiratory failure, not elsewhere classified	13 350 (3.9291)	0.1624	0.0489	3.3231	3.0408–3.6316
I12	I12.9	Hypertensive chronic kidney disease	26 422 (7.7764)	0.1498	0.0452	3.3156	3.0895–3.5582
D02	D02.20	Carcinoma *in situ* of middle ear and respiratory system	2023 (0.5954)	0.1740	0.0526	3.3075	2.6919–4.0639
W07	W07.XXXA	Fall from chair	1948 (0.5733)	0.1740	0.0526	3.3063	2.6807–4.0780
C94	C94.6	Other leukemias of specified cell type	412 (0.1213)	0.1748	0.0532	3.2860	2.0929–5.1592
N19	N19.	Unspecified kidney failure	7383 (2.1729)	0.1663	0.0508	3.2729	2.9203–3.6680
L12	L12.0	Pemphigoid	334 (0.0983)	0.1737	0.0532	3.2634	1.9740–5.3952
R26	R26.9	Abnormalities of gait and mobility	67 067 (19.7388)	0.1202	0.0369	3.2578	3.0675–3.4598
Z49	Z49.31	Encounter for care involving renal dialysis	1540 (0.4532)	0.1714	0.0528	3.2472	2.5607–4.1178
I96	I96.	Gangrene, not elsewhere classified	2079 (0.6119)	0.1708	0.0526	3.2459	2.6429–3.9864
H27	H27.8	Other specified disorders of lens	6825 (2.0087)	0.1642	0.0511	3.2170	2.8561–3.6236
I25	I25.10	Chronic ischemic heart disease	77 259 (22.7385)	0.1139	0.0355	3.2083	3.0212–3.4069
T66	T66.XXXA	Radiation sickness, unspecified	211 (0.0621)	0.1706	0.0533	3.2036	1.6912–6.0686
C34	C34.90	Malignant neoplasm of bronchus and lung	3805 (1.1199)	0.1664	0.0520	3.1962	2.7354–3.7346
E46	E46.	Unspecified protein–calorie malnutrition	3568 (1.0501)	0.1659	0.0521	3.1825	2.7098–3.7377
E44	E44.0	Protein–calorie malnutrition of moderate and mild degree	3752 (1.1043)	0.1647	0.0521	3.1623	2.7011–3.7022
C91	C91.10	Lymphoid leukemia	1854 (0.5457)	0.1661	0.0527	3.1517	2.5270–3.9307
N17	N17.9	Acute kidney failure	31 785 (9.3548)	0.1396	0.0444	3.1421	2.9347–3.3641
Z19	Z19.2	Hormone sensitivity malignancy status	174 (0.0512)	0.1667	0.0533	3.1286	1.5331–6.3847
L22	L22.	Diaper dermatitis	774 (0.2278)	0.1654	0.0531	3.1159	2.2159–4.3814
G91	G91.2	Hydrocephalus	917 (0.2699)	0.1647	0.0530	3.1053	2.2680–4.2515

(continued)

Table 1: (continued)

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
G92	G92.	Toxic encephalopathy	1085 (0.3193)	0.1631	0.0530	3.0793	2.3025–4.1180
Y73	Y73.2	Gastroenterology and urology devices associated with adverse events	735 (0.2163)	0.1633	0.0531	3.0752	2.1619–4.3743
C79	C79.51	Secondary malignant neoplasm of other and unspecified sites	2724 (0.8017)	0.1612	0.0525	3.0721	2.5499–3.7014
Z96	Z96.1	Presence of other functional implants	58 557 (17.2342)	0.1206	0.0393	3.0656	2.8838–3.2588
E78	E78.5	Disorders of lipoprotein metabolism and other lipidemias	223 873 (65.8892)	0.0692	0.0226	3.0600	2.8037–3.3397
I73	I73.9	Other peripheral vascular diseases	31 350 (9.2268)	0.1369	0.0448	3.0545	2.8506–3.2730
R18	R18.8	Ascites	2408 (0.7087)	0.1586	0.0526	3.0172	2.4710–3.6840
C66	C66.9	Malignant neoplasm of ureter	237 (0.0698)	0.1603	0.0533	3.0107	1.6104–5.6286
Z95	Z95.1	Presence of cardiac and vascular implants and grafts	34 407 (10.1265)	0.1330	0.0444	2.9986	2.8020–3.2089
Z71	Z71.89	Persons encountering health services for other counseling and medical advice, not elsewhere classified	308 757 (90.8718)	0.0568	0.0190	2.9898	2.5115–3.5592
J91	J91.8	Pleural effusion in conditions classified elsewhere	4873 (1.4342)	0.1545	0.0519	2.9798	2.5795–3.4422
G11	G11.1	Hereditary ataxia	586 (0.1725)	0.1570	0.0532	2.9538	1.9729–4.4224
I48	I48.91	Atrial fibrillation and flutter	35 951 (10.5809)	0.1301	0.0442	2.9419	2.7502–3.1470
J15	J15.9	Bacterial pneumonia, not elsewhere classified	9858 (2.9014)	0.1482	0.0505	2.9350	2.6389–3.2644
N14	N14.0	Drug- and heavy-metal-induced tubulo-interstitial and tubular conditions	405 (0.1192)	0.1556	0.0532	2.9235	1.7952–4.7611
I67	I67.89	Other cerebrovascular diseases	16 692 (4.9127)	0.1420	0.0487	2.9125	2.6714–3.1754
H26	H26.9	Other cataract	60 786 (17.8902)	0.1156	0.0398	2.9053	2.7326–3.0889
Y71	Y71.2	Cardiovascular devices associated with adverse incidents	989 (0.2911)	0.1537	0.0530	2.8978	2.1144–3.9715
J17	J17.	Pneumonia in diseases classified elsewhere	2185 (0.6431)	0.1524	0.0527	2.8925	2.3345–3.5838
J61	J61.	Pneumoconiosis due to asbestos and other mineral fibers	1189 (0.3499)	0.1531	0.0530	2.8892	2.1653–3.8551
T82	T82.818A	Complications of cardiac and vascular prosthetic devices, implants, and grafts	6593 (1.9404)	0.1479	0.0515	2.8738	2.5282–3.2668
I95	I95.9	Hypotension	32 131 (9.4566)	0.1301	0.0453	2.8710	2.6771–3.0789
I70	I70.0	Atherosclerosis	19 489 (5.7359)	0.1379	0.0482	2.8613	2.6354–3.1065
I27	I27.20	Other pulmonary heart disease	9999 (2.9429)	0.1445	0.0506	2.8580	2.5677–3.1811
W90	W90.8XXA	Exposure to other nonionizing radiation	250 (0.0736)	0.1520	0.0533	2.8541	1.5219–5.3522
I62	I62.00	Other and unspecified nontraumatic intracranial hemorrhage	1571 (0.4624)	0.1509	0.0529	2.8530	2.2142–3.6762
N40	N40.0	Benign prostatic hyperplasia	85 767 (25.2425)	0.1036	0.0363	2.8518	2.6852–3.0289
R65	R65.20	Symptoms and signs specifically associated with systemic inflammation and infection	5450 (1.6040)	0.1468	0.0518	2.8334	2.4613–3.2617
A41	A41.9	Other sepsis	12 759 (3.7552)	0.1412	0.0499	2.8303	2.5681–3.1193
C83	C83.30	Nonfollicular lymphoma	1195 (0.3517)	0.1498	0.0530	2.8268	2.1123–3.7829
L97	L97.509	Nonpressure chronic ulcer of lower limb, not elsewhere classified	13 950 (4.1057)	0.1401	0.0496	2.8231	2.5701–3.1010
I06	I06.0	Rheumatic aortic valve disease	614 (0.1807)	0.1498	0.0532	2.8189	1.8796–4.2275
C92	C92.10	Myeloid leukemia	602 (0.1772)	0.1495	0.0532	2.8123	1.8667–4.2369
G31	G31.84	Other degenerative diseases of nervous system, not elsewhere classified	21 486 (6.3237)	0.1343	0.0479	2.8064	2.5905–3.0402
G70	G70.00	Myasthenia gravis and other myoneural disorders	745 (0.2193)	0.1490	0.0531	2.8049	1.9386–4.0581
G21	G21.11	Secondary parkinsonism	2043 (0.6013)	0.1478	0.0528	2.8019	2.2364–3.5103
D61	D61.818	Other aplastic anemias and other bone marrow failure syndromes	3153 (0.9280)	0.1468	0.0525	2.7995	2.3311–3.3619
J70	J70.5	Respiratory conditions due to other external agents	438 (0.1289)	0.1484	0.0532	2.7891	1.7221–4.5172
R57	R57.0	Shock, not elsewhere classified	1089 (0.3205)	0.1478	0.0530	2.7881	2.0503–3.7914
I63	I63.9	Cerebral infarction	18 075 (5.3197)	0.1357	0.0487	2.7853	2.5572–3.0338
C19	C19.	Malignant neoplasm of rectosigmoid junction	547 (0.1610)	0.1481	0.0532	2.7847	1.8074–4.2903
H25	H25.13	Age-related cataract	127 537 (37.5361)	0.0888	0.0320	2.7742	2.6054–2.9539
W08	W08.XXXA	Fall from other furniture	544 (0.1601)	0.1471	0.0532	2.7653	1.7896–4.2730
Z75	Z75.1	Problems related to medical facilities and other care	10 861 (3.1966)	0.1394	0.0505	2.7610	2.4854–3.0672
S88	S88.119A	Traumatic amputation of lower leg	1412 (0.4156)	0.1459	0.0529	2.7556	2.0985–3.6185

(continued)

Table 1: (continued)

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
J84	J84.10	Other interstitial pulmonary diseases	7398 (2.1773)	0.1414	0.0514	2.7524	2.4303–3.1172
N08	N08.	Glomerular disorders in diseases classified elsewhere	2453 (0.7220)	0.1443	0.0527	2.7400	2.2233–3.3768
I65	I65.29	Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction	16 848 (4.9586)	0.1344	0.0491	2.7367	2.5052–2.9897
S78	S78.019A	Traumatic amputation of hip and thigh	447 (0.1316)	0.1454	0.0532	2.7329	1.6860–4.4299
J92	J92.9	Pleural plaque	1007 (0.2964)	0.1450	0.0531	2.7326	1.9780–3.7751
I69	I69.898	Sequelae of cerebrovascular disease	14 535 (4.2779)	0.1356	0.0497	2.7310	2.4866–2.9995
D64	D64.9	Other anemias	62 258 (18.3235)	0.1103	0.0405	2.7201	2.5576–2.8930
S72	S72.009A	Fracture of femur	3337 (0.9821)	0.1423	0.0524	2.7140	2.2641–3.2535
C80	C80.1	Malignant neoplasm without specification of site	1345 (0.3959)	0.1435	0.0530	2.7089	2.0438–3.5904
W05	W05.0XXA	Fall from nonmoving wheelchair, nonmotorized scooter, and motorized mobility scooter	660 (0.1942)	0.1439	0.0532	2.7080	1.8148–4.0408
S98	S98.119A	Traumatic amputation of ankle and foot	1353 (0.3982)	0.1434	0.0530	2.7069	2.0437–3.5853
R33	R33.9	Retention of urine	20 323 (5.9814)	0.1307	0.0484	2.7009	2.4861–2.9343
C71	C71.9	Malignant neoplasm of brain	557 (0.1639)	0.1436	0.0532	2.7007	1.7462–4.1768
J47	J47.9	Bronchiectasis	1749 (0.5148)	0.1424	0.0529	2.6928	2.1001–3.4529
D53	D53.9	Other nutritional anemias	4238 (1.2473)	0.1406	0.0522	2.6927	2.2886–3.1682
J44	J44.9	Other chronic obstructive pulmonary disease	63 653 (18.7340)	0.1089	0.0405	2.6858	2.5255–2.8563
I79	I79.8	Disorders of arteries, arterioles, and capillaries in diseases classified elsewhere	940 (0.2767)	0.1426	0.0531	2.6855	1.9159–3.7643
M80	M80.88XS	Osteoporosis with current pathological fracture	1227 (0.3611)	0.1418	0.0530	2.6752	1.9881–3.5997
I44	I44.0	Atrioventricular and left bundle-branch block	14 983 (4.4097)	0.1324	0.0497	2.6653	2.4270–2.9270
N26	N26.1	Unspecified contracted kidney	757 (0.2228)	0.1413	0.0531	2.6602	1.8232–3.8816
J80	J80.	Acute respiratory distress syndrome	1161 (0.3417)	0.1404	0.0530	2.6474	1.9479–3.5981
C90	C90.00	Multiple myeloma and malignant plasma cell neoplasms	1041 (0.3064)	0.1402	0.0531	2.6431	1.9115–3.6547
C22	C22.0	Malignant neoplasm of liver and intrahepatic bile ducts	1150 (0.3385)	0.1400	0.0530	2.6397	1.9385–3.5947
Y82	Y82.8	Other and unspecified medical devices associated with adverse incidents	1007 (0.2964)	0.1400	0.0531	2.6383	1.8972–3.6688
I35	I35.0	Nonrheumatic aortic valve disorders	12 454 (3.6654)	0.1320	0.0503	2.6225	2.3688–2.9033
C32	C32.9	Malignant neoplasm of larynx	930 (0.2737)	0.1387	0.0531	2.6125	1.8504–3.6883
I08	I08.0	Multiple valve diseases	3548 (1.0442)	0.1370	0.0524	2.6117	2.1819–3.1263
E11	E11.9	Type 2 diabetes mellitus	114 394 (33.6679)	0.0902	0.0346	2.6085	2.4536–2.7731
I22	I22.2	Subsequent ST elevation (STEMI) non-ST elevation (NSTEMI) myocardial infarction	897 (0.2640)	0.1382	0.0531	2.6031	1.8311–3.7006
I71	I71.4	Aortic aneurysm and dissection	12 513 (3.6828)	0.1311	0.0504	2.6027	2.3505–2.8818
I21	I21.4	Acute myocardial infarction	14 174 (4.1716)	0.1297	0.0500	2.5947	2.3550–2.8588
N04	N04.9	Nephrotic syndrome	1098 (0.3232)	0.1375	0.0531	2.5920	1.8837–3.5666
J94	J94.8	Other pleural conditions	726 (0.2137)	0.1377	0.0531	2.5916	1.7519–3.8338
D04	D04.9	Carcinoma *in situ* of skin	3845 (1.1316)	0.1355	0.0524	2.5864	2.1733–3.0780
E87	E87.6	Other disorders of fluid, electrolyte, and acid–base balance	54 353 (15.9969)	0.1097	0.0426	2.5770	2.4185–2.7459
R60	R60.0	Edema, not elsewhere classified	61 977 (18.2408)	0.1065	0.0415	2.5673	2.4126–2.7320
T45	T45.1X5A	Poisoning by, adverse effect of and underdosing of primarily systemic and hematological agents, not elsewhere classified	2220 (0.6534)	0.1351	0.0528	2.5598	2.0383–3.2146
W01	W01.0XXA	Fall on same level from slipping, tripping and stumbling	9034 (2.6588)	0.1311	0.0512	2.5594	2.2742–2.8805
C85	C85.80	Other specified and unspecified types of non-Hodgkin's lymphoma	2228 (0.6557)	0.1351	0.0528	2.5592	2.0386–3.2127
H34	H34.219	Retinal vascular occlusions	7070 (2.0808)	0.1321	0.0517	2.5575	2.2414–2.9181
J18	J18.9	Pneumonia, unspecified organism	32 422 (9.5423)	0.1187	0.0464	2.5551	2.3768–2.7467
Z45	Z45.2	Encounter for adjustment and management of implanted device	11 371 (3.3467)	0.1290	0.0507	2.5442	2.2854–2.8322
I74	I74.3	Arterial embolism and thrombosis	3254 (0.9577)	0.1337	0.0526	2.5438	2.1033–3.0764
T86	T86.10	Complications of transplanted organs and tissues	1392 (0.4097)	0.1343	0.0530	2.5349	1.9012–3.3798

(continued)

Table 1: (continued)

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
E08	E08.42	Diabetes due to underlying condition	20 437 (6.0149)	0.1237	0.0488	2.5346	2.3283–2.7591
J93	J93.83	Pneumothorax and air leak	1123 (0.3305)	0.1345	0.0531	2.5341	1.8406–3.4889
A40	A40.9	Streptococcal sepsis	789 (0.2322)	0.1343	0.0531	2.5281	1.7269–3.7010
C67	C67.9	Malignant neoplasm of bladder	4135 (1.2170)	0.1323	0.0524	2.5266	2.1310–2.9956
C18	C18.9	Malignant neoplasm of colon	4296 (1.2644)	0.1318	0.0523	2.5179	2.1295–2.9771
T44	T44.7X5A	Poisoning by, adverse effect of and underdosing of drugs primarily affecting the autonomic nervous system	831 (0.2446)	0.1336	0.0531	2.5139	1.7318–3.6493
R27	R27.0	Other lack of coordination	5819 (1.7126)	0.1306	0.0520	2.5125	2.1722–2.9061
Z93	Z93.3	Artificial opening status	4186 (1.2320)	0.1312	0.0524	2.5048	2.1131–2.9692
Z89	Z89.519	Acquired absence of limb	5730 (1.6864)	0.1302	0.0520	2.5031	2.1612–2.8992
Z43	Z43.3	Encounter for attention to artificial openings	2992 (0.8806)	0.1317	0.0526	2.5019	2.0489–3.0550
E10	E10.9	Type 1 diabetes mellitus	20 517 (6.0385)	0.1220	0.0489	2.4951	2.2911–2.7172
H35	H35.31	Other retinal disorders	60 393 (17.7746)	0.1051	0.0421	2.4933	2.3418–2.6547
I38	I38.	Endocarditis, valve unspecified	2607 (0.7673)	0.1312	0.0527	2.4880	2.0084–3.0820
I24	I24.8	Other acute ischemic heart diseases	3221 (0.9480)	0.1307	0.0526	2.4854	2.0481–3.0160
C25	C25.9	Malignant neoplasm of pancreas	636 (0.1872)	0.1321	0.0532	2.4835	1.6181–3.8117
I77	I77.1	Other disorders of arteries and arterioles	7515 (2.2118)	0.1280	0.0516	2.4789	2.1759–2.8241
R32	R32.	Unspecified urinary incontinence	18 819 (5.5387)	0.1220	0.0493	2.4746	2.2651–2.7034
I66	I66.9	Occlusion and stenosis of cerebral arteries, not resulting in cerebral infarction	883 (0.2599)	0.1314	0.0531	2.4728	1.7165–3.5623
G12	G12.21	Spinal muscular atrophy and related syndromes	685 (0.2016)	0.1314	0.0532	2.4710	1.6331–3.7387
I42	I42.9	Cardiomyopathy	15 337 (4.5139)	0.1234	0.0500	2.4677	2.2418–2.7164
I72	I72.3	Other aneurysm	3524 (1.0372)	0.1294	0.0525	2.4632	2.0446–2.9675
I05	I05.8	Rheumatic mitral valve diseases	1041 (0.3064)	0.1306	0.0531	2.4607	1.7558–3.4485
F09	F09.	Unspecified mental disorder due to known physiological condition	2150 (0.6328)	0.1298	0.0528	2.4557	1.9380–3.1118
R77	R77.0	Other abnormalities of plasma proteins	1284 (0.3779)	0.1301	0.0530	2.4522	1.8076–3.3266
D62	D62.	Acute posthemorrhagic anemia	6406 (1.8854)	0.1266	0.0519	2.4383	2.1167–2.8087
M86	M86.9	Osteomyelitis	7523 (2.2141)	0.1252	0.0517	2.4219	2.1227–2.7632
J43	J43.9	Emphysema	9950 (2.9284)	0.1238	0.0512	2.4182	2.1523–2.7169
I87	I87.2	Other disorders of veins	23 285 (6.8531)	0.1175	0.0486	2.4162	2.2250–2.6239
M81	M81.0	Osteoporosis without current pathological fracture	10 016 (2.9479)	0.1236	0.0512	2.4143	2.1494–2.7118
K72	K72.90	Hepatic failure, not elsewhere classified	1867 (0.5495)	0.1275	0.0529	2.4089	1.8641–3.1128
W19	W19.XXXA	Unspecified fall	21 689 (6.3834)	0.1178	0.0489	2.4085	2.2128–2.6214
D38	D38.1	Neoplasm of uncertain behavior of middle ear and respiratory and intrathoracic organs	1841 (0.5418)	0.1271	0.0529	2.4015	1.8543–3.1101
T83	T83.098A	Complications of genitourinary prosthetic devices, implants, and grafts	3957 (1.1646)	0.1259	0.0525	2.3983	2.0056–2.8679
I07	I07.1	Rheumatic tricuspid valve diseases	3276 (0.9642)	0.1258	0.0526	2.3898	1.9643–2.9075
M31	M31.6	Other necrotizing vasculopathies	1113 (0.3276)	0.1267	0.0531	2.3863	1.7117–3.3268
T38	T38.0X5A	Poisoning by, adverse effect of and underdosing of hormones and their synthetic substitutes and antagonists, not elsewhere classified	2095 (0.6166)	0.1260	0.0529	2.3831	1.8674–3.0411
E09	E09.65	Drug- or chemical-induced diabetes mellitus	893 (0.2628)	0.1265	0.0531	2.3814	1.6435–3.4506
E63	E63.9	Other nutritional deficiencies	1355 (0.3988)	0.1255	0.0530	2.3654	1.7469–3.2027
H90	H90.3	Conductive and sensorineural hearing loss	118 138 (34.7698)	0.0855	0.0362	2.3616	2.2218–2.5102
I61	I61.9	Nontraumatic intracerebral hemorrhage	1197 (0.3523)	0.1253	0.0531	2.3610	1.7102–3.2595
G46	G46.4	Vascular syndromes of brain in cerebrovascular diseases	4838 (1.4239)	0.1234	0.0523	2.3586	2.0018–2.7791
R13	R13.10	Aphasia and dysphagia	40 814 (12.0122)	0.1080	0.0459	2.3554	2.1977–2.5245
C20	C20.	Malignant neoplasm of rectum	935 (0.2752)	0.1251	0.0531	2.3552	1.6352–3.3920
E21	E21.3	Hyperparathyroidism and other disorders of the parathyroid gland	4412 (1.2985)	0.1233	0.0524	2.3526	1.9817–2.7930
K94	K94.23	Complications of artificial openings of the digestive system	1165 (0.3429)	0.1245	0.0531	2.3446	1.6888–3.2551
S37	S37.009A	Injury of urinary and pelvic organs	989 (0.2911)	0.1244	0.0531	2.3412	1.6399–3.3423

(continued)

Table 1: (continued)

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
S81	S81.009A	Open wound of knee and lower leg	8362 (2.4611)	0.1208	0.0516	2.3395	2.0586–2.6588
D89	D89.9	Other disorders involving the immune mechanism, not elsewhere classified	1590 (0.4680)	0.1239	0.0530	2.3378	1.7633–3.0995
G45	G45.9	Transient cerebral ischemic attacks and related syndromes	14 740 (4.3382)	0.1178	0.0504	2.3365	2.1140–2.5823
Y84	Y84.8	Other medical procedures as the cause of abnormal reaction of the patient or of later complication, without mention of misadventure at the time of procedure	3576 (1.0525)	0.1228	0.0526	2.3343	1.9295–2.8240
R47	R47.1	Speech disturbances, not elsewhere classified	8462 (2.4905)	0.1204	0.0516	2.3330	2.0539–2.6500
I45	I45.10	Other conduction disorders	15 283 (4.4980)	0.1173	0.0503	2.3302	2.1113–2.5718
G81	G81.90	Hemiplegia and hemiparesis	3445 (1.0139)	0.1225	0.0526	2.3279	1.9171–2.8267
R41	R41.2	Other symptoms and signs involving cognitive functions and awareness	42 168 (12.4107)	0.1065	0.0458	2.3270	2.1720–2.4930
I11	I11.9	Hypertensive heart disease	28 332 (8.3385)	0.1117	0.0480	2.3255	2.1510–2.5142
Q84	Q84.5	Other congenital malformations of integument	1698 (0.4997)	0.1231	0.0530	2.3233	1.7664–3.0557
Q27	Q27.9	Other congenital malformations of peripheral vascular system	1138 (0.3349)	0.1230	0.0531	2.3170	1.6589–3.2362
J12	J12.9	Viral pneumonia, not elsewhere classified	1835 (0.5401)	0.1226	0.0530	2.3155	1.7777–3.0160
T36	T36.8X5A	Poisoning by, adverse effect of, and underdosing of systemic antibiotics	1254 (0.3691)	0.1228	0.0531	2.3139	1.6824–3.1826
I99	I99.8	Other and unspecified disorders of circulatory system	4579 (1.3477)	0.1212	0.0524	2.3130	1.9511–2.7419
S32	S32.009A	Fracture of lumbar spine and pelvis	4732 (1.3927)	0.1211	0.0524	2.3121	1.9555–2.7338
J95	J95.811	Intraoperative and postprocedural complications and disorders of respiratory system, not elsewhere classified	2669 (0.7855)	0.1218	0.0528	2.3067	1.8499–2.8763
D69	D69.6	Purpura and other hemorrhagic conditions	15 284 (4.4983)	0.1161	0.0504	2.3056	2.0880–2.5458
Z51	Z51.89	Encounter for aftercare and medical care	178 296 (52.4552)	0.0729	0.0317	2.3027	2.1516–2.4644
Z99	Z99.89	Dependence on enabling machines and devices, not elsewhere classified	21 756 (6.4031)	0.1133	0.0492	2.3027	2.1125–2.5100
N05	N05.9	Unspecified nephritic syndrome	1450 (0.4268)	0.1221	0.0530	2.3017	1.7091–3.0996
N03	N03.9	Chronic nephritic syndrome	736 (0.2166)	0.1223	0.0532	2.2994	1.5164–3.4866
R34	R34.	Anuria and oliguria	720 (0.2119)	0.1222	0.0532	2.2981	1.5085–3.5011
D09	D09.0	Carcinoma *in situ* of other and unspecified sites	3148 (0.9265)	0.1210	0.0527	2.2967	1.8724–2.8172
C76	C76.0	Malignant neoplasm of other and ill-defined sites	3221 (0.9480)	0.1208	0.0527	2.2923	1.8726–2.8061
I37	I37.0	Nonrheumatic pulmonary valve disorders	1552 (0.4568)	0.1211	0.0530	2.2847	1.7112–3.0505
Z94	Z94.0	Transplanted organ and tissue status	3033 (0.8927)	0.1203	0.0527	2.2824	1.8526–2.8120
J16	J16.8	Pneumonia due to other infectious organisms, not elsewhere classified	1240 (0.3650)	0.1210	0.0531	2.2789	1.6494–3.1486
A04	A04.7	Other bacterial intestinal infections	5175 (1.5231)	0.1190	0.0523	2.2754	1.9351–2.6755
Z85	Z85.828	Personal history of malignant neoplasm	43 622 (12.8386)	0.1042	0.0458	2.2743	2.1233–2.4362
L60	L60.0	Nail disorders	53 817 (15.8392)	0.1007	0.0444	2.2688	2.1255–2.4219
H59	H59.032	Intraoperative and postprocedural complications and disorders of eye and adnexa, not elsewhere classified	2323 (0.6837)	0.1197	0.0529	2.2634	1.7830–2.8732
C77	C77.0	Secondary and unspecified malignant neoplasm of lymph nodes	2569 (0.7561)	0.1195	0.0528	2.2622	1.8024–2.8393
R53	R53.1	Malaise and fatigue	65 148 (19.1740)	0.0971	0.0430	2.2599	2.1221–2.4067
E86	E86.0	Volume depletion	28 085 (8.2658)	0.1091	0.0483	2.2594	2.0876–2.4453
T17	T17.300A	Foreign body in respiratory tract	842 (0.2478)	0.1200	0.0532	2.2563	1.5221–3.3445
R80	R80.3	Proteinuria	13 651 (4.0177)	0.1142	0.0508	2.2489	2.0245–2.4983
Z79	Z79.899	Long-term (current) drug therapy	147 374 (43.3744)	0.0777	0.0346	2.2438	2.1065–2.3899
D47	D47.2	Other neoplasms of uncertain behavior of lymphoid, hematopoietic and related tissue	5592 (1.6458)	0.1166	0.0523	2.2306	1.9049–2.6119
N31	N31.9	Neuromuscular dysfunction of bladder, not elsewhere classified	7306 (2.1503)	0.1158	0.0520	2.2287	1.9386–2.5621
D50	D50.9	Iron deficiency anemia	31 287 (9.2082)	0.1065	0.0479	2.2208	2.0569–2.3978

(continued)

Table 1: (continued)

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
S51	S51.809A	Open wound of elbow and forearm	3177 (0.9350)	0.1171	0.0527	2.2207	1.8053–2.7317
R15	R15.9	Fecal incontinence	3962 (1.1661)	0.1166	0.0526	2.2176	1.8405–2.6720
I34	I34.0	Nonrheumatic mitral (valve) disorders	11 109 (3.2695)	0.1137	0.0513	2.2167	1.9744–2.4887
I89	I89.0	Other noninfective disorders of lymphatic vessels and lymph nodes	5047 (1.4854)	0.1161	0.0524	2.2165	1.8772–2.6172
H54	H54.7	Blindness and low vision	25 803 (7.5942)	0.1080	0.0488	2.2108	2.0363–2.4001
I15	I15.8	Secondary hypertension	4169 (1.2270)	0.1161	0.0526	2.2092	1.8411–2.6510
R58	R58.	Hemorrhage, not elsewhere classified	1357 (0.3994)	0.1172	0.0531	2.2077	1.6115–3.0243
D01	D01.0	Carcinoma *in situ* of other and unspecified digestive organs	2376 (0.6993)	0.1166	0.0529	2.2045	1.7352–2.8007
R63	R63.4	Symptoms and signs concerning food and fluid intake	34 666 (10.2027)	0.1046	0.0475	2.2026	2.0448–2.3726
I36	I36.1	Nonrheumatic tricuspid valve disorders	3914 (1.1519)	0.1157	0.0526	2.2002	1.8226–2.6561)
J13	J13.	Pneumonia due to Streptococcus pneumoniae	1115 (0.3282)	0.1166	0.0531	2.1948	1.5499–3.1081
N28	N28.9	Other disorders of kidney and ureter, not elsewhere specified	27 416 (8.0689)	0.1067	0.0486	2.1941	2.0241–2.3783
I43	I43.	Cardiomyopathy in diseases classified elsewhere	1050 (0.3090)	0.1162	0.0531	2.1867	1.5269–3.1315
D68	D68.8	Other coagulation defects	5690 (1.6747)	0.1142	0.0523	2.1845	1.8648–2.5591
E83	E83.42	Disorders of mineral metabolism	22 641 (6.6636)	0.1079	0.0494	2.1827	2.0014–2.3806
E16	E16.2	Other disorders of pancreatic internal secretion	9251 (2.7227)	0.1126	0.0517	2.1799	1.9207–2.4742
C44	C44.91	Merkel cell carcinoma	21 770 (6.4072)	0.1080	0.0496	2.1778	1.9940–2.3785
H61	H61.23	Other disorders of external ear	58 221 (17.1353)	0.0966	0.0444	2.1776	2.0411–2.3232
I51	I51.7	Complications and ill-defined descriptions of heart disease	24 480 (7.2048)	0.1066	0.0492	2.1674	1.9918–2.3584
Z46	Z46.1	Encounter for fitting and adjustment of other devices	98 123 (28.8791)	0.0863	0.0399	2.1625	2.0355–2.2975
H52	H52.4	Disorders of refraction and accommodation	192 666 (56.7045)	0.0694	0.0323	2.1442	2.0003–2.2985
D41	D41.4	Neoplasm of uncertain behavior of urinary organs	3097 (0.9115)	0.1130	0.0528	2.1412	1.7289–2.6517
E20	E20.1	Hypoparathyroidism	1647 (0.4847)	0.1135	0.0530	2.1408	1.6002–2.8640
C61	C61.	Malignant neoplasm of prostate	19 707 (5.8001)	0.1069	0.0500	2.1359	1.9473–2.3427
K55	K55.20	Vascular disorders of intestine	2499 (0.7355)	0.1128	0.0529	2.1336	1.6821–2.7064
B96	B96.81	Other bacterial agents as the cause of diseases classified elsewhere	20 262 (5.9634)	0.1066	0.0500	2.1330	1.9466–2.3373
B95	B95.61	Streptococcus, Staphylococcus, and Enterococcus as the cause of diseases classified elsewhere	13 437 (3.9547)	0.1086	0.0511	2.1267	1.9078–2.3708
N32	N32.81	Other disorders of bladder	19 165 (5.6405)	0.1063	0.0502	2.1188	1.9291–2.3272
E13	E13.9	Other specified diabetes mellitus	11 229 (3.3049)	0.1089	0.0514	2.1177	1.8824–2.3824
T85	T85.398A	Complications of other internal prosthetic devices, implants and grafts	3710 (1.0919)	0.1113	0.0527	2.1128	1.7342–2.5739
I85	I85.00	Esophageal varices	2480 (0.7299)	0.1117	0.0529	2.1114	1.6608–2.6842
W18	W18.49XA	Other slipping, tripping, and stumbling and falls	13 407 (3.9459)	0.1077	0.0511	2.1079	1.8898–2.3511
R29	R29.6	Other symptoms and signs involving the nervous and musculoskeletal systems	19 639 (5.7801)	0.1055	0.0501	2.1035	1.9164–2.3089
H02	H02.839	Other disorders of eyelid	29 211 (8.5972)	0.1024	0.0487	2.1019	1.9401–2.2772
B35	B35.1	Dermatophytosis	95 767 (28.1857)	0.0854	0.0407	2.0963	1.9729–2.2274
G99	G99.0	Other disorders of nervous system in diseases classified elsewhere	4227 (1.2441)	0.1100	0.0526	2.0908	1.7351–2.5194
K26	K26.9	Duodenal ulcer	3428 (1.0089)	0.1103	0.0527	2.0904	1.7008–2.5693
I31	I31.9	Other diseases of pericardium	3328 (0.9795)	0.1103	0.0528	2.0899	1.6953–2.5764
H49	H49.20	Paralytic strabismus	1988 (0.5851)	0.1107	0.0530	2.0883	1.5957–2.7330
T87	T87.89	Complications peculiar to reattachment and amputation	1707 (0.5024)	0.1107	0.0530	2.0875	1.5620–2.7898
L62	L62.	Nail disorders in diseases classified elsewhere	1530 (0.4503)	0.1105	0.0531	2.0813	1.5318–2.8279
N47	N47.6	Disorders of prepuce	6273 (1.8462)	0.1086	0.0523	2.0761	1.7776–2.4247
N39	N39.0	Other disorders of urinary system	64 087 (18.8618)	0.0920	0.0444	2.0733	1.9446–2.2105
T46	T46.4X5A	Poisoning by, adverse effect of and underdosing of agents primarily affecting the cardiovascular system	1931 (0.5683)	0.1098	0.0530	2.0712	1.5746–2.7244
Z16	Z16.11	Resistance to antimicrobial drugs	2546 (0.7493)	0.1092	0.0529	2.0638	1.6235–2.6234
I82	I82.409	Other venous embolism and thrombosis	14 028 (4.1287)	0.1046	0.0511	2.0456	1.8351–2.2803

(continued)

Table 1: (continued)

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
N12	N12.	Tubulo-interstitial nephritis, not specified as acute or chronic	1965 (0.5783)	0.1084	0.0530	2.0449	1.5552–2.6887
S91	S91.309A	Open wound of ankle, foot, and toes	11 184 (3.2916)	0.1054	0.0516	2.0447	1.8135–2.3054
H21	H21.81	Other disorders of iris and ciliary body	5158 (1.5181)	0.1072	0.0525	2.0422	1.7199–2.4248
H01	H01.009	Other inflammation of eyelid	31 384 (9.2368)	0.0992	0.0487	2.0391	1.8843–2.2066
I97	I97.710	Intraoperative and postprocedural complications and disorders of circulatory system, not elsewhere classified	2682 (0.7894)	0.1078	0.0529	2.0371	1.6095–2.5783
L85	L85.3	Other epidermal thickening	31 066 (9.1432)	0.0991	0.0487	2.0350	1.8799–2.2029
M15	M15.9	Polyosteoarthritis	70 950 (20.8817)	0.0892	0.0439	2.0333	1.9090–2.1656
I20	I20.8	Angina pectoris	31 188 (9.1791)	0.0990	0.0487	2.0318	1.8770–2.1993
N13	N13.30	Obstructive and reflux uropathy	13 082 (3.8502)	0.1040	0.0513	2.0264	1.8109–2.2676
L57	L57.0	Skin changes due to chronic exposure of nonionizing radiation	46 813 (13.7778)	0.0945	0.0467	2.0227	1.8866–2.1685
G60	G60.9	Hereditary and idiopathic neuropathy	30 297 (8.9169)	0.0988	0.0489	2.0219	1.8661–2.1907
M10	M10.9	Gout	32 778 (9.6471)	0.0981	0.0485	2.0210	1.8693–2.1849
M1A	M1A.9XX0	Chronic gout	5350 (1.5746)	0.1060	0.0525	2.0192	1.7039–2.3928
I26	I26.99	Pulmonary embolism	7323 (2.1553)	0.1051	0.0522	2.0148	1.7400–2.3330
K56	K56.60	Paralytic ileus and intestinal obstruction without hernia	8535 (2.5120)	0.1047	0.0520	2.0141	1.7569–2.3090
G58	G58.9	Other mononeuropathies	20 738 (6.1035)	0.1011	0.0502	2.0134	1.8348–2.2093
D30	D30.3	Benign neoplasm of urinary organs	1931 (0.5683)	0.1067	0.0530	2.0119	1.5228–2.6581
K59	K59.00	Other functional intestinal disorders	59 540 (17.5235)	0.0911	0.0453	2.0108	1.8833–2.1469
R01	R01.1	Cardiac murmurs and other cardiac sounds	14 466 (4.2576)	0.1028	0.0511	2.0104	1.8045–2.2398
I47	I47.1	Paroxysmal tachycardia	12 549 (3.6934)	0.1031	0.0514	2.0053	1.7873–2.2500
L11	L11.0	Other acantholytic disorders	16 439 (4.8382)	0.1020	0.0509	2.0047	1.8095–2.2209
I49	I49.9	Other cardiac arrhythmias	59 805 (17.6015)	0.0907	0.0453	2.0015	1.8746–2.1370
M62	M62.81	Other disorders of muscle	71 400 (21.0141)	0.0882	0.0441	2.0014	1.8789–2.1319
G82	G82.20	Paraplegia (paraparesis) and quadriplegia (quadriparesis)	2430 (0.7152)	0.1058	0.0530	1.9973	1.5557–2.5643
J98	J98.4	Other respiratory disorders	35 483 (10.4432)	0.0964	0.0483	1.9959	1.8494–2.1540
C64	C64.9	Malignant neoplasm of kidney, except renal pelvis	3149 (0.9268)	0.1048	0.0528	1.9829	1.5896–2.4736
H91	H91.90	Other and unspecified hearing loss	71 156 (20.9423)	0.0876	0.0443	1.9790	1.8576–2.1083
E53	E53.8	Deficiency of other B group vitamins	19 291 (5.6776)	0.0996	0.0505	1.9712	1.7899–2.1710
R44	R44.0	Other symptoms and signs involving general sensations and perceptions	4298 (1.2650)	0.1038	0.0527	1.9697	1.6273–2.3841
R97	R97.2	Abnormal tumor markers	36 803 (10.8317)	0.0950	0.0483	1.9694	1.8259–2.1241
R91	R91.8	Abnormal diagnostic imaging of lung	37 585 (11.0618)	0.0947	0.0482	1.9658	1.8235–2.1193
H40	H40.009	Glaucoma	61 759 (18.1766)	0.0889	0.0454	1.9583	1.8344–2.0905
I16	I16.0	Hypertensive crisis	5096 (1.4998)	0.1024	0.0526	1.9481	1.6320–2.3254
Q61	Q61.00	Cystic kidney disease	7172 (2.1108)	0.1018	0.0523	1.9467	1.6744–2.2634
D49	D49.2	Neoplasms of unspecified behavior	14 001 (4.1207)	0.0998	0.0513	1.9437	1.7390–2.1726
Z76	Z76.0	Persons encountering health services in other circumstances	161 461 (47.5204)	0.0715	0.0369	1.9405	1.8214–2.0674
D07	D07.5	Carcinoma *in situ* of other and unspecified genital organs	9818 (2.8896)	0.1006	0.0519	1.9381	1.7008–2.2086
K74	K74.60	Fibrosis and cirrhosis of liver	8439 (2.4837)	0.1010	0.0521	1.9372	1.6840–2.2285
K83	K83.1	Other diseases of biliary tract	3048 (0.8971)	0.1024	0.0529	1.9355	1.5416–2.4301
Z86	Z86.010	Personal history of certain other diseases	103 774 (30.5422)	0.0803	0.0415	1.9350	1.8211–2.0561
N42	N42.9	Other and unspecified disorders of prostate	10 264 (3.0208)	0.1003	0.0519	1.9328	1.7003–2.1972
Y83	Y83.1	Surgical operation and other surgical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of procedure	11 053 (3.2531)	0.0999	0.0518	1.9296	1.7044–2.1845
L84	L84.	Corns and callosities	31 962 (9.4069)	0.0946	0.0490	1.9284	1.7801–2.0891
R04	R04.0	Hemorrhage from respiratory passages	14 831 (4.3650)	0.0988	0.0513	1.9272	1.7282–2.1491
D72	D72.829	Other disorders of white blood cells	25 660 (7.5521)	0.0958	0.0499	1.9221	1.7619–2.0968
G93	G93.3	Oher disorders of brain	39 656 (11.6714)	0.0925	0.0482	1.9201	1.7824–2.0685
B02	B02.9	Zoster [herpes zoster]	16 479 (4.8500)	0.0976	0.0511	1.9118	1.7221–2.1225
Z92	Z92.3	Personal history of medical treatment	8961 (2.6374)	0.0994	0.0521	1.9092	1.6643–2.1900
N30	N30.00	Cystitis	10 151 (2.9876)	0.0988	0.0519	1.9027	1.6710–2.1666
R78	R78.89	Finding of drugs and other substances, not normally found in blood	32 503 (9.5661)	0.0933	0.0491	1.9012	1.7551–2.0595

(continued)

Table 1: (continued)

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
R55	R55.	Syncope and collapse	30 812 (9.0684)	0.0937	0.0493	1.9004	1.7516–2.0619
E03	E03.9	Other hypothyroidism	35 891 (10.5633)	0.0925	0.0487	1.9000	1.7588–2.0526
H04	H04.123	Disorders of lacrimal systems	82 128 (24.1715)	0.0830	0.0439	1.8911	1.7770–2.0126
K27	K27.9	Peptic ulcer, site unspecified	7919 (2.3307)	0.0987	0.0522	1.8901	1.6332–2.1874
Z60	Z60.2	Problems related to social environment	11 811 (3.4762)	0.0974	0.0517	1.8817	1.6657–2.1257
E27	E27.9	Other disorders of adrenal gland	3916 (1.1525)	0.0991	0.0528	1.8767	1.5290–2.3034
F06	F06.30	Other mental disorders due to known physiological condition	31 408 (9.2438)	0.0926	0.0493	1.8761	1.7295–2.0351
Z65	Z65.9	Problems related to other psychosocial circumstances	127 694 (37.5823)	0.0753	0.0401	1.8759	1.7653–1.9935
K25	K25.9	Gastric ulcer	5442 (1.6017)	0.0985	0.0526	1.8727	1.5718–2.2312
K86	K86.1	Other disorders of pancreas	5781 (1.7014)	0.0983	0.0526	1.8696	1.5768–2.2168
K68	K68.11	Disorders of retroperitoneum	4165 (1.2258)	0.0984	0.0528	1.8654	1.5280–2.2774
H18	H18.51	Other disorders of cornea	11 506 (3.3864)	0.0961	0.0518	1.8546	1.6380–2.0999
T81	T81.89XA	Complications of procedures, not elsewhere classified	10 309 (3.0341)	0.0957	0.0520	1.8411	1.6150–2.0989
D51	D51.9	Vitamin B12 deficiency anemia	14 069 (4.1407)	0.0948	0.0515	1.8398	1.6416–2.0619
D29	D29.1	Benign neoplasm of male genital organs	6819 (2.0069)	0.0963	0.0524	1.8370	1.5670–2.1535
Z44	Z44.8	Encounter for fitting and adjustment of external prosthetic device	5211 (1.5337)	0.0967	0.0527	1.8369	1.5333–2.2005
M84	M84.369S	Disorder of continuity of bone	5832 (1.7164)	0.0965	0.0526	1.8362	1.5472–2.1791
C43	C43.9	Malignant melanoma of skin	4224 (1.2432)	0.0968	0.0528	1.8345	1.5020–2.2405
R82	R82.5	Glycosuria	14 186 (4.1752)	0.0945	0.0515	1.8328	1.6357–2.0537)
R35	R35.0	Polyuria	39 834 (11.7237)	0.0890	0.0486	1.8321	1.6989–1.9756
L82	L82.1	Seborrheic keratosis	55 603 (16.3648)	0.0859	0.0470	1.8281	1.7077–1.9571
Z91	Z91.19	Personal risk factors, not elsewhere classified	64 332 (18.9339)	0.0842	0.0461	1.8244	1.7083–1.9482
R49	R49.0	Voice and resonance	12 308 (3.6224)	0.0942	0.0518	1.8197	1.6114–2.0550
G62	G62.9	Other and unspecified polyneuropathies	14 108 (4.1522)	0.0937	0.0516	1.8167	1.6201–2.0371
H43	H43.819	Disorders of vitreous body	38 102 (11.2140)	0.0887	0.0489	1.8155	1.6812–1.9606
I83	I83.90	Varicose veins of lower extremity	14 263 (4.1978)	0.0934	0.0516	1.8107	1.6154–2.0297
S22	S22.39XA	Fracture of rib(s), sternum, and thoracic spine	10 436 (3.0715)	0.0942	0.0520	1.8102	1.5873–2.0644
S31	S31.000A	Open wound of abdomen, lower back, pelvis, and external genitals	10 430 (3.0697)	0.0942	0.0520	1.8093	1.5864–2.0635
Z13	Z13.6	Encounter for screening for other diseases and disorders	237 211 (69.8148)	0.0616	0.0341	1.8054	1.6707–1.9509
K57	K57.30	Diverticular disease of intestine	60 553 (17.8217)	0.0842	0.0466	1.8047	1.6880–1.9295
R06	R06.02	Abnormalities of breathing	118 999 (35.0232)	0.0750	0.0417	1.7984	1.6926–1.9108
R09	R09.81	Other symptoms and signs involving the circulatory and respiratory system	40 481 (11.9142)	0.0871	0.0488	1.7869	1.6567–1.9274
H31	H31.009	Other diseases of choroid	9734 (2.8649)	0.0931	0.0522	1.7845	1.5566–2.0458
Z23	Z23.	Encounter for immunization	260 232 (76.5902)	0.0594	0.0336	1.7694	1.6229–1.9292
D12	D12.0	Benign neoplasm of cecum	65 120 (19.1658)	0.0821	0.0465	1.7646	1.6519–1.8850
K92	K92.1	Other diseases of digestive system	40 170 (11.8226)	0.0860	0.0489	1.7578	1.6287–1.8971
S01	S01.00XA	Open wound of head	7728 (2.2745)	0.0921	0.0524	1.7574	1.5076–2.0485
L21	L21.9	Seborrheic dermatitis	25 335 (7.4565)	0.0885	0.0505	1.7534	1.6012–1.9200
R79	R79.89	Other abnormal findings of blood chemistry	28 403 (8.3594)	0.0879	0.0502	1.7521	1.6065–1.9110
K80	K80.20	Cholelithiasis	16 844 (4.9574)	0.0896	0.0514	1.7429	1.5645–1.9417
R31	R31.9	Hematuria	42 562 (12.5266)	0.0844	0.0489	1.7277	1.6025–1.8627
L03	L03.90	Cellulitis and acute lymphangitis	70 833 (20.8472)	0.0800	0.0463	1.7269	1.6183–1.8429
R42	R42.	Dizziness and giddiness	67 634 (19.9057)	0.0800	0.0467	1.7131	1.6040–1.8297
D48	D48.5	Neoplasm of uncertain behavior of other and unspecified sites	44 749 (13.1703)	0.0834	0.0488	1.7106	1.5883–1.8424
Z98	Z98.890	Other postprocedural states	92 911 (27.3451)	0.0763	0.0447	1.7083	1.6057–1.8174
R39	R39.15	Other and unspecified symptoms and signs involving the genitourinary system	29 413 (8.6567)	0.0858	0.0503	1.7069	1.5654–1.8611
K31	K31.89	Other diseases of stomach and duodenum	15 241 (4.4857)	0.0872	0.0517	1.6854	1.5028–1.8900
M89	M89.9	Other disorders of bone	17 841 (5.2509)	0.0863	0.0515	1.6760	1.5056–1.8657
R25	R25.2	Abnormal involuntary movements	28 206 (8.3014)	0.0846	0.0505	1.6743	1.5323–1.8294
R69	R69.	Illness, unspecified	161 563 (47.5504)	0.0675	0.0405	1.6691	1.5685–1.7761
Z09	Z09.	Encounter for follow-up exam after treatment for conditions other than malignant neoplasm	55 214 (16.2503)	0.0803	0.0481	1.6682	1.5555–1.7891
Z48	Z48.02		78 659 (23.1505)	0.0770	0.0462	1.6660	1.5627–1.7760

(continued)

Table 1: (continued)

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
		Encounter for other postprocedural aftercare					
M20	M20.40	Acquired deformities of fingers and toes	43 692 (12.8592)	0.0811	0.0492	1.6482	1.5280–1.7779
L98	L98.9	Other disorders of skin and subcutaneous tissue, not elsewhere classified	55 257 (16.2630)	0.0784	0.0485	1.6182	1.5080–1.7365
M19	M19.90	Other and unspecified osteoarthritis	89 625 (26.3780)	0.0737	0.0460	1.6021	1.5046–1.7059
F12	F12.10	Cannabis-related disorders	24 113 (7.0968)	0.0346	0.0548	0.6324	0.5463–0.7320
K58	K58.9	Irritable bowel syndrome	17 352 (5.1070)	0.0329	0.0544	0.6046	0.5071–0.7207
R51	R51.	Headache	51 370 (15.1190)	0.0335	0.0569	0.5896	0.5310–0.6546
L70	L70.0	Acne	12 335 (3.6304)	0.0317	0.0541	0.5854	0.4739–0.7233
M22	M22.40	Disorder of patella	16 168 (4.7585)	0.0317	0.0544	0.5820	0.4835–0.7005
F15	F15.20	Other stimulant-related disorders	8910 (2.6223)	0.0300	0.0540	0.5554	0.4302–0.7168
Z56	Z56.0	Problems related to employment and unemployment	34 996 (10.2998)	0.0298	0.0560	0.5319	0.4661–0.6069
A63	A63.0	Other predominantly sexually transmitted diseases, not elsewhere classified	4871 (1.4336)	0.0279	0.0537	0.5199	0.3639–0.7428
T74	T74.21XA	Adult and child neglect and other maltreatment, confirmed	3385 (0.9963)	0.0278	0.0536	0.5182	0.3376–0.7955
Z20	Z20.828	Contact with and (suspected) exposure to communicable diseases	19 317 (5.6853)	0.0279	0.0549	0.5086	0.4243–0.6096
X50	X50.0XXA	Overexertion and strenuous or repetitive movements	3150 (0.9271)	0.0244	0.0536	0.4561	0.2838–0.7327
J03	J03.90	Acute tonsillitis	5855 (1.7232)	0.0243	0.0538	0.4505	0.3175– 0.6391
A60	A60.9	Anogenital herpesviral (herpes simplex) infection	7165 (2.1088)	0.0241	0.0540	0.4475	0.3258–0.6145
Z31	Z31.5	Encounter for procreative management	2984 (0.8782)	0.0221	0.0536	0.4126	0.2471–0.6889
G43	G43.909	Migraine	42 103 (12.3915)	0.0231	0.0576	0.4016	0.3503–0.4605
N95	N95.1	Menopausal and other perimenopausal disorders	9036 (2.6594)	0.0216	0.0542	0.3982	0.2952–0.5371
R92	R92.8	Abnormal and inconclusive findings on diagnostic imaging of breast	3749 (1.1034)	0.0195	0.0537	0.3626	0.2225–0.5907
N60	N60.19	Benign mammary dysplasia	3693 (1.0869)	0.0187	0.0537	0.3479	0.2105–0.5748
A64	A64.	Unspecified sexually transmitted disease	6612 (1.9460)	0.0180	0.0540	0.3331	0.2271–0.4886
N85	N85.8	Other noninflammatory disorders of uterus, except cervix	3702 (1.0896)	0.0170	0.0537	0.3167	0.1872–0.5360
N46	N46.9	Male infertility	2364 (0.6958)	0.0161	0.0536	0.2999	0.1524–0.5904
N84	N84.1	Polyp of female genital tract	1403 (0.4129)	0.0157	0.0535	0.2932	0.1204–0.7138
N73	N73.9	Other female pelvic inflammatory disease	1373 (0.4041)	0.0138	0.0535	0.2587	0.0992–0.6745
L68	L68.0	Hypertrichosis	1024 (0.3014)	0.0127	0.0535	0.2375	0.0745–0.7569
N83	N83.20	Noninflammatory disorders of ovary, fallopian tube, and broad ligament	5025 (1.4789)	0.0127	0.0539	0.2361	0.1400–0.3984
N89	N89.8	Other noninflammatory disorders of vagina	4793 (1.4107)	0.0123	0.0539	0.2283	0.1324–0.3937
D25	D25.9	Leiomyoma of uterus	4634 (1.3639)	0.0123	0.0539	0.2282	0.1311–0.3972
N90	N90.7	Other noninflammatory disorders of vulva and perineum	988 (0.2908)	0.0121	0.0534	0.2272	0.0680–0.7594
F90	F90.9	Attention-deficit hyperactivity disorders	11 738 (3.4547)	0.0121	0.0548	0.2207	0.1552–0.3139
A74	A74.9	Other diseases caused by Chlamydiae	1082 (0.3184)	0.0102	0.0535	0.1901	0.0539–0.6713
N76	N76.0	Other inflammation of vagina and vulva	10 023 (2.9499)	0.0098	0.0547	0.1789	0.1171–0.2733
E28	E28.2	Ovarian dysfunction	2511 (0.7390)	0.0088	0.0537	0.1633	0.0669–0.3987
N94	N94.6	Pain and other conditions associated with female genital organs and menstrual cycle	9013 (2.6527)	0.0081	0.0546	0.1484	0.0908–0.2425
N92	N92.0	Excessive, frequent, and irregular menstruation	9748 (2.8690)	0.0081	0.0547	0.1483	0.0925–0.2377
N77	N77.1	Vulvovaginal ulceration and inflammation in diseases classified elsewhere	1805 (0.5312)	0.0078	0.0536	0.1448	0.0473–0.4436
N72	N72.	Inflammatory disease of cervix uteri	1687 (0.4965)	0.0071	0.0536	0.1328	0.0396–0.4452
R87	R87.619	Abnormal findings in specimens from female genital organs	6501 (1.9133)	0.0071	0.0542	0.1305	0.0703–0.2422
N80	N80.9	Endometriosis	2081 (0.6125)	0.0067	0.0536	0.1255	0.0409–0.3846
N87	N87.9	Dysplasia of cervix uteri	2020 (0.5945)	0.0064	0.0536	0.1200	0.0375–0.3839
A56	A56.00	Other sexually transmitted chlamydial diseases	1100 (0.3237)	0.0064	0.0535	0.1190	0.0244–0.5801
N97	N97.9	Female infertility	1964 (0.5780)	0.0051	0.0536	0.0950	0.0252–0.3578
Z30	Z30.09	Encounter for contraceptive management	15 303 (4.5039)	0.0050	0.0556	0.0893	0.0551–0.1446

(continued)

Table 1: (continued)

Category condition	Most common ICD-10 code	ICD-10 category description	Number (%) of cases with category condition	Case rate	Control rate	Relative risk	95% Confidence interval
N91	N91.2	Absent, scanty, and rare menstruation	2649 (0.7796)	0.0042	0.0537	0.0773	0.0218–0.2740
N93	N93.9	Other abnormal uterine and vaginal bleeding	5282 (1.5546)	0.0042	0.0541	0.0770	0.0315–0.1884
Z32	Z32.02	Encounter for pregnancy test and childbirth and childcare instruction	6339 (1.8657)	0.0024	0.0543	0.0436	0.0147–0.1289
Z33	Z33.1	Pregnant state	3827 (1.1263)	0.0010	0.0539	0.0194	0.0024–0.1585

Table 2: Multivariate model for COVID-19 death based upon pre-existing conditions

Category condition	Most common ICD-10 code	ICD-10 category condition description	Number (%) of cases with category condition	Coefficient	Standard error	P-value	95% Confidence interval	Coefficient × (RR − 1)[a]
I10	I10.	Essential (primary) hypertension	208 817 (61.4580)	0.1934	0.0075	0.0000	0.1787 to 0.2081	0.7424
J64	J64.	Unspecified pneumoconiosis	107 (0.0315)	0.2495	0.1007	0.0130	0.0521 to 0.4468	0.6695
F03	F03.90	Unspecified dementia	13 895 (4.0895)	0.1619	0.0076	0.0000	0.1471 to 0.1768	0.6683
C93	C93.10	Monocytic leukemia	122 (0.0359)	0.2194	0.0815	0.0070	0.0597 to 0.3791	0.6583
C24	C24.1	Malignant neoplasm of other and unspecified parts of biliary tract	122 (0.0359)	0.2489	0.1006	0.0130	0.0517 to 0.4461	0.6318
C71	C71.9	Malignant neoplasm of brain	557 (0.1639)	0.3400	0.0786	0.0000	0.1860 to 0.4941	0.5782
C91	C91.10	Lymphoid leukemia	1854 (0.5457)	0.2492	0.0356	0.0000	0.1794 to 0.3189	0.5362
G70	G70.00	Myasthenia gravis and other myoneural disorders	745 (0.2193)	0.2897	0.0625	0.0000	0.1671 to 0.4122	0.5229
D46	D46.9	Myelodysplastic syndromes	755 (0.2222)	0.1633	0.0333	0.0000	0.0980 to 0.2286	0.4858
L12	L12.0	Pemphigoid	334 (0.0983)	0.1955	0.0703	0.0050	0.0577 to 0.3334	0.4425
C95	C95.90	Leukemia of unspecified cell type	609 (0.1792)	0.1530	0.0476	0.0010	0.0598 to 0.2463	0.4055
N18	N18.9	Chronic kidney disease (CKD)	48 428 (14.2531)	0.1663	0.0105	0.0000	0.1457 to 0.1868	0.3998
G20	G20.	Parkinson's disease	5105 (1.5025)	0.1656	0.0196	0.0000	0.1272 to 0.2040	0.3912
C78	C78.7	Secondary malignant neoplasm of respiratory and digestive organs	1305 (0.3841)	0.1545	0.0345	0.0000	0.0868 to 0.2222	0.3834
G30	G30.9	Alzheimer's disease	4348 (1.2797)	0.0866	0.0107	0.0000	0.0655 to 0.1076	0.3712
J84	J84.10	Other interstitial pulmonary diseases	7398 (2.1773)	0.2074	0.0225	0.0000	0.1633 to 0.2516	0.3634
C85	C85.80	Other specified and unspecified types of non-Hodgkin lymphoma	2228 (0.6557)	0.2301	0.0451	0.0000	0.1417 to 0.3185	0.3588
R18	R18.8	Ascites	2408 (0.7087)	0.1669	0.0335	0.0000	0.1013 to 0.2325	0.3367
G11	G11.1	Hereditary ataxia	586 (0.1725)	0.1685	0.0640	0.0080	0.0431 to 0.2939	0.3292
C34	C34.90	Malignant neoplasm of bronchus and lung	3805 (1.1199)	0.1404	0.0272	0.0000	0.0870 to 0.1938	0.3083
Z66	Z66.	Do not resuscitate	6448 (1.8977)	0.0869	0.0105	0.0000	0.0663 to 0.1075	0.3030
F02	F02.80	Dementia in other diseases classified elsewhere	8684 (2.5558)	0.0775	0.0101	0.0000	0.0578 to 0.0972	0.3028
R26	R26.9	Abnormalities of gait and mobility	67 067 (19.7388)	0.1327	0.0091	0.0000	0.1148 to 0.1506	0.2996
C79	C79.51	Secondary malignant neoplasm of other and unspecified sites	2724 (0.8017)	0.1445	0.0299	0.0000	0.0859 to 0.2031	0.2994
G12	G12.21	Spinal muscular atrophy and related syndromes	685 (0.2016)	0.2008	0.0842	0.0170	0.0359 to 0.3658	0.2954
C22	C22.0	Malignant neoplasm of liver and intrahepatic bile ducts	1150 (0.3385)	0.1762	0.0596	0.0030	0.0594 to 0.2929	0.2889
D02	D02.20	Carcinoma *in situ* middle ear and respiratory system	2023 (0.5954)	0.1246	0.0342	0.0000	0.0577 to 0.1915	0.2875
C18	C18.9	Malignant neoplasm of colon	4296 (1.2644)	0.1874	0.0333	0.0000	0.1221 to 0.2526	0.2845
R64	R64.	Cachexia	797 (0.2346)	0.1066	0.0384	0.0060	0.0313 to 0.1818	0.2820
N40	N40.0	Benign prostatic hyperplasia	85 767 (25.2425)	0.1412	0.0103	0.0000	0.1209 to 0.1615	0.2615
C90	C90.00	Multiple myeloma and malignant plasma cell neoplasms	1041 (0.3064)	0.1577	0.0595	0.0080	0.0411 to 0.2743	0.2591
I25	I25.10	Chronic ischemic heart disease	77 259 (22.7385)	0.1158	0.0095	0.0000	0.0972 to 0.1344	0.2557
Z96	Z96.1	Presence of other functional implants	58 557 (17.2342)	0.1228	0.0101	0.0000	0.1031 to 0.1425	0.2537
E11	E11.9	Type 2 diabetes mellitus	114 394 (33.6679)	0.1488	0.0118	0.0000	0.1256 to 0.1720	0.2393
Z74	Z74.09	Problems related to care provider dependency	17 940 (5.2800)	0.0917	0.0102	0.0000	0.0716 to 0.1117	0.2368
L89	L89.90	Pressure ulcer	8092 (2.3816)	0.0834	0.0130	0.0000	0.0579 to 0.1090	0.2350
C32	C32.9	Malignant neoplasm of larynx	930 (0.2737)	0.1421	0.0653	0.0300	0.0140 to 0.2701	0.2291
J61	J61.	Pneumoconiosis due to asbestos and other mineral fibers	1189 (0.3499)	0.1202	0.0467	0.0100	0.0287 to 0.2116	0.2271
R54	R54.	Age-related physical debility	11 357 (3.3425)	0.0696	0.0096	0.0000	0.0508 to 0.0884	0.2160
J44	J44.9		63 653 (18.7340)	0.1281	0.0121	0.0000	0.1043 to 0.1519	0.2160

(continued)

Table 2: (continued)

Category condition	Most common ICD-10 code	ICD-10 category condition description	Number (%) of cases with category condition	Coefficient	Standard error	P-value	95% Confidence interval	Coefficient × (RR − 1)[a]
		Other chronic obstructive pulmonary disease						
I48	I48.91	Atrial fibrillation and flutter	35 951 (10.5809)	0.1048	0.0114	0.0000	0.0824 to 0.1272	0.2035
I96	I96.	Gangrene, not elsewhere classified	2079 (0.6119)	0.0857	0.0322	0.0080	0.0225 to 0.1488	0.1925
I37	I37.0	Nonrheumatic pulmonary valve disorders	1552 (0.4568)	0.1488	0.0670	0.0260	0.0175 to 0.2800	0.1912
E78	E78.5	Disorders of lipoprotein metabolism and other dyslipidemias	223 873 (65.8892)	0.0921	0.0127	0.0000	0.0672 to 0.1170	0.1897
I71	I71.4	Aortic aneurysm and dissection	12 513 (3.6828)	0.1183	0.0192	0.0000	0.0808 to 0.1559	0.1896
I50	I50.9	Heart failure	36 427 (10.7210)	0.0771	0.0102	0.0000	0.0572 to 0.0971	0.1863
H25	H25.13	Age-related cataract	127 537 (37.5361)	0.1014	0.0129	0.0000	0.0762 to 0.1267	0.1799
I85	I85.00	Esophageal varices	2480 (0.7299)	0.1587	0.0712	0.0260	0.0192 to 0.2983	0.1764
J96	J96.01	Respiratory failure, not elsewhere classified	13 350 (3.9291)	0.0753	0.0135	0.0000	0.0488 to 0.1019	0.1749
N19	N19.	Unspecified kidney failure	7383 (2.1729)	0.0749	0.0170	0.0000	0.0417 to 0.1082	0.1702
J47	J47.9	Bronchiectasis	1749 (0.5148)	0.0978	0.0454	0.0310	0.0089 to 0.1867	0.1656
M81	M81.0	Osteoporosis without current pathological fracture	10 016 (2.9479)	0.1163	0.0249	0.0000	0.0675 to 0.1652	0.1645
D04	D04.9	Carcinoma *in situ* of skin	3845 (1.1316)	0.1033	0.0345	0.0030	0.0357 to 0.1708	0.1639
H27	H27.8	Other disorders of lens	6825 (2.0087)	0.0739	0.0173	0.0000	0.0401 to 0.1078	0.1638
H90	H90.3	Conductive and sensorineural hearing loss	118 138 (34.7698)	0.1200	0.0145	0.0000	0.0915 to 0.1485	0.1634
E03	E03.9	Other hypothyroidism	35 891 (10.5633)	0.1812	0.0244	0.0000	0.1334 to 0.2290	0.1631
D64	D64.9	Other anemias	62 258 (18.3235)	0.0916	0.0122	0.0000	0.0677 to 0.1154	0.1576
B02	B02.9	Zoster (herpes zoster)	16 479 (4.8500)	0.1667	0.0329	0.0000	0.1022 to 0.2312	0.1520
N25	N25.81	Disorders resulting from impaired renal tubular function	6475 (1.9057)	0.0635	0.0191	0.0010	0.0261 to 0.1008	0.1478
I73	I73.9	Other peripheral vascular diseases	31 350 (9.2268)	0.0715	0.0114	0.0000	0.0492 to 0.0938	0.1469
H61	H61.23	Other disorders of external ear	58 221 (17.1353)	0.1234	0.0162	0.0000	0.0916 to 0.1552	0.1453
Z43	Z43.3	Encounter for attention to artificial openings	2992 (0.8806)	0.0951	0.0412	0.0210	0.0144 to 0.1758	0.1428
H91	H91.90	Other and unspecified hearing loss	71 156 (20.9423)	0.1438	0.0204	0.0000	0.1039 to 0.1838	0.1408
H26	H26.9	Other cataract	60 786 (17.8902)	0.0719	0.0110	0.0000	0.0504 to 0.0933	0.1370
H35	H35.31	Other retinal disorders	60 393 (17.7746)	0.0900	0.0132	0.0000	0.0641 to 0.1158	0.1344
C67	C67.9	Malignant neoplasm of bladder	4135 (1.2170)	0.0867	0.0338	0.0100	0.0203 to 0.1530	0.1324
Z95	Z95.1	Presence of cardiac and vascular implants and grafts	34 407 (10.1265)	0.0659	0.0121	0.0000	0.0422 to 0.0896	0.1317
R62	R62.7	Lack of expected normal physiological development in childhood and adults	3414 (1.0048)	0.0395	0.0150	0.0080	0.0102 to 0.0689	0.1295
J90	J90.	Pleural effusion, not elsewhere classified	5673 (1.6696)	0.0519	0.0175	0.0030	0.0176 to 0.0862	0.1257
R63	R63.4	Symptoms and signs concerning food and fluid intake	34 666 (10.2027)	0.1042	0.0190	0.0000	0.0669 to 0.1415	0.1253
J43	J43.9	Emphysema	9950 (2.9284)	0.0875	0.0256	0.0010	0.0372 to 0.1377	0.1241
L97	L97.509	Nonpressure chronic ulcer of lower limb, not elsewhere classified	13 950 (4.1057)	0.0648	0.0189	0.0010	0.0278 to 0.1019	0.1181
R60	R60.0	Edema, not elsewhere classified	61 977 (18.2408)	0.0741	0.0128	0.0000	0.0490 to 0.0992	0.1161
C61	C61.	Generalized hyperhidrosis	19 707 (5.8001)	0.0974	0.0262	0.0000	0.0460 to 0.1489	0.1106
H54	H54.7	Blindness and low vision	25 803 (7.5942)	0.0907	0.0203	0.0000	0.0510 to 0.1303	0.1098
K74	K74.60	Fibrosis and cirrhosis of liver	8439 (2.4837)	0.1148	0.0497	0.0210	0.0175 to 0.2122	0.1076
D63	D63.1	Anemia in chronic diseases classified elsewhere	14 823 (4.3626)	0.0421	0.0124	0.0010	0.0177 to 0.0665	0.1073
N47	N47.6	Disorders of prepuce	6273 (1.8462)	0.0979	0.0421	0.0200	0.0155 to 0.1804	0.1054
M10	M10.9	Gout	32 778 (9.6471)	0.1014	0.0223	0.0000	0.0576 to 0.1452	0.1035
I67	I67.89	Other cerebrovascular disease	16 692 (4.9127)	0.0534	0.0157	0.0010	0.0226 to 0.0842	0.1021
I70	I70.0	Atherosclerosis	19 489 (5.7359)	0.0537	0.0147	0.0000	0.0248 to 0.0825	0.1000
C44	C44.91	Other and unspecified malignant neoplasm of skin	21 770 (6.4072)	0.0769	0.0250	0.0020	0.0280 to 0.1259	0.0906
I63	I63.9	Cerebral infarction	18 075 (5.3197)	0.0507	0.0173	0.0030	0.0169 to 0.0845	0.0905
T82	T82.818A	Complications of cardiac and vascular prosthetic devices, implants and grafts	6593 (1.9404)	0.0462	0.0232	0.0470	0.0006 to 0.0917	0.0866
M15	M15.9	Polyosteoarthritis	70 950 (20.8817)	0.0799	0.0191	0.0000	0.0424 to 0.1173	0.0826
J18	J18.9	Pneumonia, unspecified organism	32 422 (9.5423)	0.0512	0.0155	0.0010	0.0208 to 0.0817	0.0796
Z65	Z65.9	Problems related to other psychosocial circumstances	127 694 (37.5823)	0.0833	0.0209	0.0000	0.0423 to 0.1243	0.0730
I65	I65.29		16 848 (4.9586)	0.0413	0.0162	0.0110	0.0096 to 0.0729	0.0717

(continued)

Table 2: (continued)

Category condition	Most common ICD-10 code	ICD-10 category condition description	Number (%) of cases with category condition	Coefficient	Standard error	P-value	95% Confidence interval	Coefficient × (RR − 1)[a]
		Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction						
R01	R01.1	Cardiac murmurs and other cardiac sounds	14 466 (4.2576)	0.0708	0.0309	0.0220	0.0102 to 0.1313	0.0715
R33	R33.9	Retention of urine	20 323 (5.9814)	0.0408	0.0164	0.0130	0.0086 to 0.0729	0.0694
R32	R32.	Unspecified urinary incontinence	18 819 (5.5387)	0.0441	0.0192	0.0220	0.0064 to 0.0817	0.0650
R80	R80.3	Proteinuria	13 651 (4.0177)	0.0517	0.0262	0.0490	0.0003 to 0.1030	0.0646
N17	N17.9	Acute kidney failure	31 785 (9.3548)	0.0282	0.0123	0.0220	0.0041 to 0.0523	0.0604
R97	R97.2	Abnormal tumor markers	36 803 (10.8317)	0.0617	0.0248	0.0130	0.0131 to 0.1103	0.0598
H02	H02.839	Other disorders of eyelid	29 211 (8.5972)	0.0526	0.0216	0.0150	0.0102 to 0.0950	0.0580
L57	L57.0	Skin changes due to chronic exposure of nonionizing radiation	46 813 (13.7778)	0.0494	0.0226	0.0290	0.0051 to 0.0937	0.0505
E87	E87.6	Other disorders of fluid, electrolyte, and acid–base balance	54 353 (15.9969)	0.0312	0.0138	0.0240	0.0041 to 0.0583	0.0492
R91	R91.8	Abnormal findings on diagnostic imaging of lung	37 585 (11.0618)	−0.0542	0.0251	0.0310	−0.1035 to −0.0049	−0.0523
I51	I51.7	Complications and ill-defined descriptions of heart disease	24 480 (7.2048)	−0.0507	0.0225	0.0240	−0.0948 to −0.0066	−0.0592
R31	R31.9	Hematuria	42 562 (12.5266)	−0.0824	0.0309	0.0080	−0.1430 to −0.0219	−0.0600
R78	R78.89	Finding of drugs and other substances, not normally found in blood	32 503 (9.5661)	−0.0692	0.0268	0.0100	−0.1217 to −0.0166	−0.0624
Z09	Z09.	Encounter for follow-up exam after completed treatment for conditions other than malignant neoplasm	55 214 (16.2503)	−0.0987	0.0319	0.0020	−0.1612 to −0.0361	−0.0660
R42	R42.	Dizziness and giddiness	67 634 (19.9057)	−0.0950	0.0282	0.0010	−0.1503 to −0.0398	−0.0677
R55	R55.	Syncope and collapse	30 812 (9.0964)	−0.0755	0.0277	0.0070	−0.1298 to −0.0211	−0.0680
M62	M62.81	Other disorders of muscle	71 400 (21.0141)	−0.0695	0.0206	0.0010	−0.1099 to −0.0291	−0.0696
Z86	Z86.010	Personal history of certain other diseases	103 774 (30.5422)	−0.0745	0.0197	0.0000	−0.1132 to −0.0358	−0.0697
N13	N13.30	Obstructive and reflux uropathy	13 082 (3.8502)	−0.0708	0.0338	0.0360	−0.1369 to −0.0046	−0.0727
I12	I12.9	Hypertensive chronic kidney disease	26 422 (7.7764)	−0.0329	0.0131	0.0120	−0.0585 to −0.0073	−0.0762
E83	E83.42	Disorders of mineral metabolism	22 641 (6.6636)	−0.0670	0.0234	0.0040	−0.1128 to −0.0212	−0.0792
L03	L03.90	Cellulitis and acute lymphangitis	70 833 (20.8472)	−0.1097	0.0282	0.0000	−0.1651 to −0.0544	−0.0797
L98	L98.9	Other disorders of skin and subcutaneous tissue, not elsewhere classified	55 257 (16.2630)	−0.1296	0.0345	0.0000	−0.1971 to −0.0621	−0.0801
F06	F06.30	Other mental disorders due to physiological condition	31 408 (9.2438)	−0.0931	0.0291	0.0010	−0.1502 to −0.0360	−0.0816
G93	G93.3	Other disorders of brain	39 656 (11.6714)	−0.0957	0.0253	0.0000	−0.1453 to −0.0461	−0.0881
E86	E86.0	Volume depletion	28 085 (8.2658)	−0.0714	0.0210	0.0010	−0.1126 to −0.0302	−0.0899
Z79	Z79.899	Long-term (current) drug therapy	147 374 (43.3744)	−0.0736	0.0162	0.0000	−0.1054 to −0.0419	−0.0915
D50	D50.9	Iron deficiency anemia	31 287 (9.2082)	−0.0753	0.0208	0.0000	−0.1160 to −0.0345	−0.0919
Z91	Z91.19	Personal risk factors not elsewhere classified	64 332 (18.9339)	−0.1130	0.0250	0.0000	−0.1620 to −0.0640	−0.0932
K56	K56.60	Paralytic ileus and intestinal obstruction without hernia	8535 (2.5120)	−0.0953	0.0406	0.0190	−0.1748 to −0.0159	−0.0966
M20	M20.40	Acquired deformities of fingers and toes	43 692 (12.8592)	−0.1552	0.0345	0.0000	−0.2228 to −0.0875	−0.1006
I47	I47.1	Paroxysmal tachycardia	12 549 (3.6934)	−0.1055	0.0346	0.0020	−0.1732 to −0.0377	−0.1061
M19	M19.90	Other and unspecified osteoarthritis	89 625 (26.3780)	−0.1818	0.0320	0.0000	−0.2445 to −0.1190	−0.1095
B95	B95.61	Streptococcus, Staphylococcus, and Enterococcus as the cause of diseases classified elsewhere	13 437 (3.9547)	−0.1003	0.0321	0.0020	−0.1631 to −0.0374	−0.1130
R25	R25.2	Abnormal involuntary movements	28 206 (8.3014)	−0.1680	0.0389	0.0000	−0.2443 to −0.0918	−0.1133
F05	F05.	Delirium due to known physiological condition	3612 (1.0631)	−0.0458	0.0203	0.0240	−0.0855 to −0.0061	−0.1148
J98	J98.4	Other respiratory disorders	35 483 (10.4432)	−0.1159	0.0247	0.0000	−0.1644 to −0.0674	−0.1154
S22	S22.39XA	Fracture of rib(s), sternum and thoracic spine	10 436 (3.0715)	−0.1438	0.0473	0.0020	−0.2366 to −0.0511	−0.1165
K31	K31.89	Other diseases of stomach and duodenum	15 241 (4.4857)	−0.1706	0.0496	0.0010	−0.2679 to −0.0734	−0.1169
G46	G46.4	Vascular syndromes of brain in cerebrovascular diseases	4838 (1.4239)	−0.0887	0.0379	0.0190	−0.1631 to −0.0144	−0.1205
I11	I11.9	Hypertensive heart disease	28 332 (8.3385)	−0.0920	0.0190	0.0000	−0.1291 to −0.0548	−0.1219
I13	I13.0	Hypertensive heart and chronic kidney disease	9823 (2.8911)	−0.0454	0.0133	0.0010	−0.0716 to −0.0193	−0.1239
Z92	Z92.3	Personal history of medical treatment	8961 (2.6374)	−0.1416	0.0468	0.0030	−0.2334 to −0.0498	−0.1287
H43	H43.819	Disorders of vitreous body	38 102 (11.2140)	−0.1599	0.0280	0.0000	−0.2148 to −0.1049	−0.1304
Z48	Z48.02		78 659 (23.1505)	−0.1961	0.0303	0.0000	−0.2554 to −0.1368	−0.1306

(continued)

Table 2: (continued)

Category condition	Most common ICD-10 code	ICD-10 category condition description	Number (%) of cases with category condition	Coefficient	Standard error	P-value	95% Confidence interval	Coefficient × (RR − 1)[a]
		Encounter for other postprocedural aftercare						
G81	G81.90	Hemiplegia and hemiparesis	3445 (1.0139)	−0.0999	0.0456	0.0280	−0.1893 to −0.0105	−0.1327
Y83	Y83.1	Surgical and medical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of procedure	11 053 (3.2531)	−0.1500	0.0426	0.0000	−0.2335 to −0.0666	−0.1394
D62	D62.	Acute posthemorrhagic anemia	6406 (1.8854)	−0.1002	0.0306	0.0010	−0.1601 to −0.0403	−0.1441
I20	I20.8	Angina pectoris	31 188 (9.1791)	−0.1400	0.0241	0.0000	−0.1872 to −0.0928	−0.1445
R06	R06.02	Abnormalities of breathing	118 999 (35.0232)	−0.1827	0.0247	0.0000	−0.2311 to −0.1342	−0.1459
G62	G62.9	Other and unspecified polyneuropathies	14 108 (4.1522)	−0.1832	0.0409	0.0000	−0.2635 to −0.1030	−0.1496
Z13	Z13.6	Encounter for screening for other diseases and disorders	237 211 (69.8148)	−0.1886	0.0286	0.0000	−0.2447 to −0.1325	−0.1519
S91	S91.309A	Open wound of ankle, foot and toes	11 184 (3.2916)	−0.1519	0.0374	0.0000	−0.2253 to −0.0786	−0.1587
R39	R39.15	Other and unspecified symptoms and signs involving the genitourinary system	29 413 (8.6567)	−0.2332	0.0372	0.0000	−0.3061 to −0.1604	−0.1648
Z98	Z98.890	Other postprocedural states	92 911 (27.3451)	−0.2348	0.0272	0.0000	−0.2881 to −0.1815	−0.1663
T83	T83.098A	Complications of genitourinary prosthetic devices, implants and grafts	3957 (1.1646)	−0.1205	0.0408	0.0030	−0.2004 to −0.0406	−0.1685
H52	H52.4	Disorders of refraction and accommodation	192 666 (56.7045)	−0.1513	0.0212	0.0000	−0.1928 to −0.1097	−0.1731
I16	I16.0	Hypertensive crisis	5096 (1.4998)	−0.2349	0.0548	0.0000	−0.3423 to −0.1275	−0.2227
J16	J16.8	Pneumonia due to other infectious organisms, not elsewhere classified	1240 (0.3650)	−0.1815	0.0750	0.0160	−0.3285 to −0.0345	−0.2321
Z23	Z23.	Encounter for immunization	260 232 (76.5902)	−0.3022	0.0320	0.0000	−0.3649 to −0.2395	−0.2325
G21	G21.11	Secondary parkinsonism	2043 (0.6013)	−0.1384	0.0412	0.0010	−0.2193 to −0.0576	−0.2494
I97	I97.710	Intraoperative and postprocedural complications and disorders of circulatory system, not elsewhere classified	2682 (0.7894)	−0.2555	0.0660	0.0000	−0.3849 to −0.1260	−0.2650
Z16	Z16.11	Resistance to antimicrobial drugs	2546 (0.7493)	−0.2529	0.0682	0.0000	−0.3866 to −0.1192	−0.2690
T87	T87.89	Complications peculiar to reattachment and amputation	1707 (0.5024)	−0.2549	0.0842	0.0020	−0.4199 to −0.0899	−0.2772
W05	W05.0XXA	Fall from nonmoving wheelchair, nonmotorized scooter and motorized mobility scooter	660 (0.1942)	−0.1834	0.0706	0.0090	−0.3219 to −0.0450	−0.3132

[a] Ranked in descending order by contribution to the logit function.

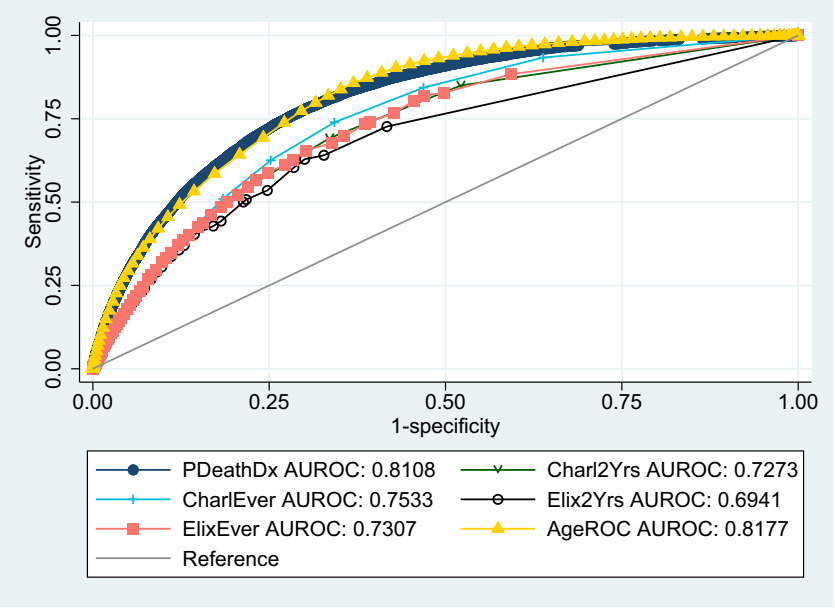


Figure 2: Comparison of AUROC

Table 3: Comparison of methods for handling comorbidities

Attributes	Charlson	Elixhauser	PdeathDx
Diagnosis specific	No	No	Yes
Includes all relevant diagnosis	No	No	Yes
Number of comorbidities	19	30	153
Weighting	Arbitrary	None	Actual risk
Includes protective factors	No	Yes	Yes
Handles rare conditions	No	No	Yes
Effect of each comorbidity adjusted for others	No	No	Yes
Identifies all comorbid patterns and associated risks	No	No	Yes
Setting of extracted diagnostic codes	Inpatient only	Inpatient only	Inpatient and outpatient

those that we have examined thus far. Models using conventional comorbidity indices often assign little weight or usually do not include some of the highest risk conditions (e.g. degenerative neurological diseases); the same is true of conditions associated with COVID-19 severity (e.g. pemphigoid). Moreover, our model revealed poor prognoses were assigned to those with dementia, degenerative neurological diseases, and severe disabilities—conditions not usually associated with cardiorespiratory injury or impaired immunity. These disorders are often associated with a poor quality of life that dictates a conservative approach to treatment. If this decision is common for COVID-19 patients, then death may be more indicative of the patient's baseline condition than severity of illness. In that event, this outcome may not be suitable for studies of interventions. Finally, multivariate analysis showed that some high-risk conditions became protective when adjusted for the effect of other components of the model. It would have been a mistake to treat the effect of these conditions as independent and additive.

We did not include age in our model for PDeathDx. First, it was intended to represent pre-existing conditions in an overarching model containing multiple domains. One domain comprised demographic characteristics including age at diagnosis. More importantly, we did not want age to displace the conditions highly correlated with age in the model. To understand the mechanisms that lead to a fatal outcome, explanatory variables should take precedence over disease markers. If age is modeled, it should be for a residual effect once causal factors have been included. Finally, age-based models do not support decision making at the point of care. For example, a physician might feel comfortable withdrawing care if the patient had Alzheimer's disease, but not simply because the patient was old. Clinicians make recommendations based upon an assessment of the underlying conditions. It is the patient's prerogative to decide what is appropriate based upon age and quality of life. Still, in light of a reviewer's comment, we added age to the model. With age alone having better performance than PDeathDx, we tested its inclusion to the original model. As expected, its addition led to better performance: AUROC = 0.848; $P < 0.001$.

We identified two studies using clinical information (i.e. laboratory results, vital signs) with a higher AUROC, each limited to the inpatient setting and comprising a few hundred patients [20, 21]. Thus, we anticipate the next step in our approach; including demographics, laboratory values, and vital signs; would be the inpatient counterpart to this model, with a higher AUROC than found in this study. By using the current model in the outpatient setting, expeditiously identifying higher risk patients could allow time for preventive measures (e.g. conversations about potentially better management of pre-existing high-risk conditions, individualized messaging about masking or vaccination) to occur before infection or re-infection.

We included all diagnoses in the medical record because some conditions have an effect over the patient's lifetime even if they have not been recently active. Examples include intravenous drug use or sickle cell trait. We also wanted to test our computing resources to see if they were capable of handling problems of this size. (Fortunately, our computing resources were more than sufficient.) Finally, to develop the most efficient model, it is reasonable to start with a comprehensive list of diagnoses and work backward. That strategy allows one to determine if time-limited sampling compromises the ability of PDeathDx to discriminate between survivors and nonsurvivors. Alternatively, starting with a fixed time frame for diagnoses is arbitrary and provides no information about the benefits of more remote data.

However, we still note this to be the major limitation of our approach: A person with chronic renal failure (CRF) who undergoes a transplant and regains normal renal function will still be included in the analysis of CRF. Second, PDeathDx requires programming at a high level, takes more time, and uses more computing resources. One hurdle is the systematic search for candidate diagnoses among millions of entries in the electronic record and performing screening statistical tests on thousands of root diagnoses. The other is creating a diagnostic array in which each patient is given a score for every significant diagnosis experienced by the cohort. The table must then be transferred to a statistical program capable of handling hundreds of predictors and a large number of rows. Third, the results of this analysis are dependent upon the accuracy of the documentation of pre-existing conditions, testing positive, and mortality. Documentation exists for 99% capture rate for deaths occurring internal and external to the VA [22]. Fourth, our conclusions are limited to patients with characteristics like the veteran population, which comprised older, majority male, patients. However, we note a study found similarities with the Medicare population [23].

With an AUROC = 0.811 and better performance than conventional comorbidity indices, this method shows promise. Allocating better estimates of patient risk which are informed from others' experiences within the same healthcare system provides a complementary approach to those already in existence to support the learning health system. The approach needs to be replicated in different healthcare systems as differing care across regions and countries, unique patient characteristics in each system, and emerging variants over time may reveal different risk and protective conditions (and thus corresponding probabilities). Further studies should be done on other populations and conditions before the method should be widely applied. If validated, our method could provide a more robust alternative to

comorbidity scores for handling pre-existing conditions in multivariate models.

Data availability

Data not publicly available.

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Conflict of interest

Contents are expressed by the authors and do not represent the views of the Department of Veterans Affairs or the US Government.

References

1. Johns Hopkins Coronavirus Resource Center. *Mortality Analyses*. Johns Hopkins University & Medicine, 2020. https://coronavirus.jhu.edu/data/mortality (21 March 2022, date last accessed).
2. National Center for Health Statistics. *FastStats: Influenza*. Centers for Disease Control and Prevention, 2022. https://www.cdc.gov/nchs/fastats/flu.htm (1 February 2022, date last accessed).
3. Xie Y, Bowe B, Maddukuri G, Al-Aly Z. Comparative evaluation of clinical manifestations and risk of death in patients admitted to hospital with COVID-19 and seasonal influenza: cohort study. *BMJ* 2020;**371**:m4677. https://doi.org/10.1136/bmj.m4677.
4. King JT, Yoon JS, Rentsch CT *et al.* Development and validation of a 30-day mortality index based on pre-existing medical administrative data from 13,323 COVID-19 patients: the Veterans Health Administration COVID-19 (VACO) Index. *PLoS One* 2020;**15**:e0241825. https://doi.org/10.1371/journal.pone.0241825.
5. Ioannou GN, Green P, Fan VS *et al.* Development of COVIDVax model to estimate the risk of SARS-CoV-2-related death among 7.6 million US veterans for use in vaccination prioritization. *JAMA Netw Open* 2021;**4**:e214347.
6. Barda N, Riesel D, Akriv A *et al.* Developing a COVID-19 mortality risk prediction model when individual-level data are not available. *Nat Commun* 2020;**11**:1–9. https://doi.org/10.1038/s41467-020-18297-9.
7. Hippisley-Cox J, Coupland CAC, Mehta N *et al.* Risk prediction of covid-19 related death and hospital admission in adults after covid-19 vaccination: national prospective cohort study. *BMJ* 2021;**374**:n2244.
8. Cohn BA, Cirillo PM, Murphy CC *et al.* SARS-CoV-2 vaccine protection and deaths among US veterans during 2021. *Science* 2022;**375**:331–36. https://doi.org/10.1126/science.abm0620.
9. Bennett TD, Moffitt RA, Hajagos JG *et al.*; National COVID Cohort Collaborative (N3C) Consortium. Clinical characterization and prediction of clinical severity of SARS-CoV-2 infection among US adults using data from the US National COVID Cohort Collaborative. *JAMA Netw Open* 2021;**4**:e2116901. https://doi.org/10.1001/jamanetworkopen.2021.16901.
10. Yao Z, Zheng X, Zheng Z *et al.* Construction and validation of a machine learning-based nomogram: a tool to predict the risk of getting severe coronavirus disease 2019 (COVID-19). *Immun Inflamm Dis* 2021;**9**:595–607. https://doi.org/10.1002/iid3.421.
11. Marcos M, Belhassen-Garcia M, Sanchez-Puente A *et al.* Development of a severity of disease score and classification model by machine learning for hospitalized COVID-19 patients. *PLoS One* 2021;**16**:e0240200. https://doi.org/10.1371/journal.pone.0240200.
12. Lee DS, Ma S, Chu A *et al.*; CORONA Collaboration. Predictors of mortality among long-term care residents with SARS-CoV-2 infection. *J Am Geriatr Soc* 2021;**69**:3377–88. https://doi.org/10.1111/jgs.17425.
13. Douville NJ, Douville CB, Mentz G *et al.* Clinically applicable approach for predicting mechanical ventilation in patients with COVID-19. *Br J Anaesth* 2021;**126**:578–89. https://doi.org/10.1016/j.bja.2020.11.034.
14. Tuty Kuswardhani RA, Henrina J, Pranata R *et al.* Charlson comorbidity index and a composite of poor outcomes in COVID-19 patients: a systematic review and meta-analysis. *Diabetes Metab Syndr* 2020;**14**:2103–09. https://doi.org/10.1016/j.dsx.2020.10.022.
15. Austin SR, Wong YN, Uzzo RG *et al.* Why summary comorbidity measures such as the Charlson Comorbidity Index and Elixhauser Score work. *Med Care* 2015;**53**:e65–72. https://doi.org/10.1097/MLR.0b013e318297429c.
16. Charlson ME, Pompei P, Ales KL *et al.* A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;**40**:373–83.
17. Elixhauser A, Steiner C, Harris DR *et al.* Comorbidity measures for use with administrative data. *Med Care* 1998;**36**:8–27.
18. Keppel G, Wickens TD. *Design and Analysis: A Researcher's Handbook*. 4th edn. Upper Saddle River, NJ: Pearson Prentice Hall, 2004, 117–19.
18. Romano PS, Roos LL, Jollis JG. Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. *J Clin Epidemiol* 1993;**46**:1075–79. Discussion 81–90.
19. Hou W, Zhao Z, Chen A *et al.* Machining learning predicts the need for escalated care and mortality in COVID-19 patients from clinical variables. *Int J Med Sci* 2021;**18**:1739–45. https://doi.org/10.7150/ijms.51235.
20. Ma X, Ng M, Xu S *et al.* Development and validation of prognosis model of mortality risk in patients with COVID-19. *Epidemiol Infect* 2020;**148**:e168. https://doi.org/10.1017/S0950268820001727.
21. Arnold N. *CDW Date of Death Analysis and Vital Status File Comparison Update*. Washington, D.C.: Department of Veterans Affairs Data Quality Program Office of Informatics and Analytics Health Insurance Governance, 2019, 1–11.
22. Wong ES, Wang V, Liu CF *et al.* Do Veterans Health Administration enrollees generalize to other populations? *Med Care Res Rev* 2016;**73**:493–507.