Comorbidities and health care systems differences among states as it relates to COVID-19

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Introduction

Comorbidities, such as cardiovascular disease (CVD), congestive obstructive pulmonary disease (COPD), diabetes mellitus (DM), hypertension (HTN), and obesity, have been associated with poorer COVID-19-related prognoses [1]. However, little is known about how these comorbidities and socioeconomic factors (e.g., minority percentage, uninsured status, nursing homes/1000, number of hospital beds/1000) collectively preclude worse COVID-19 outcomes. We compared characteristics of each state with their corresponding COVID-19 case fatality rate to develop a deeper understanding of state-by-state COVID-19 risk and inform allocation of resources, prevention strategies, and policy.

Methods

Data on demographics, comorbidities, hospital systems, and COVID-19 case fatality rates across 50 states and the District of Columbia (DC) were analyzed and stratified by the United States average. Comorbidities data were obtained from the Centers for Disease Control and Behavioral Risk Factor Surveillance System [2,3]. Data regarding demographics and hospital systems in State Health Facts were used with permission from the Kaiser Family Foundation [4–9].

We compared case fatality rates for all regions (51 values per predictor) above and below the national average for that predictor using independent-samples t-test, assuming unequal variances, with significance at a p-value of <0.05. A multiple linear regression analysis was performed on 12 independent variable predictors to determine the possible case fatality rates at the state level.

Results

Maine, West Virginia, and Vermont had the highest rates of asthma (123, 123, and 120 cases/1000 persons), while Texas, South Dakota, and Iowa had the lowest rates (74, 79, and 79 cases/1000 persons). Maine, Vermont, and Florida had the oldest mean age of the total population (37, 36, and 35 years), while Utah, DC, and Texas had the youngest (21, 22, and 24 years). Alaska, North Dakota, and Wyoming had the highest male to female (M:F) gender ratio (1.04), while DC, Virginia, and Tennessee had the lowest ratio (0.89, 0.92, and 0.92). Case fatality rates were significantly greater in states above vs. below the national averages for asthma (p-value 0.013), age (p-value 0.040), and M:F (p-value 0.0014). All other variables investigated were not significantly different between states (all p-value ≤ 0.15) (Table 1).

A multiple linear regression analysis indicated coefficients and p-values for each independent variable as follows: Age >55 (coefficient: 0.16, p-value: 0.23), Minority Population (0.05, 0.21), M:F (-14.32, 0.26), Uninsured (-0.20, 0.45), Asthma (0.02, 0.56), COPD (0.04, 0.41), CVD (0.01, 0.86), DM (-0.03, 0.52), HTN (-0.07, 0.70), Obesity (-0.01, 0.60), Nursing Homes (13.99, 0.5), and Hospital Beds (-0.53, 0.37). The coefficient of determination R^2 is 0.27.

Discussion

Understanding the risk and potential impact of the COVID-19 pandemic at the state level is vital for outbreak preparedness and community management. This review is consistent with current literature indicating increased rates of preexisting disease are associated with worse health outcomes [10,11]. Asthma and increased age were significantly greater among states with higher case fatality. In contrast to reportedly higher COVID-19-related deaths among men, lower case fatalities were observed in states with higher M:F ratios.

This study expands upon individual hospital-level data to identify state-wide risk factors for COVID-19. Social factors such as accessibility to healthcare, uninsured rates, urban vs. rural

Table 1. *Demographics, comorbidities, and hospital data during the COVID-19 pandemic per state*

State	Demographics[$]				Comorbidities (per 1000)[2][#]						Hospital System[$]		COVID-19 (current as of 6/09/20)[3][~]		
	Age over 55 (%)[4]	Minority Population (%)[5]	M:F (2017)[6]	Uninsured (%)[7]	Asthma	COPD	CVD	DM	HTN	Obesity (BMI > 30)	Nursing Homes Per 1000 (2017)[8]	Hospital Beds per 1000[9]	Cases per 1000	Mortalities per 1000	Case Fatality Rate (%)
United States	**29**	31	**0.96**	9	**95**	66	43	109	323	309	0.049	2.4	6.1	0.35	5.67
Alabama	**31**	31	**0.92**	10	**105**	103	61	145	419	362	0.048	3.1	4.5	0.15	3.4
Alaska	**25**	27	**1.04**	12	**92**	59	31	88	318	295	0.025	2.2	0.8	0.01	1.81
Arizona	**30**	40	**0.96**	9	**100**	71	43	108	307	295	0.021	1.9	4	0.11	2.85
Arkansas	**30**	24	**0.96**	10	**98**	98	64	139	414	371	0.079	3.2	3.3	0.05	1.59
California	**26**	45	**0.96**	12	**85**	46	32	104	284	258	0.031	1.8	3.4	0.12	3.54
Colorado	**27**	26	**1**	9	**91**	44	27	70	259	230	0.04	1.9	5.1	0.28	5.47
Connecticut	**32**	27	**0.96**	10	**103**	53	37	97	305	274	0.064	2	12.7	1.18	9.26
Delaware	**33**	31	**0.92**	12	**101**	70	43	119	349	335	0.048	2.2	10.7	0.44	4.09
District of Columbia	**22**	56	**0.89**	9	**116**	53	25	84	264	247	0.027	4.4	14.1	0.74	5.23
Florida	**35**	42	**0.94**	10	**87**	83	52	126	346	307	0.033	2.6	3	0.13	4.28
Georgia	**26**	41	**0.92**	12	**89**	73	46	126	331	325	0.035	2.4	5.1	0.22	4.21
Hawaii	**32**	22	**0.96**	9	**93**	41	31	115	306	249	0.031	1.9	0.5	0.01	2.67
Idaho	**28**	14	**1**	10	**87**	57	37	102	298	284	0.041	1.9	1.9	0.05	2.6
Illinois	**28**	31	**0.96**	12	**87**	66	34	100	323	318	0.059	2.5	10.4	0.49	4.73
Indiana	**29**	16	**0.96**	9	**100**	90	50	125	352	341	0.085	2.7	5.8	0.36	6.16
Iowa	**30**	10	**0.96**	10	**79**	58	44	100	315	353	0.143	3	7.2	0.2	2.79
Kansas	**29**	18	**0.98**	12	**98**	67	44	116	328	344	0.098	3.3	3.8	0.08	2.22
Kentucky	**30**	11	**0.96**	9	**115**	121	63	137	394	366	0.066	3.2	2.7	0.11	4.11
Louisiana	**28**	37	**0.92**	10	**89**	99	60	141	390	368	0.061	3.3	9.5	0.65	6.84
Maine	**37**	3	**0.96**	12	**123**	81	52	106	348	304	0.077	2.5	2	0.08	3.83
Maryland	**29**	40	**0.92**	9	**93**	57	41	120	324	309	0.038	1.9	10	0.48	4.77
Massachusetts	**31**	20	**0.96**	9	**102**	51	35	86	286	257	0.06	2.3	15.6	1.1	7.1
Michigan	**31**	19	**0.96**	12	**112**	86	50	117	347	330	0.045	2.5	6.6	0.61	9.14
Minnesota	**30**	13	**1**	9	**83**	44	34	89	266	301	0.068	2.5	5.2	0.22	4.31
Mississippi	**29**	41	**0.92**	10	**97**	97	53	144	408	395	0.071	4	6.2	0.29	4.71
Missouri	**31**	16	**0.96**	12	**94**	91	51	115	320	350	0.087	3.1	2.5	0.14	5.56
Montana	**34**	10	**1**	9	**100**	60	42	94	290	269	0.07	3.3	0.5	0.02	3.28
Nebraska	**29**	16	**1**	10	**89**	63	38	97	306	341	0.115	3.6	8.4	0.1	1.19
Nevada	**29**	39	**1**	12	**80**	73	43	108	327	295	0.02	2.1	3.3	0.15	4.7
New Hampshire	**34**	5	**1**	9	**118**	80	38	103	300	296	0.056	2.1	3.9	0.22	5.63
New Jersey	**30**	33	**0.96**	10	**84**	56	37	108	330	257	0.042	2.4	18.8	1.4	7.43
New Mexico	**31**	60	**0.96**	12	**99**	63	34	125	305	323	0.036	1.8	4.4	0.2	4.41
New York	**30**	34	**0.92**	9	**101**	58	38	110	294	276	0.032	2.7	20	1.59	7.95
North Carolina	**29**	32	**0.92**	10	**94**	81	57	125	348	330	0.043	2.1	3.6	0.1	2.76
North Dakota	**28**	12	**1.04**	12	**82**	51	43	94	295	351	0.109	4.3	3.9	0.1	2.5
Ohio	**31**	16	**0.96**	9	**95**	85	50	122	347	340	0.085	2.8	3.4	0.21	6.19
Oklahoma	**29**	25	**0.96**	10	**103**	85	58	125	377	348	0.079	2.8	1.9	0.09	5.08
Oregon	**31**	16	**0.96**	12	**116**	69	50	110	301	299	0.033	1.6	1.2	0.04	3.33
Pennsylvania	**32**	18	**0.96**	9	**100**	71	49	113	326	309	0.056	2.9	6.2	0.49	7.99
Rhode Island	**32**	22	**0.94**	10	**119**	69	39	109	331	277	0.082	2.1	15.4	0.79	5.11
South Carolina	**32**	32	**0.92**	12	**91**	82	49	133	381	343	0.039	2.4	3	0.11	3.76
South Dakota	**30**	15	**1**	9	**79**	46	44	93	308	301	0.127	4.8	6.4	0.08	1.19
Tennessee	**29**	22	**0.92**	10	**98**	106	57	138	387	344	0.048	2.9	4.1	0.07	1.61
Texas	**24**	52	**0.96**	12	**74**	62	38	126	325	348	0.044	2.3	2.7	0.07	2.43
Utah	**21**	17	**1**	9	**93**	42	24	84	245	278	0.032	1.8	4	0.04	1.01
Vermont	**36**	3	**0.96**	10	**120**	62	36	92	304	275	0.06	2.1	1.8	0.09	5.12
Virginia	**29**	28	**0.92**	12	**85**	64	38	105	324	304	0.035	2.1	6.3	0.18	2.89
Washington	**29**	18	**1**	9	**96**	51	38	99	295	287	0.029	1.7	3.3	0.16	4.83
West Virginia	**35**	5	**0.96**	10	**123**	153	83	162	435	395	0.07	3.8	1.2	0.05	3.89
Wisconsin	**31**	14	**0.98**	12	**90**	53	38	87	308	320	0.066	2.1	3.7	0.11	3.07
Wyoming	**31**	13	**1.04**	9	**87**	64	37	88	308	290	0.068	3.5	1.7	0.03	1.77

Note: Color gradation is provided to aid the reader. Red indicates the higher value in the corresponding column, and green indicates a lower value in the corresponding column. Significant independent variables columns are bolded and were calculated relative to the predicators United States national average.

Abbreviations: M:F, male to female ratio; COPD, congestive obstructive pulmonary disease; CVD, cardiovascular disease; DM, diabetes mellitus; HTN, hypertension; BMI, body mass index.

*No Hawaiian or Pacific Islander minority groups reported.

[&]No Hawaiian, Pacific Islander, or Native American minority groups reported.

[^]No Native American minority group reported.

[#]Data from Behavioral Risk Factor Surveillance System.

[$]Data from the Kaiser Family Foundation.

[~]Data from the CDC COVID Tracker.

populations, and unemployment status affect the care patients receive. Structural inequalities such as poverty rates, healthcare racial bias, and increased preexisting conditions impact minority groups differently.

To address some of the limitations in an ecological study design, we further evaluated associations in multiple linear regression. While no single variable was significantly associated with mortality, in combination, our multiple linear regression suggested ~27% of the case fatality rate can be predicted by the comorbidity and hospital system variables discussed in this study. There may be other factors not addressed in this study that may impact the case fatality rate thus stressing the need for additional research.

Data regarding deaths can be confounded when a patient has multiple comorbidities. Additionally, the available data are limited and partially self-reported, leading to less accurate measurement of predictors (i.e., comorbidities). Deaths can be difficult to compare when each state records deaths at different frequencies and older patients were disproportionately affected early during the pandemic, diverting states' initial infectious trajectory (e.g., New York).

Other limitations are the exclusion of Hawaiian and Pacific Islander populations and Native Americans along with the inability to separate risk factors between minority groups.

Conclusion

Despite the initial decline in cases, with reopening, some states may be at higher risk for COVID-19 outbreaks, due in part to older populations and high asthma rates. Preparing at the state level is imperative to combating COVID-19 outbreaks, limiting spread, and guiding resource allocation. A state-specific COVID-19-Readiness Score may help identify the highest risk states for COVID-19 outbreaks, ensure adequate prevention mechanisms, and help direct further resources.

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