1   Population based estimates of comorbidities affecting risk for complications from COVID-19 in

2   the US

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13   Running title: Adults at increased risk of COVID-19 complications

14   Article Summary Line: Overall, 45.4% of US adults were estimated to be at heightened risk of

15   COVID-19 complications due to co-morbidities, increasing from 19.8% for ages 18-29 years to

16   80.7% for ages 80+ years, with state-to-state variation.

17   Biographical Sketch: Mary Adams is currently consulting as On Target Health Data LLC in

18   Suffield, CT but was an epidemiologist and BRFSS Coordinator for Connecticut from 1987 to

19   2003. She has nearly 50 peer-reviewed publications on a wide range of topics, but with a focus

20   on chronic diseases (including dementia) and their risk factors.

21

22   Abstract (144 words)

23   We used 2017 Behavioral Risk Factor Surveillance System (BRFSS) data (N=444,649) to

24   estimate the proportion of US adults who report comorbidities that suggest heightened risk of

25   complications from COVID-19. Co-morbidities included cardiovascular disease, chronic

26   obstructive pulmonary disease (COPD), diabetes, asthma, hypertension, and/or cancer other than

27   skin, based on data from China. Overall 45.4% (95% CI 45.1-45.7) of adults reported any of the

28   6 comorbidities, increasing from 19.8% (19.1-20.4) for ages 18-29 years to 80.7% (79.5-81.8)

29   for ages 80+ years. State rates ranged from 37.3% (36.2-38.5) in Utah to 58.7% (57.0-60.4) in

30   West Virginia. Rates also varied by race/ethnicity, health insurance status, and employment.

31   Excluded were residents of nursing homes or assisted living facilities. Although almost certainly

32   an underestimate of all adults at risk due to these exclusions, these results should help in

33   estimating healthcare needs for adults with COVID-19 complications living in the community.

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37 Introduction

38   Since COVID-19 was discovered in China in late 2019, cases have spread far and wide and

39 are putting a strain on healthcare systems in many countries. Data from China indicate that while

40 81% of patients had mild cases, 14% of cases were severe and 5% were critical. (*1,2*). The

41 overall case fatality rate (CFR) in China for 55,924 confirmed cases was 3.8% (*3*) with

42 increased rates in adults with comorbid conditions including cardiovascular disease (CVD;

43 CFR=13.2%, diabetes (9.2%), chronic respiratory disease (8.0%), hypertension (8.4%), and

44 cancer (7.6%); the case fatality rate for those with none of these comorbid conditions was 1.4%

45 (*3*). Our objective for this study was to use population based US data to estimate the

46 approximate fraction of adults in the community who might be at heightened risk for

47 complications from COVID-19 because they reported one of the 6 chronic conditions with high

48 CFR in China.

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50 Methods

51 We used publicly available 2017 Behavioral Risk Factor Surveillance System (BRFSS) data (*4*)

52 from telephone surveys of 444,649 randomly selected adults ages 18 and older in the 50 states

53 and the District of Columbia (DC). The BRFSS includes only non-institutionalized adults so

54 residents of nursing homes and assisted living facilities are among those not surveyed. We chose

55 to use 2017 data in order to include hypertension which was not addressed in 2018. Data were

56 adjusted for the probability of selection and weighted to be representative of the adult population

57 in each state by age, gender, race/ethnicity, marital status, education, home ownership, and

58 telephone type and included weights and stratum variables needed for analysis. The median

59   response rate for cell phone and land line surveys combined was 47.2%, ranging from 33.9% in

60   California to 61.1% in Utah (*5*). In addition to residents of nursing homes or assisted living

61   facilities, persons unable to respond to a telephone survey are also excluded during the random

62   selection process within a household. Reliability and validity of the BRFSS have been found to

63   be moderate to high for many survey measures, in particular those used here which can be

64   checked versus medical records (*6*).

65

66   Measures

67   The key variable was a composite measure including adults reporting they were ever told

68   they had cardiovascular disease (CVD: a heart attack, angina, coronary heart disease, or a

69   stroke), diabetes, current asthma (included as a chronic respiratory disease (*2*)), chronic

70   obstructive pulmonary disease (COPD), hypertension, and/ or cancer other than skin. The

71   number of comorbid conditions was counted for each respondent and the proportion of all adults

72   who reported at least one of the comorbid conditions was considered to represent adults at

73   heightened risk of complications from COVID-19. A secondary measure was receipt of a

74   seasonal influenza vaccination in the past year as a rough estimate of potential demand for a

75   COVID-19 vaccine when available.

76   Demographic measures included age group (18-29, 30-39, 40-49, 50-59, 60-69, 70-79, and

77   80+ years, which was created by combining 5 year age groups provided in the data set), self-

78   reported race/ethnicity (non-Hispanic white, Black or African American, Hispanic of any race,

79   American Indian/Alaska native, Asian/Pacific Islander, and other), health insurance coverage

80   (any kind of health care coverage, including health insurance, prepaid plans such as HMOs, or

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81 government plans such as Medicare, or Indian Health Service), employment status (employed or

82 self-employed, out of work, homemaker, student, retired, or unable to work), and state of

83 residence which included the District of Columbia.

84 Analysis

85 Stata version 14.1 (Stata Corp LP, College Station, TX) was used for data analysis to

86 account for the complex sample design of the BRFSS.   Point estimates and 95% confidence

87 intervals are reported using the landline and cell phone weights, plus stratum and PSU variables

88 supplied in the data set (*4*). Missing values were excluded from analysis. A total of 11,508

89 records from the original survey sample of 444,649 were excluded due to missing data for any of

90 the 6 chronic conditions, leaving a total N of 433,141. An additional 5,694 records were

91 excluded due to missing values for age resulting in a final N for data including age groups of

92 427,447.

93 We also used available case fatality rates from China (*3*) to estimate the fraction of adults

94 in that country with any of the 6 comorbid conditions. We used the formula below and different

95 estimates of the CFR for adults with at least one of the comorbid conditions, ranging from 7.6% -

96 13.2%, including 9.28% which was the average, and 8.4% which is the rate for hypertension, the

97 most prevalent comorbid condition (*3*); 1.4% was the CFR for those with none of the 6 and 3.8%

98 was the overall CFR.

99 Formula: $(CFR * X) + (1.4 * (1 - X)) = 3.8$ where CFR = rate of risk group and X= % in that risk

100 group.

101

102   Results

103   Among all 444,649 survey respondents, 48.7% were male, 13.9% were ages 70+, 63.3%

104   were white, 18.2% were retired, and 12.1% were uninsured, with similar results for the study

105   sample with 11,508 records with missing values removed. Overall 45.4% (95% CI 45.1-45.7) of

106   respondents reported one or more of the 6 comorbidities and were considered at heightened risk

107   for complications from COVID-19. Among all adults, 26.7% (26.5-27.0) reported 1 co-

108   morbidity, 12.0% (11.8-12.2) reported 2, 4.7% (4.6-4.8%) reported 3 and 2.0% (1,9-2.1) reported

109   4 or more. Prevalence rates of the separate comorbidities were 8.5% for CVD, 6.6% for COPD,

110   9.1% for asthma, 10.8% for diabetes, 32.4% for hypertension, and 6.8% for cancer. Rates of

111   reporting one or more of the comorbid conditions increased from 19.8% (19.1-20.4) for ages 18-

112   29 years to 80.7% (79.5-81.8) for ages 80+ years (Table 1.) While the percentage of adults with

113   any of the comorbidities increased with age, over half (53.4%) of the total were ages 18-59 years

114   because there are more adults in that age range compared with those 60 and older (71.3% vs.

115   28.7% respectively). State rates ranged from 37.3% (36.2-38.5) in Utah to 58.7% (57.0-60.4) in

116   West Virginia. Rates also varied by self-reported race/ethnicity, health insurance status, and

117   employment, but not by gender (Table 1).

118   State results presented in Table 2 list the number of adults in each state at increased risk of

119   complications and the percentage that number represents among all US adults who report at least

120   one of the co-morbidities. These results were obtained directly from Stata which takes into

121   account the complex sample design so will not agree with results obtained by simply dividing the

122   state population estimate in the Table by 111.9 million. Results for reporting a seasonal flu

123   vaccination in the past year were 40.3% (40.0-40.6) among all adults, including 33.7% (33.3-

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124   34.2) for adults with none of the comorbidities and 48.0% (47.5-48.5) among those with any of

125   the six.

126   Using the data from China (3) we estimated that between 20.3% and 38.7% of Chinese

127   adults had any of the 6 comorbid conditions with the percentage most likely between 30.5% and

128   34.2%.

129   Discussion

130   We found that 45.4% of US adults, with a wide range across age groups and states, may be

131   at heightened risk of complications from COVID-19 due to existing comorbid conditions. And

132   while the rates increase with age group to about 80% among those ages 70 and older, due to the

133   fact that the majority (71%) of US adults is younger than age 60, 53% of those at heightened risk

134   of complications are also younger than age 60 years. That is consistent with the finding that

135   >60% of adults with multiple (2 or more) chronic conditions were younger than age 65 (7).

136   Many of these younger adults with comorbid conditions may require hospitalization for these

137   complications. Results in Tables 1 and 2 may be helpful to localities planning healthcare system

138   needs for COVID-19. The median value of having any of the co-morbidities for all states is

139   45.3, for planning purposes, states with rates in Table 1 that are above 45.3 might require

140   proportionally more ICU beds and ventilators than those with rates below 45.3.

141   Currently there is a dearth of data on adults at risk for complications from COVID-19 that

142   can be used for comparison. One source is a recent report from the Kaiser Foundation (8) that

143   found 41% of US adults at risk of serious illness from COVID-19, defined as all adults ages 60

144   and older and those 18-59 years with heart disease, cancer, COPD, or diabetes. Note that

145   hypertension, which is the most common comorbid condition, was omitted in that study (8).

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146   From our own estimates of the fraction of adults in China with any of the 6 comorbid conditions,

147   we estimated that fraction as likely between 30.5% and 34% of all adults based on the average

148   case fatality rate or that of the most prevalent condition, and within the range of 20.3-38.7%.

149   From these few comparisons, it appears that the percentage of US adults with comorbid

150   conditions increasing their risk of complications from COVID-19 is even higher than that in

151   China. The implications for the US, if this is true, are disturbing but would be consistent with

152   obesity rates in China being lower than in the US (*9*). In a recent US study that included all these

153   comorbid conditions except cancer, obesity was a major contributor to diabetes, hypertension,

154   and asthma and at least an indirect contributor to CVD (*10*). Other risk factors also contribute to

155   these comorbid conditions (*11*) and will have different prevalence rates in different countries and

156   population groups within countries.

157   The list of chronic conditions used in our analysis is very similar to groups at increased risk

158   for seasonal influenza complications (*12*) except that latter group includes obese adults and

159   children <2 years and excludes people with hypertension. Both lists include people with chronic

160   diseases for which behavioral risk factors have been well identified (*10,11*). Behavioral risk

161   factors appear to be very common among US adults with >95% of all adults reporting one or

162   more (*10*) of the 7 CVD risk factors of smoking, sedentary lifestyle, obesity, diabetes,

163   hypertension, high cholesterol, and inadequate fruit and vegetable consumption. Results from

164   that study (*10*) found those 7 risk factors together contributed to an average of 41.4% of the

165   burden of 5 of the 6 comorbidities (all except cancer) used in this current study, with obesity and

166   smoking contributing the most.

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168   Results showing seasonal flu vaccination rates below 50%, even for those with any of the 6

169   chronic conditions that increase risk of complication from COVID-19, are concerning. Although

170   a vaccine specific for this coronavirus is currently unavailable, results for seasonal flu

171   vaccination suggest that it may not be widely used. It is encouraging that those with any of the 6

172   co-morbidities appear more likely to be vaccinated for seasonal influenza than those with none.

173   Limitations

174   Our study does not address possible differences in contracting the disease, only the risk of

175   developing complications among those with COVID-19, based on results from China (*1-3*). Only

176   non-institutionalized adults are surveyed so 1.3 million adults in nursing homes (*13*) were

177   excluded which almost certainly underestimates risk, as the first death in the US from COVID-

178   19 was a nursing home resident (*14*). Data are self-reported and reliability and validity can vary

179   for different measures tested (*6*). But as long as a respondent was told they had a chronic

180   condition, validity was high. Low response rates could introduce bias but, as noted, validity

181   appears high for the measures used in this study. Results are specific for this coronavirus in the

182   US.

183   Conclusion: These results indicating 45.4% of adults are at potentially heightened risk of

184   complications from COVID-19 due to chronic conditions should help state health officials in

185   estimating health care needs. The US may never determine an accurate case fatality rate but it

186   appears likely that it would be greater than the 3.8% reported for China. It should also be clear

187   that while adults ages 70 and older are at higher risk it is because they are more likely to have the

188   chronic conditions identified as increasing risk but that the majority of adults at risk are actually

189   younger than age 70.

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Table 1. Demographics of adults with any of 6 chronic conditions [*]

increasing risk for COVID-19 complications; 2017 Behavioral Risk

Factor Surveillance System

Population Group	Percent	95% CI	Sample Size
Total	45.4	45.1-45.7	433,141
Gender			
Males	45.4	44.9-45.9	191,193
Females	45.4	45.0-45.9	241,695
Age (years)			
18-29	19.8	19.1-20.4	46,660
30-39	26.8	26.0-27.5	49,475
40-49	38.1	37.3-39.0	53,609
50-59	55.1	54.3-55.9	79,550
60-69	68.0	67.3-68.6	96,663
70-79	79.5	78.7-80.2	67,733
80+	80.7	79.5-81.8	33,757
Race/ethnicity			
White (non-Hispanic)	48.0	47.7-48.4	329,193
Black	52.1	51.1-53.1	35,087
Hispanic	35.5	34.5-36.5	31,624
American Indian/Alaska Native	55.5	52.9-58.1	8,082
Asian/Pacific Islander	27.8	25.9-29.7	10,117
Other	46.5	44.5-48.4	10,854
Employment			
Employed/self-employed	35.4	35.0-35.8	217,975
Out of work	47.0	45.5-48.5	18,644
Homemaker	39.6	38.2-41.0	22,790
Student	18.1	16.9-19.4	11,634
Retired	75.7	75.1-76.3	128,162
Unable to work	79.3	78.3-80.3	30,510
Insurance status			

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Insured	47.1	46.8-47.5	397,495
Uninsured	33.4	32.4-34.4	34,052
State			
AL	54.2	52.6-55.9	6,565
AK	43.6	40.7-46.5	3,124
AZ	44.6	43.6-45.6	15,086
AR	53.3	50.7-55.8	5,126
CA	41.0	39.6-42.4	9,149
CO	40.0	38.8-41.2	9,486
CT	45.0	43.7-46.3	10,298
DE	48.7	46.5-50.9	4,015
DC	38.3	36.4-40.1	4,400
FL	46.9	45.4-48.5	21,442
GA	45.6	44.0-47.2	5,895
HI	44.0	42.5-45.5	7,645
ID	42.6	40.7-44.5	4,791
IL	44.9	43.3-46.6	5,498
IN	48.7	47.5-49.8	13,489
IA	44.9	43.6-46.2	7,553
KS	45.9	45.1-46.8	21,233
KY	53.2	51.5-55.0	8,391
LA	51.6	49.7-53.5	4,680
ME	49.9	48.3-51.5	9,513
MD	44.9	43.5-46.2	13,179
MA	43.4	41.5-45.4	6,670
MI	49.4	48.2-50.6	10,584
MN	38.8	37.9-39.7	16,714
MS	51.9	49.8-54.0	4,937
MO	46.2	44.6-47.8	7,394
MT	44.0	42.3-45.8	5,793
NE	43.4	42.2-44.6	15,039
NV	46.1	43.7-48.5	3,683
NH	45.9	44.0-47.8	5,605
NJ	45.6	44.0-47.1	11,399

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NM	45.3	43.5-47.0	6,376
NY	42.2	41.0-43.4	11,951
NC	47.5	45.6-49.3	4,800
ND	42.0	40.5-43.6	6,862
OH	48.3	46.9-49.6	11,975
OK	50.7	49.0-52.3	6,369
OR	44.7	43.1-46.3	5,186
PA	47.8	46.2-49.5	6,405
RI	47.8	45.9-49.8	5,444
SC	49.9	48.6-51.3	10,953
SD	43.3	41.2-45.5	6,844
TN	51.1	49.3-53.0	5,679
TX	43.7	41.8-45.5	11,941
UT	37.3	36.2-38.5	9,994
VT	45.8	44.1-47.5	6,346
VA	45.2	43.8-46.6	9,394
WA	44.0	42.9-45.1	12,822
WV	58.7	57.0-60.4	5,332
WI	43.9	42.1-45.7	5,716
WY	44.0	42.2-45.9	4,376

[*] Cardiovascular disease, diabetes, chronic obstructive pulmonary disease, asthma, hypertension, and/or cancer other than skin.

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244 Table 2. Number of adults with any of 6 chronic conditions* increasing risk for COVID-19

245 complications and the percentage of the total in each state; 2017 Behavioral Risk Factor

246 Surveillance System.

State	# Adults at risk	% of total
AL	1,997,864	1.78
AK	237,208	0.21
AZ	2,351,799	2.1
AR	1,181,105	1.06
CA	12,240,142	10.93
CO	1,701,776	1.52
CT	1,239,597	1.11
DE	357,530	0.32
DC	213,357	0.19
FL	7,696,749	6.88
GA	3,541,358	3.16
HI	486,156	0.43
ID	534,533	0.48
IL	4,404,556	3.93
IN	2,428,188	2.17
IA	1,067,133	0.95
KS	983,323	0.88
KY	1,789,444	1.6
LA	1,806,330	1.61

ME	530,809	0.47
MD	2,054,758	1.84
MA	2,302,809	2.06
MI	3,749,235	3.35
MN	1,625,778	1.45
MS	1,150,036	1.03
MO	2,137,650	1.91
MT	356,113	0.32
NE	616,905	0.55
NV	1,048,591	0.94
NH	485,340	0.43
NJ	3,106,880	2.78
NM	701,585	0.63
NY	6,419,321	5.73
NC	3,713,582	3.32
ND	243,096	0.22
OH	4,268,748	3.81
OK	1,461,941	1.31
OR	1,418,689	1.27
PA	4,738,414	4.23
RI	393,069	0.35
SC	1,912,134	1.71
SD	281,110	0.25
TN	2,610,800	2.33

TX	8,977,387	8.02
UT	796,721	0.71
VT	226,397	0.2
VA	2,921,171	2.61
WA	2,464,452	2.2
WV	827,193	0.74
WI	1,949,872	1.74
WY	194,544	0.17
Total	111,943,278	100

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248   * Cardiovascular disease, diabetes, chronic obstructive pulmonary disease,

249   asthma, hypertension, and/or cancer other than skin.