Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Research paper

Relationship between physical and mental health comorbidities and COVID-19 positivity, hospitalization, and mortality

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ABSTRACT

Background: Understanding the association between separate and combined mental and physical health diagnoses and COVID-19 outcomes is greatly needed to address the severity of illness.
Methods: Data on 24,034 patients screened for COVID-19 as of July 2020 were extracted from the Froedtert/Medical College of Wisconsin Epic medical record. COVID-19 outcomes were defined as positive screens, proportion hospitalized among positive screens, and proportion that died among positive and hospitalized population. The primary independent variable was a 3-category variable: physical health diagnosis alone, mental health diagnosis alone, and combined mental and physical health diagnoses. Logistic regression and Cox proportional hazard models were used to examine the independent relationship between separate and combined diagnoses and COVID-19 outcomes.
Results: Compared to physical health diagnosis alone, mental health diagnosis alone had lower odds of screening positive (OR=0.68, CI=0.51;0.92) and was not associated with hospitalization or mortality among positive screens. Combined had lower odds of screening positive (OR=0.78, CI=0.69;0.88) and higher odds of hospitalization among positive screens after adjusting for demographics (OR=1.58, CI=1.20;2.08) but lost significance in the fully adjusted model. No category of diagnoses was associated with mortality.
Limitations: Analysis is cross-sectional and cannot speak to any causal relationships.
Conclusions: Overall, compared to physical health diagnosis alone, mental health diagnosis and combined had lower odds of positive screens. However, individuals with combined were more likely to be hospitalized, after adjusting for demographics only. These findings add new evidence for risk of COVID-19 and related hospitalization in individuals who have a physical and mental health diagnosis.

1. Introduction

Since its emergence in Wuhan, China (WHO, 2020; Zhu et al., 2020), coronavirus disease 2019 (COVID-19) has quickly spread around the world, creating unprecedented economic hardship, worsened health status, and loss of life globally (Nicola et al., 2020; Baud et al., 2020). As of January 13, 2021, there have been 90,054,813 confirmed cases, including 1945,610 deaths, reported to the World Health Organization (WHO) (WHO, 2020) World Health Organization (WHO) 2020. Within the United States, 22,522,749 total cases and 375,124 total deaths have been reported to the Center for Disease Control and Prevention (CDC) as of January 13, 2021 (Center for Disease Control and Prevention: COVID-19 2019).

The impact of COVID-19 has been extensive, with some patient groups experiencing increased risk for infection such as the elderly and those with pre-existing physical health conditions, namely hypertension, chronic kidney disease, diabetes, cardiovascular disease, cerebrovascular disease, and chronic obstructive pulmonary disease (Nandy et al., 2020; Cuschieri et al., 2020; Orioli et al., 2020; Wu et al., 2020; Sousa et al., 2020; Imam et al., 2020; Vepa et al., 2020; Bello-Chavolla et al., 2020; Yang et al., 2020; Zhou et al., 2020). In addition to increased risk for contracting COVID-19, evidence shows that individuals with pre-existing physical health conditions are at an increased risk for hospitalization and increased risk for early death among positive screens. For example, in a retrospective cohort study in China, individuals with kidney and cardiovascular disease were shown to have worse prognoses

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for their COVID-19 infections compared to those without pre-existing conditions (Zhou et al., 2020). In Brazil, individuals with pre-existing conditions who screened positive for COVID-19, had 8.9 times higher risk for mortality compared to those without pre-existing conditions (Sousa et al., 2020) with similar findings shown in the US (Harrison et al., 2020) and across other countries (Singh and Misra, 2020).

In addition to the increased risk that pre-existing physical health conditions create for COVID-19 and related outcomes, emerging evidence shows that pre-existing mental health conditions may also confer significant risk for infection as well as increasing risk for hospitalization and mortality among positive screens (Wang et al., 2020; Brown et al., 2020), however findings remain mixed. For example, initial evidence from South Korea examined the risk of COVID-19 infection and severity of outcomes across a nationwide cohort and found that pre-existing mental health conditions did not significantly increase risk for infection and there was a marginal increased risk for severe outcomes (Lee et al., 2020). Conversely, evidence that became available as of November 2020 is demonstrating that individuals with pre-existing and recently diagnosed mental health conditions have a higher risk of infection, higher risk of hospitalization after infection, and an increased risk of mortality compared to individuals without diagnosed mental health conditions (Wang et al., 2020).

Given the consistent rise in incidence, there remains an urgent need to understand populations who are at increased risk, such as those with pre-existing mental health conditions, for infection and severity of outcomes that may lead to early mortality. Moreover, an important question that remains unanswered is understanding the risk for COVID-19 infection and severity of outcomes among individuals with co-occurring physical and mental health conditions. While evidence has identified the increased risk that individuals with pre-existing physical health conditions alone and pre-existing mental health conditions alone have, whether this risk remains or is amplified among individuals who have co-occurring mental and physical health conditions remains largely unknown. Therefore, the aim of this study is to investigate the relationship between separate and combined pre-existing mental and physical health diagnoses and three COVID-19 related outcomes (positive test result, hospitalization, and mortality). We hypothesized that the highest risk group would be individuals with combined mental and physical health diagnoses, and that this group would be associated with higher likelihood of COVID-19 positive test, hospitalization, and mortality compared to either physical or mental health diagnosis only.

2. Methods

2.1. Sample population

This study was a cross-sectional analysis of data obtained from the Froedtert/Medical College of Wisconsin (MCW) Epic medical record. The Froedtert/MCW system is the only academic medical center in Southeastern Wisconsin consisting of five hospitals and forty health centers and clinics in Southeastern Wisconsin. Approximately one fourth of COVID-19 tests in the state of Wisconsin have been conducted through the Froedtert/MCW system. Testing guidelines for the Froedtert/MCW system at the time of this analysis included recommended testing of health care workers and students who may have been exposed to COVID-19, symptomatic patients, patients scheduled for a procedure or planned admission to the hospital, patients admitted to the hospital, patients discharged to a skilled nursing facility, and patients within an ambulatory care setting.

2.2. COVID-19 status

COVID-19 testing was conducted using the CDC protocol, which included a nasopharyngeal specimen and oropharyngeal specimen from each patient using a mini-tip and regular sized flocked swab (Copan Diagnostics, Murrieta, CA), respectively. Swabs were transported to the laboratory in viral transport media (M6, ThermoFisher, Lenexa, KS). Testing was performed by RNA extracted using the bioMerieux eMag (bioMerieux, March l' Etoile, FR), and RT PCR performed on ABI 7500 Fast DX thermocyclers (ThermoFisher, Waltham, MA). Patients were considered to be positive cases if their initial test or any follow-up test result was marked as 'Detected'.

2.3. Hospitalization and mortality

Patients with a positive COVID-19 result were further identified as having been hospitalized or not hospitalized using an inpatient admission after the date of the COVID-19 test was completed. All-cause mortality was ascertained based on evidence of death in the medical records and a positive test for COVID-19. Cause-specific mortality could not be ascertained, so analysis was based on all-cause mortality.

2.4. Physical and mental health conditions

Physical and mental health conditions were defined based on ICD-9 or ICD-10 codes within the medical record using the Enhanced Elixhauser categorization validated by Quan and colleagues (Quan et al., 2005), see Table 1 for ICD-9/ICD-10 codes. Physical conditions included: congestive heart failure, cardiac arrhythmias, valvular disease, pulmonary circulation disorders, peripheral vascular disorders, hypertension (uncomplicated and complicated), paralysis, other neurological disorders, chronic pulmonary disease, diabetes (uncomplicated and complicated, hypothyroidism, renal failure, liver disease, peptic ulcer disease excluding bleeding, AIDS/HIV, cancer (lymphoma, metastatic cancer, solid tumor without metastasis), rheumatoid arthritis/collagen vascular diseases, Coagulopathy, Obesity, weight loss, fluid and electrolyte disorders, anemia (blood loss anemia and deficiency anemia) (Quan et al., 2005). Mental health conditions included: alcohol abuse, drug abuse, psychoses, depression (Quan et al., 2005).

Individuals were categorized into one of three categories: (1) those with any of the physical conditions but no mental health conditions were categorized as "physical only"; (2) those with any of the mental health conditions but no physical health conditions were categorized as "mental only"; and (3) those with at least one physical health diagnosis and at least one mental health diagnosis were categorized as "combined". All study procedures were approved by the Institutional Review Board prior to any procedures starting.

2.5. Covariates

Demographic information included sex (categorized as male or female), age (at date of COVID-19 test, used as a continuous variable), race/ethnicity (based on self-report in the medical record, and categorized as Non-Hispanic White, Non-Hispanic Black, and Hispanic/Other Race), county of residence (based on zip code, and categorized into Milwaukee county, and other Wisconsin county/out of state), and primary payer (categorized as managed care/commercial, Medicare, Medicaid, and self-pay/uninsured). Risk factors included tobacco use (categorized into never smoked or former smoker/current smoker) and body mass index (BMI) (calculated from most recent height and weight, grouped into underweight [BMI<18.50]; normal weight [BMI>=18.50 & BMI<=24.99]; overweight [BMI>=25.00 & BMI<=29.99]; and obese [BMI>=30.00]).

2.6. Statistical analysis

Descriptive statistics were conducted to summarize sample characteristics. ANOVA, Chi-square, and Fisher's exact tests were used to calculate differences between demographic and clinical factors by physical only, mental only, and combined. Comparisons were conducted first in the full sample and then in those who tested positive for COVID-19.

Table 1
ICD-9/ICD-10 Codes for Physical Health Diagnosis and Mental Health Diagnosis.

Physical Health Diagnosis	ICD-9/ICD-10 Code
congestive heart failure	ICD-9 codes 398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4–425.9, 428.x; ICD-10 codes I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5– I42.9, I43.x, I50.x, P29.0
cardiac arrhythmias	ICD-9 codes 426.0, 426.13, 426.7, 426.9, 426.10, 426.12, 427.0–427.4, 427.6–427.9, 785.0, 996.01, 996.04, V45.0, V53.3; ICD-10 codes I44.1–I44.3, I45.6, I45.9, I47.x–I49.x, R00.0, R00.1, R00.8, T82.1, Z45.0, Z95.0
valvular disease	ICD-9 codes 093.2, 394.x–397.x, 424.x, 746.3–746.6, V42.2, V43.3; ICD-10 codes A52.0, I05.x–I08.x, I09.1, I09.8, I34.x–I39.x, Q23.0–Q23.3, Z95.2– Z95.4
pulmonary circulation disorders	ICD-9 codes 415.0, 415.1, 416.x, 417.0, 417.8, 417.9; ICD-10 codes I26.x, I27.x, I28.0, I28.8, I28.9
peripheral vascular disorders	ICD-9 codes 093.0, 437.3, 440.x, 441.x, 443.1– 443.9, 447.1, 557.1, 557.9, V43.4; ICD-10 codes I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9
Hypertension (uncomplicated and complicated)	ICD-9 codes 401.x, 402.x–405.x; ICD-10 codes I10.x, I11.x–I13.x, I15.x
paralysis	ICD-9 codes 334.1, 342.x, 343.x, 344.0–344.6, 344.9; ICD-10 codes G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0–G83.4, G83.9
other neurological disorders	ICD-9 codes 331.9, 332.0, 332.1, 333.4, 333.5, 333.92, 334.x–335.x, 336.2, 340.x, 341.x, 345.x, 348.1, 348.3, 780.3, 784.3; ICD-10 codes G10.x–G13.x, G20.x–G22.x, G25.4, G25.5, G31.2, G31.8, G31.9, G32.x, G35.x–G37.x, G40.x, G41.x, G93.1, G93.4, R47.0, R56.x
chronic pulmonary disease	ICD-9 codes 416.8, 416.9, 490.x –505.x, 506.4, 508.1, 508.8; ICD-10 codes I27.8, I27.9, J40.x–J47.x, J60.x–J67.x, J68.4, J70.1, J70.3
diabetes (uncomplicated and complicated)	ICD-9 codes 250.0–250.3, 250.4–250.9; ICD-10 codes E10.0, E10.1, E10.9, E11.0, E11.1, E11.9, E12.0, E12.1, E12.9, E13.0, E13.1, E13.9, E14.0, E14.1, E14.9, E10.2–E10.8, E11.2–E11.8, E12.2– E12.8, E13.2–E13.8, E14.2–E14.8
hypothyroidism	ICD-9 codes 240.9, 243.x, 244.x, 246.1, 246.8; ICD-10 codes E00.x–E03.x, E89.0
renal failure	ICD-9 codes 403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 585.x, 586.x, 588.0, V42.0, V45.1, V56.x; ICD-10 codes I12.0, I13.1, N18.x, N19.x, N25.0, Z49.0– Z49.2, Z94.0, Z99.2
liver disease	ICD-9 codes 070.22, 070.23, 070.32, 070.33, 070.44, 070.54, 070.6, 070.9, 456.0–456.2, 570.x, 571.x, 572.2–572.8, 573.3, 573.4, 573.8, 573.9, V42.7; ICD-10 codes B18.x, I85.x, I86.4, I98.2, K70.x, K71.1, K71.3– K71.5, K71.7, K72.x– K74.x, K76.0, K76.2–K76.9, Z94.4
peptic ulcer disease excluding bleeding	ICD-9 codes 531.7, 531.9, 532.7, 532.9, 533.7, 533.9, 534.7, 534.9; ICD-10 codes K25.7, K25.9, K26.7, K26.9, K27.7, K27.9, K28.7, K28.9
AIDS/HIV	ICD-9 codes 042.x–044.x; ICD-10 codes B20.x–B22.x, B24.x
cancer (lymphoma, metastatic cancer, solid tumor without metastasis)	ICD-9 codes 200.x–202.x, 203.0, 238.6, 196.x–199.x, 140.x–172.x, 174.x– 195.x; ICD-10 codes C81.x–C85.x, C88.x, C96.x, C90.0, C90.2, C77.x–C80.x, C00.x–C26.x, C30.x–C34.x, C37.x–C41.x, C43.x, C45.x–C58.x, C60.x–C76.x, C97.x
rheumatoid arthritis/collagen vascular diseases	ICD-9 codes 446.x, 701.0, 710.0– 710.4, 710.8, 710.9, 711.2, 714.x, 719.3, 720.x, 725.x, 728.5, 728.89, 729.30; ICD-10 codes L94.0, L94.1, L94.3, M05.x, M06.x, M08.x, M12.0, M12.3, M30.x, M31.0–M31.3, M32.x–M35.x, M45.x, M46.1, M46.8, M46.9
Coagulopathy	ICD-9 codes 286.x, 287.1, 287.3– 287.5; ICD-10 codes D65–D68.x, D69.1, D69.3–D69.6
Obesity	ICD-9 codes 278.0; ICD-10 codes E66.x
weight loss	ICD-9 codes 260.x–263.x, 783.2, 799.4; ICD-10 codes E40.x–E46.x, R63.4, R64
fluid and electrolyte disorders	ICD-9 codes 253.6, 276.x; ICD-10 codes E22.2, E86.x, E87.x
anemia (blood loss anemia and deficiency anemia)	ICD-9 codes 280.0, 280.1–280.9, 281.x; ICD-10 codes D50.0, D50.8, D50.9, D51.x–D53.x
Mental Health Diagnosis	**ICD-9/ICD-10**
alcohol abuse	ICD-9 codes 265.2, 291.1–291.3, 291.5–291.9, 303.0, 303.9, 305.0, 357.5, 425.5, 535.3, 571.0– 571.3, 980.x, V11.3; ICD-10 codes F10, E52, G62.1, I42.6, K29.2, K70.0, K70.3, K70.9, T51.x, Z50.2, Z71.4, Z72.1
drug abuse	ICD-9 codes 292.x, 304.x, 305.2– 305.9, V65.42; ICD-10 codes F11.x–F16.x, F18.x, F19.x, Z71.5, Z72.2
psychoses	ICD-9 codes 293.8, 295.x, 296.04, 296.14, 296.44, 296.54, 297.x, 298.x; ICD-10 codes F20.x, F22.x–F25.x, F28.x, F29.x, F30.2, F31.2, F31.5
depression	ICD-9 codes 296.2, 296.3, 296.5, 300.4, 309.x, 311; ICD-10 codes F20.4, F31.3–F31.5, F32.x, F33.x, F34.1, F41.2, F43.2

Conditions Defined using the Enhanced Elixhauser Categorization Validated by Quan and Colleagues (see reference Quan et al., 2005).

Unadjusted and adjusted logistic regression and Cox proportional hazard models were then run to understand the independent relationship between physical only, mental only, combined and COVID-19 related outcomes. The first set of models estimated the odds of having a positive COVID-19 case by physical only and mental only within all adults tested in the health system. The second set of models estimated the odds of hospitalization by physical only, mental only, and combined in adults with a positive COVID-19 test. The third set of models estimated the hazard ratio for mortality by physical only, mental only, and combined in adults with a positive COVID-19 test. Each set of models were first run unadjusted, followed by models adjusted for demographics (sex, age, race/ethnicity). Finally, a fully adjusted model was run adjusting for sex, age, race/ethnicity, geographic location, primary payer, tobacco use, and BMI category. SAS version 9.4 (SAS Institute, Cary NC) was used for all analyses. Two sided tests were conducted, and $p<0.05$ was considered statistically significant.

3. Results

There were 33,065 patients aged 18 and above who had a COVID-19 test based on medical lab results. Among this group, 24,034 patients had ICD-9/ICD-10 codes to allow determination of whether they had either physical health or mental health conditions pre-existing before the COVID-19 test.

Table 2 shows characteristics of adults tested for COVID-19. Overall, 24,034 adults were tested of which 55% were characterized as physical only, 4% were characterized as mental only, and 40% were combined. In the full sample, mean age was 56 years, 73.9% were non-Hispanic White, 19.7% were non-Hispanic Black, and 6.4% were Hispanic/Other race, 44.7% lived in Milwaukee County, 50.1% were current/former smokers, and 6.0% tested positive for COVID-19.

Table 3 shows the characteristics for those who tested positive for

Table 2
Characteristics of Adults Tested for COVID-19 in Milwaukee and Southeast Wisconsin by Physical and Mental Health Diagnoses.

	Total (n = 24,034)	Physical Health Diagnosis Only (n = 13,326)	Mental Health Diagnosis Only (n = 1049)	Both Mental and Physical Health Diagnosis (n = 9659)	p-value
Sex					<0.0001
Female	60.4%	56.5%	65.0%	65.3%	
Male	39.6%	43.5%	35.0%	34.7%	
Age, mean (SD)	55.9 (18.3)	57.6 (18.4)	37.4 (13.2)	55.5 (17.3)	<0.0001
Race/ethnicity					<0.0001
NH White	73.9%	75.8%	77.2%	70.9%	
NH Black	19.7%	17.3%	13.6%	23.6%	
Hispanic/Other	6.4%	6.9%	9.3%	5.5%	
Location					<0.0001
Other county/out of state	55.3%	60.0%	52.0%	49.1%	
Milwaukee county	44.7%	40.0%	48.0%	50.9%	
Primary payor					<0.0001
Managed care	40.1%	43.1%	63.2%	33.3%	
Medicare	42.3%	42.7%	7.5%	45.6%	
Medicaid	12.9%	9.2%	20.6%	17.1%	
Self-pay/Uninsured	4.7%	5.0%	8.7%	4.0%	
Tobacco use status					<0.0001
Non-smoker	49.9%	56.1%	54.5%	40.9%	
Current/Former smoker	50.1%	43.9%	45.5%	59.1%	
BMI					<0.0001
Normal weight [BMI>=18.50 & BMI<=24.99]	22.6%	22.0%	33.4%	22.4%	
Underweight [BMI<18.50]	2.1%	2.0%	1.5%	2.2%	
Overweight [BMI>=25.00 & BMI<=29.99]	28.4%	29.5%	35.6%	26.3%	
Obese [BMI>=30.00]	46.9%	46.6%	29.5%	49.0%	
COVID Positive Test	6.0%	6.7%	5.0%	5.2%	<0.0001

P-values based on ANOVA, Chi-square, and Fisher's exact tests used to calculate differences between demographic and clinical factors by physical only, mental only, and combined.

Table 3
Characteristics of Positive COVID-19 Cases in Milwaukee and Southeast Wisconsin by Physical and Mental Health Diagnoses.

	Total (n = 1454)	Physical Health Diagnosis Only (n = 897)	Mental Health Diagnosis Only (n = 52)	Both Mental and Physical Health Diagnosis (n = 505)	p-value
Sex					<0.0001
Female	58.8%	54.1%	65.4%	66.5%	
Male	41.2%	45.9%	34.6%	33.5%	
Age, mean (SD)	52.4 (18.3)	52.4 (18.4)	37.7 (15.8)	54.0(17.8)	<0.0001
Race/ethnicity					0.04
NH White	45.9%	45.1%	63.5%	45.3%	
NH Black	44.1%	43.9%	26.9%	46.3%	
Hispanic	10.0%	10.9%	9.6%	8.3%	
Location					0.03
Other county/out of state	34.9%	37.3%	26.9%	31.3%	
Milwaukee county	65.1%	62.7%	73.1%	68.7%	
Primary payor					<0.0001
Managed care	41.7%	46.4%	55.8%	31.9%	
Medicare	34.7%	31.2%	11.5%	43.2%	
Medicaid	16.5%	14.5%	19.2%	19.8%	
Self-pay/Uninsured	7.1%	7.9%	13.5%	5.1%	
Tobacco use status					<0.0001
Non-smoker	60.8%	66.7%	70.6%	49.2%	
Current/Former smoker	39.2%	33.3%	29.4%	50.8%	
BMI					0.0002
Normal weight [BMI>=18.50 & BMI<=24.99]	17.8%	17.2%	28.9%	17.8%	
Underweight [BMI<18.50]	1.2%	0.8%	2.2%	1.9%	
Overweight [BMI>=25.00 & BMI<=29.99]	21.3%	21.9%	42.2%	18.5%	
Obese [BMI>=30.00]	59.6%	60.1%	26.7%	61.8%	
Hospitalization	24.6%	22.4%	7.7%	30.1%	<0.0001
Mortality	5.9%	5.1%	1.9%	7.7%	0.08

P-values based on ANOVA, Chi-square, and Fisher's exact tests used to calculate differences between demographic and clinical factors by physical only, mental only, and combined.

COVID-19. Overall, 58.8% were women, mean age was 52 years, 45.9% were non-Hispanic White, 44.1% were non-Hispanic Black, and 10% were Hispanic/Other race. Additionally, 61.7% were physical only, 3.6% were mental only, and 34.7% were combined.

Table 4 shows the unadjusted and adjusted association between the mental only and the physical only and odds of a positive COVID-19 test. In the unadjusted model, compared to physical only, those with mental only and those with combined had significantly lower odds of screening

Table 4
Unadjusted and adjusted association between mental and physical health diagnoses and odds of positive COVID-19 test (n = 24,034).

	Unadjusted Odds Ratio	Odd Ratio Adjusted for Demographics	Fully Adjusted Odd Ratio
Diagnoses			
Physical Health Diagnosis only	Ref	Ref	Ref
Mental Health Diagnosis only	**0.72*** **(0.54–0.96)**	**0.68*** **(0.51–0.92)**	0.89 (0.65–1.23)
Both Physical and Mental Health Diagnosis	**0.76***** **(0.68–0.86)**	**0.69***** **(0.61–0.77)**	**0.78***** **(0.69–0.88)**

*p<0.05, **p<0.01, ***p<0.001.
Variables in demographics adjusted model included race/ethnicity, sex and age.
Variables in fully adjusted model included race/ethnicity, sex, age, county, payer, tobacco use and BMI.

positive (OR=0.72; CI=0.54;0.96 and OR=0.76; CI=0.68;0.86, respectively). After adjusting for demographic factors, compared to physical only, odds of screening positive remained significantly lower for those with a mental only (OR=0.68; CI=0.51;0.92) and those with combined (OR=0.69; CI=0.61; 0.77). In the fully adjusted model, only those with combined had significantly lower odds of screening positive (OR=0.78; CI=0.69;0.88) compared to those who had physical only.

Table 5 shows the unadjusted and adjusted association between mental only and physical only and odds of hospitalization and hazards of death in patients with a positive COVID-19 test. In the unadjusted models, compared to physical only, those having mental only had significantly lower odds of hospitalization (OR=0.29; CI=0.10;0.81), and those having combined had significantly higher odds of hospitalization (OR=1.49; CI=1.17;1.91). After adjusting for demographic factors, only individuals with combined remained significantly associated with higher odds of hospitalization compared to those with physical only (OR=1.58; CI=1.20;2.08). Physical only and mental only categories were not significantly associated with increased odds of hospitalization in the fully adjusted model. There was no significant relationship between the physical only, mental only, or combined and mortality.

4. Discussion

Using data from the electronic medical record in a large health system across Southeastern Wisconsin, this study identified three primary findings. First, compared to individuals with physical only, individuals with mental only and individuals with combined were less likely to screen positive for COVID-19. This relationship held after adjustment for demographic and clinical risk available in the medical record. Secondly, among adults who tested positive for COVID-19, those with mental only were less likely to be hospitalized compared to those with physical only. After adjusting for demographic factors, insurance, county of residence, tobacco use and BMI this relationship lost significance. Individuals with combined were more likely to be hospitalized compared to those with physical only. This relationship remained significant after adjusting for demographic factors, but it lost statistical significance after adjusting for insurance type, county of residence, tobacco use, and BMI. Finally, there was no significant relationship between physical only, mental only, or combined with mortality for individual who tested positive for COVID-19.

4.1. Mental health diagnosis

The current study found that individuals with a mental health diagnosis had an overall lower risk for testing positive for COVID-19 when adjusting for demographic factors, this relationship lost significance once adjusting for county of residence, payer, tobacco use, and BMI. Additionally, mental health diagnosis was not associated with hospitalization or mortality among those who tested positive for COVID-19. These findings vary from existing evidence which shows that individuals with a mental health diagnosis have an increased risk for testing positive for COVID-19 and are at an increased risk for hospitalization and mortality among positive screens (Wang et al., 2020; Taquet et al., 2020). Specifically, in a recently published study across 360 US hospitals, patients who were newly diagnosed with depression or schizophrenia had an increased risk for testing positive for COVID-19 compared to those without depression and without schizophrenia, respectively (Wang et al., 2020). Additionally, patients with a mental health diagnosis who tested positive for COVID-19 were more likely to be hospitalized (Wang et al., 2020). Similarly, a large US based study examined the relationship between existing psychiatric disorders and risk for COVID-19 across 54 health care organizations and found that among patients with existing psychiatric disorders, risk for testing positive for COVID-19 was 1.65 times higher compared to those without existing psychiatric disorders (Taquet et al., 2020). In addition to increased risk of testing positive for COVID-19 and increased risk for hospitalization, recent evidence out of five hospitals in the Northeast region of the US also showed that among those who tested positive for COVID-19 with existing mental health disorders also had an increased risk for mortality compared to those who tested positive for COVID-19 and did not have an existing mental health disorder (Li et al., 2020). Given the small sample size in the current study for individuals with a mental health diagnosis, further investigation is needed to understand the risk of infection that individuals with a mental health diagnosis have as well as risk for hospitalization and mortality among positive screens. Additionally, specific diagnoses of mental health disorders may also be an important factor that should be accounted for that may be driving the differences seen across studies.

4.2. Physical health diagnosis

Evidence for the increased risk of testing positive for COVID-19 among individual with pre-existing physical health diagnosis has been

Table 5
Unadjusted and adjusted models for association between mental and physical health diagnoses and odds of hospitalization and hazards of death in patients with a positive COVID-19 test (n = 1454).

	Hospitalization (Odds Ratio (95% CI))			**Mortality** (Hazard Ratio (95% CI))		
	Unadjusted	**Adjusted for Demographics**	**Fully Adjusted**	**Unadjusted**	**Adjusted for Demographics**	**Fully Adjusted**
Diagnoses						
Physical Health Diagnosis only	Ref	Ref	Ref	Ref	Ref	Ref
Mental Health Diagnosis only	**0.29*** **(0.10–0.81)**	0.74 (0.24–2.27)	0.46 (0.14–1.55)	0.39 (0.05–2.86)	1.08 (0.15–7.90)	1.08 (0.15–8.05)
Both Physical and Mental Health Diagnosis	**1.49**** **(1.17–1.91)**	**1.58**** **(1.20–2.08)**	1.06 (0.79–1.44)	1.52 (0.99–2.32)	1.36 (0.89–2.10)	1.33 (0.85–2.08)

*p<0.05, **p<0.01, ***p<0.001.
Variables in demographics adjusted model included race/ethnicity, sex and age.
Variables in fully adjusted model included race/ethnicity, sex, age, county, payer, tobacco use and BMI.

well documented in the literature (CDC, 2020) as well as the increased risk that pre-existing physical health diagnoses present for hospitalization and mortality across countries (Atkins et al., 2020; Harrison et al., 2020). In the UK for example, risk for COVID-19, hospitalization, and mortality were examined in a community cohort of 269,070 individuals with pre-existing physical health conditions (Atkins et al., 2020). Findings showed that across 15 physical health diagnosis examined, including depression and dementia, all conditions were associated with testing positive for COVID-19 except one, osteoarthritis. Additionally, conditions such as pneumonia, diabetes, and COPD were all associated with increased risk for hospitalization (Atkins et al., 2020). In the US, across 24 health systems representing the Northeast, Midwest, South, and West, conditions such as myocardial infarction, congestive heart failure, COPD, and liver disease were associated with increased risk of mortality among individuals who tested positive for COVID-19 (Harrison et al., 2020). Similar findings have been found in China, with hypertension, diabetes, and cardiovascular disease being common pre-existing conditions among COVID-19 positive patients as well as risk factors for COVID-19 severity (Yang et al., 2020).

4.3. Combined mental health and physical health diagnosis

While evidence from the literature has demonstrated the risk that pre-existing mental health diagnoses and physical health diagnoses both present for COVID-19, as well as the risk for hospitalization and mortality, much less is known about the risk that combined mental and physical health diagnoses present for COVID-19, hospitalization, and mortality. The current findings show that compared to those with a physical health diagnosis alone, individuals with combined have lower odds of testing positive after adjusting for demographics and in the fully adjusted models. For those with combined who tested positive for COVID-19, risk of hospitalization was 1.58 compared to those with a physical diagnosis alone after adjusting for demographics, and this relationship did not hold once adjusting for county of residence, payer, tobacco use, and BMI. There was no significant increased risk of mortality for those with combined compared to those with a physical health diagnosis only. Existing research examining the role of mental health diagnoses and physical health diagnoses on risk of COVID-19 have primarily controlled for the presence of a co-occurrence. For example, Wang and colleagues examined the risk of COVID-19, hospitalization, and mortality among individuals with existing or new mental health diagnosis and adjusted for the presence of physical health diagnosis such as cancer, cardiovascular disease, diabetes, COPD etc. (Wang et al., 2020). While controlling for the presence of physical health diagnosis is a critical first step in establishing the risk that mental health diagnoses present for COVID-19 infection, hospitalization and or death, a next step needed in our understanding is the risk that co-occurring mental health and physical health diagnoses have for COVID-19 infection and severity of illness that may increase hospitalization and early mortality.

The findings presented here provide new knowledge on risk of COVID-19 and related outcomes among individuals with pre-existing physical and mental health conditions and have implications across the clinical, research, and policy level. Specifically, evidence shows that individuals with combined mental and physical health diagnoses have higher rates of morbidity and healthcare use, as well as worse quality of life, in comparison to individuals with either physical or mental health conditions alone (Zhou et al., 2020), and as such may be experiencing an increased vulnerability to COVID-19 and COVID-19 severity. From a clinical standpoint, primary prevention efforts should continue to screen patients with combined mental and physical health conditions and prioritization should be considered even among non-symptomatic patients to mitigate the risk of COVID-19 and to minimize illness severity if COVID-19 is contracted. From a research standpoint, while evidence is being generated to identify risk factors for COVID-19, there remains the need to understand how combined mental and physical health diagnoses impact risk of COVID-19, hospitalization, and mortality. These results provide new data, however further investigation is still needed. From a policy standpoint, the results presented here add to the existing body of evidence and demonstrate those with an increased risk of hospitalization once COVID-19 is contracted. While the relationship between combined and risk of hospitalization lost significance after adjusting for county of residence, payer, tobacco use, and BMI, given the severity of COVID-19 further prioritization for receipt of vaccines once available should be considered for individuals with combined physical and mental health diagnosis.

5. Limitations

This study has some limitations that should be considered. First, the analysis was conducted using medical records, so data that is unavailable in the record, such as socioeconomic status, could not be incorporated into the analysis. Additionally, analyses are cross-sectional and therefore cannot speak to causality of the relationship. Second, the study was conducted in one large health system located in the Midwest United States and may not be representative of all regions or health systems within the US. Finally, physical and mental health conditions were defined based on the Enhanced Elixhauser categorization validated by Quan and colleagues (Quan et al., 2005), however this study did not control for medications such as certain antipsychotics which may produce side effects such as obesity and metabolic syndrome, conditions associated with increased risk of COVID-19. Future analysis should consider the role of medication.

6. Conclusion

In conclusion, this study found that adults who had combined physical and mental health diagnoses, were less likely to test positive for COVID-19 but more likely to be hospitalized when they screened positive compared to individuals with a physical health diagnosis only after adjusting for demographics. While this relationship lost significance after adjusting for county of residence, payer, tobacco use, and BMI, these findings add new evidence for individuals who have combined physical and mental health diagnoses and risk of hospitalization once diagnosed with COVID-19. However, additional research is needed to understand the role that pre-existing mental health diagnoses and comorbid mental and physical health diagnoses have in testing positive for COVID-19 and for COVID-19 severity once contracted, and to understand if these relationships vary across vulnerable and marginalized communities.

CRediT authorship contribution statement

Josh Egede: Conceptualization, Writing - original draft, Writing - review & editing. **Jennifer A Campbell:** Conceptualization, Writing - review & editing. **Rebekah J Walker:** Conceptualization, Formal analysis, Writing - review & editing. **Emma Garacci:** Formal analysis. **Aprill Z Dawson:** Conceptualization, Writing - review & editing. **Leonard E Egede:** Funding acquisition, Formal analysis, Writing - review & editing, Formal analysis, Writing - review & editing.

Declaration of Competing Interest

All authors declare they have no conflict of interest.

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Data Availability: Data used for this study is available upon request from LEE

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