**Co-morbidities Associated with Mortality in 31,461 Adults with COVID-19 in the United States: A Federated Electronic Medical Record Analysis**

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**Abstract**

**Background** At the beginning of June 2020, there were nearly seven million reported cases of coronavirus disease 2019 (COVID-19) worldwide and over 400,000 deaths in people with COVID-19. The objective of this study was to determine associations between co-morbidities listed in the Charlson co-morbidity index and mortality among patients in the United States (US) with COVID-19.

**Methods and Findings** A retrospective cohort study of adults with COVID-19 from 24 health care organizations in the US was conducted. The study included adults aged 18-90 years with COVID-19 coded in their electronic medical records between January 20, 2020, and May 26, 2020. Results were also stratified by age groups (<50 years, 50-69 years or 70-90 years). A total of 31,461 patients were included. Median age was 50 years [interquartile range (IQR), 35-63] and 54.5% (n=17,155) were female. The most common comorbidities listed in the Charlson co-morbidity index were chronic pulmonary disease (17.5%, n=5,513) and diabetes mellitus (15.0%, n=4,710). Multivariate logistic regression analyses showed older age (Odds Ratio (OR) per year 1.06; 95% confidence interval (CI), 1.06-1.07; p<0.001), male sex (OR 1.75; 95% CI, 1.55-1.98; p<0.001), being black or African American compared to white (OR 1.50; 95% CI, 1.31-1.71; p<0.001), myocardial infarction (OR 1.97; 95% CI, 1.64-2.35; p<0.001), congestive heart failure (OR 1.42; 95% CI, 1.21-1.67; p<0.001), dementia (OR 1.29; 95% CI, 1.07-1.56; p=0.008), chronic pulmonary disease (OR 1.24; 95% CI, 1.08-1.43; p=0.003), mild liver disease (OR 1.26; 95% CI, 1.00-1.59; p=0.046), moderate/severe liver disease (OR 2.62; 95% CI, 1.53-4.47; p<0.001), renal disease (OR 2.13; 95% CI, 1.84-2.46; p<0.001) and metastatic solid tumour (OR 1.70; 95% CI, 1.19-2.43; p=0.004) were associated with higher odds of mortality with COVID-19. Older age, male sex and being black or African American (compared to being white) remained significantly associated with higher odds of death in age-stratified analyses. There were differences in which co-morbidities were significantly associated with mortality between age groups. Limitations include that the data were collected from the health care organization electronic medical record databases and some co-morbidities may be underreported and ethnicity was unknown for 24% of participants. Deaths during an inpatient or outpatient visit at the participating health care organizations were recorded, however deaths occurring outside of the hospital setting are not well captured.

**Conclusions** Identifying patient characteristics and conditions associated with mortality with COVID-19 is important for hypothesis-generating for clinical trials and to develop targeted intervention strategies.

**Author Summary**

*Why Was This Study Done?*

* Coronavirus disease 2019 (COVID-19) has led to a public health emergency internationally.
* As of June 2020, there were over 400,000 deaths reported with COVID-19 globally and over 110,000 deaths were in the United States, but many people have also recovered.
* Due to the unprecedented outbreak of COVID-19 worldwide, little is known about which underlying health conditions may impact a person’s likelihood of dying with COVID-19.
* Some previous studies have suggested being older, from a black, Asian or minority ethnic (BAME) background and having certain health conditions may increase risk of death with COVID-19, but further evidence is needed to understand factors which influence this.

*What Did the Researchers Do and Find?*

* The research utilised a network of 24 healthcare organizations in the United States which provided de-identified data from electronic medical records of patients.
* 31,461 adults with COVID-19 coded in their electronic medical records were included in the study after a search of the network between January 20, 2020 to May 26, 2020.
* We determined associations between age, sex, ethnicity, co-morbidities and death with COVID-19 during the study period.
* After accounting for the other included factors in the study, being older, being male, being black or African American and having a history of myocardial infarction, congestive heart failure, dementia, mild liver disease, moderate/severe liver disease, renal disease or metastatic solid tumour were all associated with higher odds of death with COVID-19.
* There were differences in which co-morbidities were associated with death when we stratified the results by age group.

*What Do These Findings Mean?*

* Identifying factors associated with death with COVID-19 could help with hypothesis-generating for clinical trials and identify patients who may need to be targeted for early intervention or monitoring.
* The study has limitations including some health conditions may be underreported or incorrectly coded in electronic medical records at the time of data entry and all deaths of participants may not have been captured.

**Introduction**

Coronavirus disease 2019 (COVID-19) was first reported in Wuhan, China in December 2019 [1]. Subsequently, COVID-19 was declared a Public Health Emergency of International Concern on January 30, 2020 by the World Health Organization. The first confirmed case of COVID-19 reported in the United States (US) was in Washington State on January 20, 2020 [2]. At the beginning of June 2020, 213 countries and territories had reported almost 7 million cases of COVID-19, with over 400,000 deaths reported with COVID-19, and over 110,000 deaths in the US alone [3].

An emerging evidence base has started to identify factors which associate with adverse outcomes for people with COVID-19. Older age is the most consistent risk factor for severity of COVID-19 which has emerged from the literature so far [4-6]. There is some evidence to suggest being male, black or African American ethnicity, from certain ethnic minority backgrounds or having a history of conditions including cardiovascular or cerebrovascular diseases, hypertension, diabetes mellitus or chronic kidney disease is associated with increased COVID-19 severity and/or mortality [5, 7-12].

More studies are needed to determine associations between co-morbidities and outcomes for patients with COVID-19. Multimorbidity is closely linked to frailty status [13], which is used in decision-making for Critical Care admission [14]. The objective of the study was to determine associations between age, sex, ethnicity, co-morbidities and mortality of adults with COVID-19 in the US.

**Methods**

The study used data from TriNetX, a global federated health research network which provided an anonymised dataset of electronic medical records (EMRs). The TriNetX network was searched on June 9, 2020 and a de-identified dataset of patients with COVID-19 aged up to 90 years identified in EMRs between January 20, 2020 and May 26, 2020 was provided. The data on the research network comes from academic medical centers, specialty physician practices and community hospitals. Further details about TriNetX processes and standardization of data are S1 Text.

Patients with COVID-19 were identified following criteria provided by TriNetX based on Centers for Disease Control and Prevention (CDC) coding guidelines [15]. Patients were included if they had one or more of the following International Classification of Diseases, Ninth Revision and Tenth Revision, Clinical Modification (ICD-10-CM) codes in their EMRs: U07.1 COVID-19; B97.29 Other coronavirus as the cause of diseases classified elsewhere; B34.2 Coronavirus infection, unspecified; or a positive test result identified with COVID-19 specific laboratory Logical Observation Identifiers Names and Codes (LOINCs). The code U07.2 COVID-19, virus not identified, was also searched for, but no patients were found to have this code recorded. Patients with ICD-9 code 079.89 were excluded to reduce the likelihood of patients with false positive COVID-19 because this code may still be used occasionally as a "catch-all” code for >50 viral infections.

The study included all patients with COVID-19 recorded in their EMRs from participating health care organizations. This included both inpatient and outpatient care settings, but the type of visit was not well recorded. History of co-morbidities listed in the Charlson co-morbidity index were identified if the patient had a corresponding ICD code for the condition since January 1, 2015 in their EMRs captured in TriNetX [16]. The time frame was chosen based on a previous study which examined co-morbidities in a five-year interval [17]. Deaths during an inpatient or outpatient visit at the participating health care organizations were recorded, however deaths occurring outside of the hospital setting are not well captured. As date of death was not available in the downloaded de-identified dataset from TriNetX, we estimated date of death based on the most recent date recorded in the patient electronic medical records from the following: diagnosis (date), procedure (date), encounter (end date), vital signs (date), medication (start date). We estimated time to mortality following COVID-19 using the estimated date of death minus the first recording of COVID-19 in the EMRs (either from a positive laboratory test result or ICD-10-CM code).

Descriptive statistics included proportions for categorical variables and medians and interquartile ranges (IQRs) for continuous variables. Unadjusted and multivariate logistic regressions were performed to explore associations between age, sex, ethnicity, co-morbidities and mortality. Any death during the study period captured in electronic medical records of the participating healthcare organisations was included in the analysis. Variables identified as statistically significant predictors with a significance level of p<0.05 were planned to be inserted into a forward multivariate logistic model. All variables were statistically significant in unadjusted analysis and inserted to the multivariate model, apart from in age-stratified analyses. No imputations were made for missing data. Data were requested from TriNetX and all analyses were conducted with Stata v.14.0.

This study is reported as per the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline (S1 STROBE Checklist) [18]. No published prospective analysis plan was produced. Analyses were planned prior to download of the study data from TriNetX. Upon receipt of the data, we were informed that date of death was not available due to data privacy agreements and therefore planned Cox proportional hazard models were changed to logistic regression models. We also changed the search to only include people with COVID-19 coded in their EMRs two weeks before the search date, to allow a two-week time window for potential follow-up and to be comparable with a cohort study which examined co-morbidities and mortality with COVID-19 in the UK [19]. We further limited analyses to people aged 18 years or over and performed age-stratified analyses. We did not impose any further exclusion criteria to limit selection bias.

*Ethics statement*

No ethical approval was obtained as no patient identifiable information was received and the data were analyzed anonymously.

**Results**

In total 33,488 patients from 24 healthcare organizations had one or more of the specified COVID-19 codes or a positive laboratory test in their EMRs during the study period. Patients in the cohort were distributed between the four large Census Bureau designated regions of the US as follows: 27% (n=9,040) in the Northeast, 21% (n=6,898) in the Midwest, 30% (n=10,192) in the South, 21% (n=7,181) in the West and 0.5% (n=177) were unknown. Of the patients identified, 50.3% (n=16,833) were identified from ICD codes only (U07.1, B97.29 or B34.2); 15.2% (n=5,096) were identified from the ICD codes B97.29 or B34.2 only.

Of the total number of patients, 2.0% (n=670) did not have age or sex recorded within the TriNetX network and were excluded from analyses. A further 1,357 patients were aged <18 years and were also excluded. Therefore, 31,461 patients were included in analyses. The median (IQR) age was 50 (35-63) years and 54.5% (n=17,155) were female. In total, 45.2% (n=14,255) of participants were white according to their EMRs and 27.8% (n=8,758) were black or African American; smaller proportions of people from other ethnicities were identified and ethnicity was unknown for 23.8% (n=7,476). Of the total cohort, 59.6% (18,734) of patients did not have a record of any of the co-morbidities listed in the Charlson co-morbidity index; 17.4% (n=5,458) had one co-morbidity listed, 7.9% (n=2,473) had 2 co-morbidities, and 15.2% (n=4,796) had ≥3 co-morbidities. The most common co-morbidities were chronic pulmonary disease (17.5%, n=5,513) and diabetes mellitus without chronic complications (15.0%, n=4,710) (Table 1).

Of the 31,461 patients 5.3% (n=1,669) had no end date recorded on a healthcare organization encounter during the study period and therefore may have not yet been discharged. The median (IQR) estimated time in the study was 54 days (36-68). During the study period, 4.1% (n=1,296) patients were recorded as deceased and the estimated median (interquartile range) time to mortality after first recording of COVID-19 was 9 days (4-17). Of the total patient cohort, 4.1% (n=1,296) had a procedure code indicating invasive mechanical ventilation during the study period in EMRs. Of the patients who died, 49.5% (n=642) had a procedure code for invasive mechanical ventilation compared to 2.2% (n=654) of patients who were not recorded as deceased.

In unadjusted analyses the following variables were associated with higher odds of death: older age, male sex, being black or African American compared to white, and all co-morbidities investigated (Table 2). Being Asian or having unknown ethnicity compared to being white were associated with lower odds of death. On multivariate analyses, higher odds of death were associated with older age (Odds Ratio (OR) per year 1.063; 95% confidence interval (CI), 1.058-1.068; p<0.001), male sex (OR 1.75; 95% CI, 1.55-1.98; p<0.001), being black or African American compared to white (OR 1.50; 95% CI, 1.31-1.71; p<0.001), myocardial infarction (OR 1.97; 95% CI, 1.64-2.35; p<0.001), congestive heart failure (OR 1.42; 95% CI, 1.21-1.67; p<0.001), dementia (OR 1.29; 95% CI, 1.07-1.56; p=0.008), chronic pulmonary disease (OR 1.24; 95% CI, 1.08-1.43; p=0.003), mild liver disease (OR 1.26; 95% CI, 1.00-1.59; p=0.046), moderate/severe liver disease (OR 2.62; 95% CI, 1.53-4.47; p<0.001), renal disease (OR 2.13; 95% CI, 1.84-2.46; p<0.001) and metastatic solid tumour (OR 1.70; 95% CI, 1.19-2.43; p=0.004). Being native Hawaiian or other Pacific Islander was associated with higher odds of death compared to being white, but there were only 115 people identified as native Hawaiian or other Pacific Islander in this cohort. Having an unknown ethnicity was associated with reduced odds of death compared to being white (OR 0.74; 95% CI, 0.60-0.90, p=0.003).

*Age-stratified analyses*

Differences between age groups were found when results were stratified by age group (<50 years, 50-69 years or 70-90 years). For all age groups, older age, being male and being Black or African American compared to being white were associated with higher odds of death in multivariate analyses. When examining co-morbidities, history of myocardial infarction and renal disease were associated with higher odds of death for all age groups, but there were differences across age groups for other co-morbidities and associations with mortality. For people aged <50 years, history of mild liver disease, renal disease and any malignancy were associated with higher odds of death. For people aged 50-69 years, history of congestive heart failure, chronic pulmonary disease, moderate/severe liver disease, metastatic solid tumour and AIDS/HIV were all associated with higher odds of death. For people aged 70-90 years, history of congestive heart failure and dementia were associated with higher odds of death (S1 Table, S2 Table and S3 Table).

**Discussion**

In this retrospective cohort study, we identified 31,461 adults with confirmed COVID-19 from electronic medical records from 24 health care organizations in the US between January 20, 2020 and May 26, 2020. Older age, male sex, black or African American ethnicity and a history of myocardial infarction, congestive heart failure, dementia, chronic pulmonary disease, mild liver disease, moderate/severe liver disease, renal disease and metastatic solid tumour were associated with higher odds of mortality after adjustment for these factors and other co-morbidities.

Older age has been frequently reported to be an important factor associated with disease severity or mortality in patients with COVID-19 [4-6]. There is some previous evidence to suggest men, people who are black or African American or from certain ethnic minority backgrounds may also be higher risk for COVID-19 [7-10]. Underlying co-morbidities including pre-existing concurrent cardiovascular or cerebrovascular diseases, hypertension and diabetes mellitus have been reported as highly prevalent in studies of COVID-19 patients and/or associated with poorer outcomes for these patients [5, 7, 11]. This study further suggests that cardiovascular conditions such as previous myocardial infarction or congestive heart failure may be important factors influencing mortality in patients with COVID-19. Furthermore, a recent meta-analysis of four studies suggested chronic kidney disease may be associated with enhanced risk of severe COVID-19 infection [12]. The results of this study agree with a recent UK-based cohort study which showed an association between older age, male sex, cardiac disease, non-asthmatic pulmonary disease, kidney disease, liver disease, malignancy and dementia and higher mortality in hospital for patients with COVID-19 [19]. The UK-based study also showed an association between obesity and higher mortality, which could not be explored in the current study due to paucity of data on body mass index.

Age-stratified analyses in the current study highlighted the potential importance of considering age groups when examining associations between co-morbidities and mortality with COVID-19. We found a history of myocardial infarction or renal disease to be associated with mortality in all age groups, but there were differences found between age groups for which other co-morbidities associated with mortality. In this study a borderline association was found in this study between AIDS/HIV and mortality with COVID-19 when examining all adults, but age-stratified analyses suggested AIDS/HIV was associated with significantly higher odds of mortality only in people aged 50-69 years. Patients with AIDS/HIV represented a small proportion of the total patient population and larger studies of patients with AIDS/HIV and COVID-19 are needed to further determine the association. The findings in this study of an association between liver disease and mortality for patients with COVID-19 are in line with a recently published study which used data from TriNetX and showed patients with pre-existing liver disease had a higher risk of mortality with COVID-19 [20].

**Limitations**

This study has several limitations. The data were collected from health care organization EMR databases and some co-morbidities may be underreported, and ethnicity was not available for all participants. Residual confounding may include lifestyle factors and socioeconomic status which were not available from electronic medical records. Body mass index was only available for approximately 5% of participants, so was not included in analyses. We could also not determine the influence of attending different healthcare organizations due to data privacy restrictions. In these analyses we found a significant association between those with ‘unknown’ ethnicity from EMRs and reduced odds of death compared to white patients. Participants with unknown ethnicity may have been participants who did not fit in the limited prespecified ethnicity categories within TriNetX, but this could not be explored further given restrictions on data privacy. Only age at death, not date of death was available in downloaded data so time-to-event analyses could not be performed. Participants who died with COVID-19 after the study end date would have been recorded as alive in the present analyses and deaths outside of the participating health care organizations are not well captured. The data in EMRs is susceptible to errors in coding or data entry when patient information is translated to ICD codes. In this study, we looked at any history of the co-morbidities identified in the Charlson co-morbidity index since 2015. We could not determine if the patient was no longer living with the condition. Recording of ICD codes in administrative data may vary by factors such as age, number of comorbidities, severity of illness, length of hospitalization, and whether in-hospital death occurred [21]. The data were from multiple healthcare organizations in the US but may not be representative of the wider US population and the generalisability of the results beyond this cohort is unclear.

**Conclusions**

Increasing age, being male, being black or African American compared to white and a history of myocardial infarction, congestive heart failure, dementia, chronic pulmonary disease, moderate/severe liver disease, renal disease and metastatic solid tumour were associated with mortality in adults with COVID-19. There were differences in which co-morbidities were associated with higher odds of mortality depending on age group.

**References**

1. Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A Novel Coronavirus from Patients with Pneumonia in China, 2019. New Eng J Med. 2020;382(8): 727-33. doi: 10.1056/NEJMoa2001017.

2. Holshue ML, DeBolt C, Lindquist S, Lofy KH, Wiesman J, Bruce H, et al. First Case of 2019 Novel Coronavirus in the United States. New Eng J MEd. 2020;382(10): c929-36. doi: 10.1056/NEJMoa2001191.

3. European Centre for Disease Prevention and Control. Situation update worldwide, as of 9 June 2020 [04/05/2020]. Available from: https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases.

4. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020;395(10229): 1054-62. doi: 10.1016/s0140-6736(20)30566-3.

5. Du R-H, Liang L-R, Yang C-Q, Wang W, Cao T-Z, Li M, et al. Predictors of Mortality for Patients with COVID-19 Pneumonia Caused by SARS-CoV-2: A Prospective Cohort Study. Eur Respir J. 2020;55(5): 2000524. doi: 10.1183/13993003.00524-2020.

6. Verity R, Okell LC, Dorigatti I, Winskill P, Whittaker C, Imai N, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. Lancet Infect Dis. 2020;20(6): 669-677. doi: 10.1016/s1473-3099(20)30243-7.

7. Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area. JAMA. 2020. doi: 10.1001/jama.2020.6775.

8. Yang X, Yu Y, Xu J, Shu H, Xia Ja, Liu H, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med. 2020;S2213-600(20) 30079-5. doi: 10.1016/S2213-2600(20)30079-5.

9. Yancy CW. COVID-19 and African Americans. JAMA. 2020; 323(19): 1891-1892. doi:10.1001/jama.2020.6548.

10. Rimmer A. Covid-19: Two thirds of healthcare workers who have died were from ethnic minorities. BMJ. 2020;369: m1621. doi: 10.1136/bmj.m1621.

11. Shi S, Qin M, Shen B, Cai Y, Liu T, Yang F, et al. Association of Cardiac Injury With Mortality in Hospitalized Patients With COVID-19 in Wuhan, China. JAMA Cardiology. 2020. doi: 10.1001/jamacardio.2020.0950.

12. Henry BM, Lippi G. Chronic kidney disease is associated with severe coronavirus disease 2019 (COVID-19) infection. Int Urol Nephrol. 2020. doi: 10.1007/s11255-020-02451-9.

13. Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G. Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. J Gerontol A Biol Sci. 2004;59(3): 255-63. doi: 10.1093/gerona/59.3.m255.

14. National Institute for Health and Care Excellence. COVID-19 rapid guideline: critical care in adults 2020 [updated 29/04/2020; cited 2020 04/05/2020]. Available from: https://www.nice.org.uk/guidance/ng159.

15. Centers for Disease Control and Prevention. ICD-10-CM Official Coding Guidelines - Supplement Coding encounters related to COVID-19 Coronavirus Outbreak 2020 [cited 2020 8 June 2020]. Available from: https://www.cdc.gov/nchs/data/icd/ICD-10-CM-Official-Coding-Gudance-Interim-Advice-coronavirus-feb-20-2020.pdf.

16. Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med care. 2005;43(11): 1130-9. doi: 10.1097/01.mlr.0000182534.19832.83.

17. Singh B, Singh A, Ahmed A, Wilson GA, Pickering BW, Herasevich V, et al. Derivation and validation of automated electronic search strategies to extract Charlson comorbidities from electronic medical records. Mayo Clin Proc. 2012;87(9): 817-24. doi: 10.1016/j.mayocp.2012.04.015.

18. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008;61(4): 344-9. doi: 10.1016/j.jclinepi.2007.11.008.

19. Docherty AB, Harrison EM, Green CA, Hardwick HE, Pius R, Norman L, et al. Features of 20 133 UK patients in hospital with covid-19 using the ISARIC WHO Clinical Characterisation Protocol: prospective observational cohort study. BMJ. 2020;369:m1985. doi: 10.1136/bmj.m1985.

20. Singh S, Khan A. Clinical Characteristics and Outcomes of COVID-19 Among Patients with Pre-Existing Liver Disease in United States: A Multi-Center Research Network Study. Gastroenterology. 2020;S0016-5085(20): 30585-0. doi: 10.1053/j.gastro.2020.04.064.

21. Chong WF, Ding YY, Heng BH. A comparison of comorbidities obtained from hospital administrative data and medical charts in older patients with pneumonia. BMC Health Serv Res. 2011;11:105-. doi: 10.1186/1472-6963-11-105.

**S1 Table**

Unadjusted and multivariate analysis of factors associated with mortality in adults aged <50 with COVID-19 coded in the TriNetX research network as of May 26, 2020 (n=15,578).

**S2 Table**

Unadjusted and multivariate analysis of factors associated with mortality in adults aged 50-69 with COVID-19 coded in the TriNetX research network as of May 26, 2020 (n=10,698).

**S3 Table**

Unadjusted and multivariate analysis of factors associated with mortality in adults aged 70-90 years with COVID-19 coded in the TriNetX research network as of May 26, 2020 (n=5,185).

**S1 STROBE Checklist**

STROBE checklist.

**S1 Text**

TriNetX standardization of data.

**S1 Data**

Summary information derived from the dataset used in the analyses in this study.

Table 1. Baseline characteristics of patients with COVID-19 in the TriNetX research network as of May 26, 2020.

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristics** | **All participants**  (n=31,461) | **Deceased**  (n=1,296) | **Alive**  (n=30,165) |
| **Age**, median (IQR), years | 50 (35-63) | 72 (63-80) | 49 (35-62) |
| <50 | 49.5 (15,578) | 8.0 (104) | 51.3 (15,474) |
| 50-59 | 18.6 (5,855) | 11.2 (145) | 18.9 (5,710) |
| 60-69 | 15.4 (4,843) | 22.0 (285) | 15.1 (4,558) |
| 70-79 | 9.6 (3,015) | 30.8 (399) | 8.7 (2,616) |
| 80-91 | 6.9 (2,170) | 28.0 (363) | 6.0 (1,807) |
| **Sex** |  |  |  |
| Female | 54.5 (17,155) | 41.1 (532) | 55.1 (16,623) |
| Male | 45.5 (14,306) | 59.0 (764) | 44.9 (13,542) |
| **Ethnicity** |  |  |  |
| White | 45.2 (14,255) | 48.5 (629) | 45.1 (13,596) |
| Black or African American | 27.8 (8,758) | 39.0 (506) | 27.4 (8,252) |
| Asian | 2.5 (791) | 1.2 (16) | 2.6 (775) |
| Native Hawaiian or other Pacific Islander | 0.4 (115) | 0.7 (9) | 0.4 (106) |
| American Indian or Alaska Native | 0.3 (96) | 0 | 0.3 (96) |
| Unknown | 23.8 (7,476) | 10.5 (136) | 24.3 (7,340) |
| **Weighted Charlson co-morbidity index** |  |  |  |
| 0 | 59.6 (18,734) | 17.3 (224) | 61.4 (18,510) |
| 1 | 17.4 (5,458) | 16.1 (208) | 17.4 (5,250) |
| 2 | 7.9 (2,473) | 14.4 (187) | 7.6 (2,286) |
| ≥3 | 15.2 (4,796) | 52.2 (677) | 13.7 (4,119) |
| **Co-morbidities within the Charlson co-morbidity index** |  |  |  |
| Myocardial Infarction | 4.1 (1,280) | 20.2 (262) | 3.4 (1,018) |
| Congestive Heart Failure | 7.3 (2,297) | 30.8 (399) | 6.3 (1,898) |
| Peripheral Vascular Disease | 5.1 (1,601) | 18.2 (236) | 4.5 (1,365) |
| Cerebrovascular Disease | 6.1 (1,922) | 19.6 (254) | 5.5 (1,668) |
| Dementia | 3.3 (1,031) | 15.4 (199) | 2.8 (832) |
| Chronic Pulmonary Disease | 17.5 (5,513) | 30.2 (391) | 17.0 (5,122) |
| Rheumatic Disease | 2.2 (681) | 4.2 (54) | 2.1 (627) |
| Peptic Ulcer Disease | 1.4 (432) | 2.9 (37) | 1.3 (395) |
| Mild Liver Disease | 4.8 (1,497) | 9.3 (121) | 4.6 (1,376) |
| Moderate/Severe Liver Disease | 0.4 (138) | 1.7 (22) | 0.4 (116) |
| Diabetes Mellitus without Chronic Complications | 15.0 (4,710) | 32.4 (420) | 14.2 (4,290) |
| Hemiplegia or Paraplegia | 1.3 (421) | 3.0 (39) | 1.3 (382) |
| Renal Disease | 8.7 (2,735) | 37.5 (486) | 7.5 (2,249) |
| Any Malignancya | 6.3 (1,966) | 14.8 (192) | 5.9 (1,774) |
| Metastatic Solid Tumour | 1.2 (383) | 3.9 (51) | 1.1 (332) |
| AIDS/HIV | 0.7 (226) | 1.3 (17) | 0.7 (209) |

IQR: Interquartile range. Results are %(n) unless otherwise stated. aAny malignancy, including lymphoma and leukaemia, except malignant neoplasm of skin. Co-morbidities based on ICD-10 codes from 2015.

Table 2. Unadjusted and multivariate analysis of factors associated with mortality in adults with COVID-19 coded in the TriNetX research network as of May 26, 2020 (n=31,461).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Unadjusted results** | | **Multivariate results** | |
| Characteristics | Death with COVID-19, OR (95%CI) | P-value | Death with COVID-19, OR (95%CI) | P-value |
| Age (per year) | 1.074 (1.069, 1.078) | <0.001 | 1.063 (1.058, 1.068) | <0.001 |
| Male Sex | 1.76 (1.57, 1.97) | <0.001 | 1.75 (1.55, 1.98) | <0.001 |
| Ethnicity |  |  |  |  |
| White | Ref |  | Ref |  |
| Black or African American | 1.33 (1.18, 1.49) | <0.001 | 1.50 (1.31, 1.71) | <0.001 |
| Asian | 0.45 (0.27, 0.74) | 0.002 | 0.60 (0.36, 1.01) | 0.06 |
| Native Hawaiian or other Pacific Islander | 1.84 (0.92, 3.64) | 0.09 | 3.63 (1.75, 7.52) | 0.001 |
| American Indian or Alaska Native | - | - | - | - |
| Unknown | 0.40 (0.33, 0.48) | <0.001 | 0.74 (0.60, 0.90) | 0.003 |
| Co-morbidities within the Charlson co-morbidity index | |  |  |  |
| Myocardial Infarction | 7.25 (6.25, 8.42) | <0.001 | 1.97 (1.64, 2.35) | <0.001 |
| Congestive Heart Failure | 6.62 (5.84, 7.52) | <0.001 | 1.42 (1.21, 1.67) | <0.001 |
| Peripheral Vascular Disease | 4.70 (4.04, 5.46) | <0.001 | 0.89 (0.74, 1.07) | 0.20 |
| Cerebrovascular Disease | 4.16 (3.60, 4.82) | <0.001 | 1.07 (0.90, 1.28) | 0.44 |
| Dementia | 6.40 (5.42, 7.55) | <0.001 | 1.29 (1.07, 1.56) | 0.008 |
| Chronic Pulmonary Disease | 2.11 (1.87, 2.39) | <0.001 | 1.24 (1.08, 1.43) | 0.003 |
| Rheumatic Disease | 2.05 (1.54, 2.72) | <0.001 | 1.17 (0.85, 1.60) | 0.16 |
| Peptic Ulcer Disease | 2.21 (1.57, 3.12) | <0.001 | 0.76 (0.52, 1.12) | 0.21 |
| Mild Liver Disease | 2.15 (1.77, 2.62) | <0.001 | 1.26 (1.00, 1.59) | 0.046 |
| Moderate/Severe Liver Disease | 4.47 (2.83, 7.08) | <0.001 | 2.62 (1.53, 4.47) | <0.001 |
| Diabetes without Chronic Complications | 2.89 (2.56, 3.26) | <0.001 | 1.11 (0.96, 1.27) | 0.16 |
| Hemiplegia or Paraplegia | 2.42 (1.73, 3.38) | <0.001 | 0.76 (0.52, 1.09) | 0.14 |
| Renal Disease | 7.45 (6.60, 8.40) | <0.001 | 2.13 (1.84, 2.46) | <0.001 |
| Any Malignancy | 2.78 (2.37, 3.27) | <0.001 | 0.87 (0.72, 1.06) | 0.17 |
| Metastatic Solid Tumour | 3.68 (2.73, 4.97) | <0.001 | 1.70 (1.19, 2.43) | 0.004 |
| AIDS/HIV | 1.91 (1.16, 3.13) | 0.011 | 1.71 (1.00, 2.93) | 0.051 |

CI: confidence interval, OR: Odds Ratio. American Indian or Alaska Native omitted because there were no deaths among this group. Only characteristics p<0.05 in the unadjusted analyses were included in the multivariate analysis.