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LONG-TERM CARE FACILITIES AS A RISK FACTOR FOR DEATH DUE TO COVID-19:EVIDENCE FROM EUROPEAN COUNTRIES AND U.S. STATES

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Abstract

A large percentage of the deaths from COVID-19 occur among residents of long-term care facilities. There are two possible reasons for this phenomenon. First, the structural features of such settings may lead to death. Alternatively, it is possible that individuals in these facilities are in poorer health than those living elsewhere, and that these individuals would have died even if they had not been in these facilities. Our findings show that, controlling for the population density and the percentage of older adults in the population, there is a significant positive association between the number of long-term care beds per capita and COVID-19 mortality rates. This finding provides support for the claim that long-term care living arrangements (of older people) are a significant risk factor for dying from COVID-19.

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Long-Term Care Facilities as a Risk Factor for Death Due to COVID-19: Evidence from European Countries and U.S. States

Neil Gandal, Matan Yonas, Michal Feldman, Ady Pauzner, and Avraham Tabbach[1]

July 2, 2020

Abstract

A large percentage of the deaths from COVID-19 occur among residents of long-term care facilities. There are two possible reasons for this phenomenon. First, the structural features of such settings may lead to death. Alternatively, individuals living in these facilities are in poorer health than those living elsewhere, and they would have died even if they had not been in these facilities.

Using both European and U.S. data, our findings show that, controlling for the percentage of older adults in the population, the number of hospital beds per capita, and the population density there is a significant positive association between the number of long-term care beds (LTCB) per capita and COVID-19 mortality rates, where COVID-19 mortality rates are for the whole country or state, not just the older population. This finding provides support for the claim that long-term care living arrangements (of older people) are a significant risk factor for dying from COVID-19.

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1. Introduction

A large percentage of the deaths worldwide from COVID-19 have occurred among residents of long-term care institutions.[2] *Euronews* reported that deaths due to COVID-19 among such long-term care residents could account for more than 50% of all COVID-19 deaths in Europe.[3] According to an article in *The Guardian*, data from the Kaiser Family Foundation indicates that COVID-19 deaths among long-term care residents account for more than 50% of all deaths attributed to COVID-19 in fourteen states in the United States. Additionally, the same article notes that in the state of New Hampshire, 72% of COVID-19 deaths occurred among those living in long-term care settings.[4] Overall, according to the *New York Times*,[5] more than one third of the deaths in the United States from COVID-19 have occurred among long-term care residents. The U.S. Center for Disease Control and Prevention (CDC) has formally stated that generally, people 65 years and older, and in particular "People who live in a nursing home or long-term care facility" are at high-risk for severe illness from COVID-19.[6]

There are two possible explanations for the higher COVID-19 mortality rates in long-term care facilities:

1. The structural features of such settings, such as a communal living area, multiple residents in a room, care provided by multiple caregivers to multiple care recipients, etc., can lead to a greater number of deaths.
2. Individuals living in these facilities are in poorer health than those living outside of such facilities and they would have been likely to die even if they had not been living in these facilities.

These two explanations have different policy implications.

This paper examines the two competing explanations by studying the association between long-term care beds per capita in a country and COVID-19 deaths per capita. Using (I) country-level data from Europe and (II) state-level data from the United States,[7] and controlling for the percentage of older adults in the population, the number of hospital beds per capita, and the population density, we find that there is a significant positive association between the number of long-term-care beds per capita[8] and total COVID-19 mortality rates in European countries

[2] See Comas-Herrera et. al. (2020).
[3] https://www.euronews.com/2020/04/17/coronavirus-care-homes-could-be-where-over-half-of-europe-s-covid-19COVID-19-deaths-occur-says-new. See also the report by Comas-Herrera et. al., 2020.
[4] https://www.theguardian.com/us-news/2020/may/11/nursing-homes-us-data-coronavirus
[5] https://www.nytimes.com/2020/05/12/business/nursing-homes-coronavirus.html
[6] https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/groups-at-higher-risk.html
[7] All data sources can be found in the Appendix.
[8] We do not have data on how many people aged seventy-five and older are living in long-term care settings. Therefore, we use long-term care beds per capita as a proxy for older persons living in long-

and US states.[9] This finding supports the thesis that living in long-term care facilities presents a significant mortality risk factor for older people contracting COVID-19. The fact that the results regarding the association between long-term care beds per capita and death rates per capita are qualitatively similar across European Countries and U.S. States suggests that they are robust.

Our results also provide a partial, preliminary explanation as to why the death rates from COVID-19 differ so widely among (I) European Countries and (II) U.S. states. In fact, we show that LTCB per capita explains an additional 44% of the variation in variation in death rates among European countries and an additional 42 percent of the variation among U.S. States![10]

1.1 Related Literature

Ciminelli and Garcia-Mandicó (2020a) examine the effectiveness of different lockdown policies in Italy using death registry data. They find that shutting down non-essential services reduced COVID-19 mortality, while closing factories did not. In another study, Sá (2020) uses data on infections and mortality for small regions in England and Wales to study the association between socioeconomic factors and COVID-19. They find that areas with large households and areas with greater use of public transport have higher infection rates. They stress the importance of reducing the risk of infection on public transportation. Ciminelli and Garcia-Mandicó (2020b) show that within the area of the epidemic epicenter in Italy, the COVID-19 mortality rate was up to 50% higher in municipalities far from an intensive care unit (ICU), a sign that congestion of the emergency care system may have prevented critical patients from being treated on time. Bayer and Kuhn (2020) attribute the differences in COVID-19 fatality rates to intergenerational interactions. They argue that countries with more intergenerational interactions (where the young live with the old) have higher case fatality rates. None of these papers examines how LTCB per capita are associated with COVID-19 mortality.

term care facilities. Since such facilities are typically "full to capacity," we believe is an excellent proxy for the number of people living in such setting.

[9] The death rates are for the country or the state as a whole, not just the older population. We run the analysis separately because the European and U.S. definitions of long-term care beds are different.

[10] We show the calculations when we report the results.

2. Analysis Using European Countries and U.S. States

This research seeks to examine the factors that are associated with deaths per capita from COVID-19, and, in particular, long-term care beds per capita. Before we write down and estimate an econometric model, we examine the raw data.

2.1 Data for European Countries

The data employed in the study are[11]

- Deaths_cap = deaths from COVID-19 per million residents[12]
- LTCB_cap = number of long-term care beds per million residents[13]
- Per_75 = the percentage of the population aged 75 and older
- Pop_den = the population density: residents per square kilometer.
- Hosp_cap = Hospital Beds per million residents
- Mobility - Our mobility index was calculated by taking the average of the following "Google mobility" indices (I) "Residential", (II) "Workplace", (III) "Transit", and (IV) "Retail & Recreation". We use mobility data in the robustness analysis.

We included all European countries for which we have data on long-term beds per capita. We have data on thirty-two of the thirty-six European countries with more than 600,000 residents.[14] Figure 1a shows a scatter plot of deaths per capita in relation to long-term care beds per capita for these countries. The figure shows that there is a large difference in the number of long-term care beds per capita. The figure also suggests that there is a positive association between Long-term care beds per capita and COVID-19 Deaths per capita.

[11] See Appendix A for the data sources for all variables.
[12] We wanted to use data after the "first wave." Hence, for Europe we use data from mid-May and from the U.S, we use data from mid-June.
[13] The U.S. definition is of LTCB in the U.S. is as follows: nursing facility residents in certified nursing facilities surveyed in the U.S. The European Health Information Gateway, which is the source for the European data, defines for long-term care beds as "beds available for people requiring long-term care in institutions (other than hospitals.) See the sources in Appendix A. Although the quality of the settings, and their structures may differ, the facilities included are consistent and well-defined in both the U.S. and Europe.
[14] Two small island countries, Iceland and Malta, were excluded from the analysis. We also excluded Russia and Turkey since these countries are primarily in Asia. Our results are qualitatively unchanged if we include Russia and Turkey.

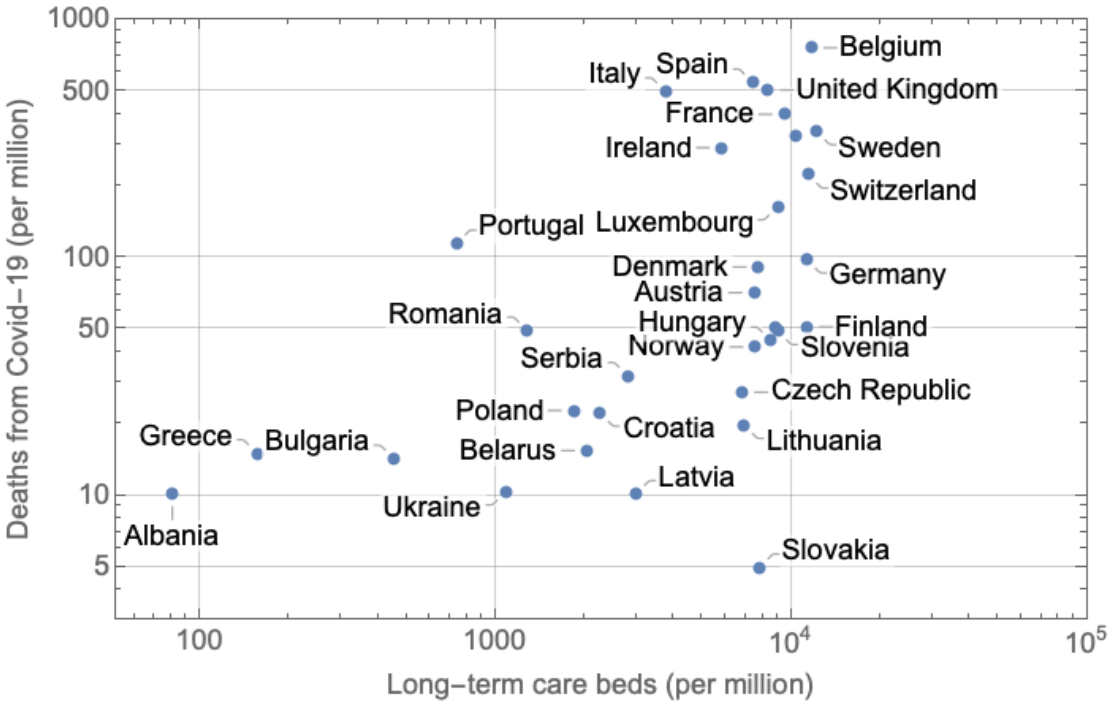

Figure 1a: COVID-19 Deaths per capita versus LTCB per capita: 32 Countries: logarithmic scale.

Descriptive Statistics for European Countries are shown in Table 1a.

Table 1a: Descriptive Statistics (N=32)

Variable	Mean	Std. Error	Minimum	Maximum
Deaths per capita	153.3	197.9	5.0	760.0
LTCB per capita	6,196.3	3,945.5	80.7	12,140.0
Per_75	0.088	0.017	0.06	0.12
Population Density	123.7	96.6	14.5	412.5
Hospital Beds per capita	5,896.8	1,968.4	2,200.0	11,200.0
Mobility*	118.4	32.6	34.5	183.5

* 31 Countries (excluding Albania)

In Table 2a below we report the correlations among the logarithms of the variables.[15] Long-term beds per capita is positively correlated with COVID-19 deaths per capita (0. 53.) Deaths per capita is positively correlated with the percentage of the population aged 75 and over (correlation 0.32,) with the population density (correlation 0.43,) and with Mobility (0.46.)

[15] As we discuss below, the log/log model where the variables appear in logarithms is our preferred model. Hence, in the table, we show the correlation of the variables in logarithms. In Appendix B, we show the correlations in levels of the variables.

Observe that deaths per capita is negatively correlated with hospital beds per capita (correlation -0.40.) There is virtually no correlation between LTCB and the other independent variables!

Table 2a: Correlations among the natural logarithm of the Variables (32 European Countries)

	Deaths per cap	LTCB per cap	Per_75	Population Density	Hosp Beds per cap
Deaths per capita	1.00				
LTCB per capita	0.53	1.00			
Per_75	0.32	0.16	1.00		
Population Density	0.43	0.09	-0.05	1.00	
Hospital Beds per capita	-0.40	0.13	-0.14	-0.01	1.00
Mobility*	0.46	0.04	0.15	0.46	-0.30

* 31 Countries (excluding Albania)

2.2 Data for US States

We use the same variables for U.S. States (plus Washington D.C.)[16] as we did for Europe. Figure 1b shows a scatter plot of deaths per capita in relation to long-term care beds per capita for U.S. States. It shows that there is a large difference in the number of long-term care beds per capita state by state. It also suggests that there is a positive association between Long-term care beds per capita and COVID-19 Deaths per capita for US states.

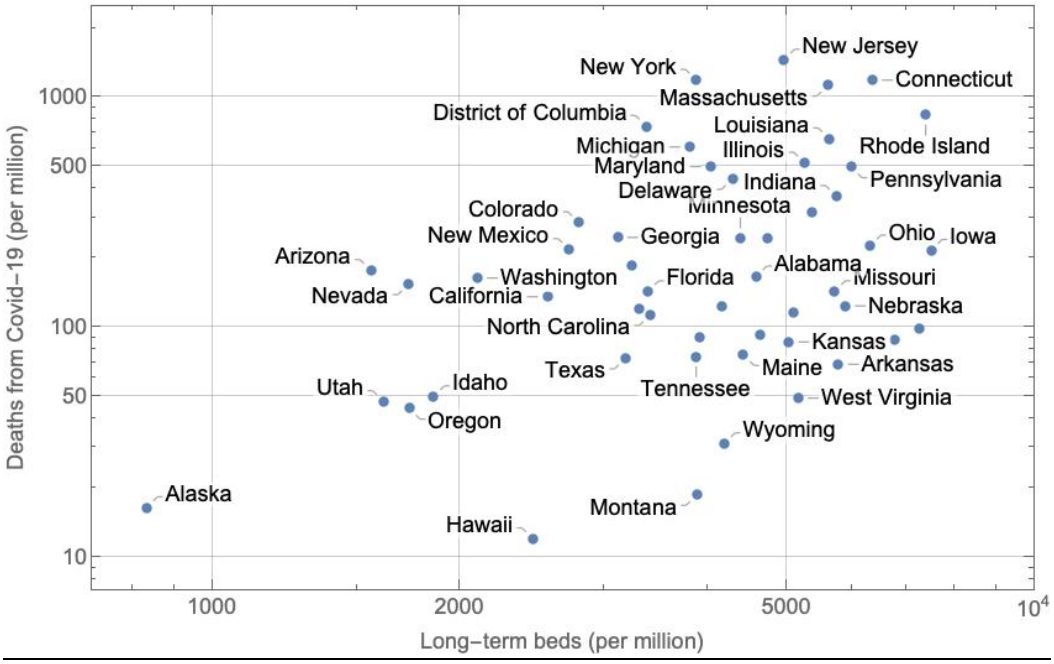

Figure 1b: COVID-19 Deaths per capita versus LTCB per capita: US States + DC: logarithmic scale.

[16] The results are unchanged if we exclude Washington D.C. from the analysis.

Descriptive Statistics for US States are shown in Table 1b.

Table 1b: Descriptive Statistics (N=51)

Variable	Mean	Std. Error	Minimum	Maximum
Deaths per capita	293.9	339.9	12.0	1,448.9
LTCB per capita	4,246.3	1,629.9	831.1	7,492.1
Per_75	0.070	0.01	0.04	0.09
Population Density	3,646.5	5,565.4	14.6	37,144.7
Hospital Beds per capita	2,431.1	646.5	1,459.8	4,484.2
Mobility	82.3	22.7	37.4	159.9

In Table 2b below, we report the correlations among the logarithms of the variables. Like the European data, long-term beds per capita is positively correlated with COVID-19 deaths per capita (0. 43.) Deaths per capita are positively correlated with the percentage of the population aged 75 and over (correlation 0.13,) with the population density (correlation 0.54,) and with Mobility (0.52.) Observe that deaths per capita is virtually uncorrelated with hospital beds per capita (correlation -0.09.)

Table 2b: Correlations among the Natural Logarithms of the Variables (50 US States + DC, N=51)

	Deaths per cap	LTCB per cap	Per_75	Population Density	Hosp Beds per cap
Deaths per capita	1.00				
LTCB per capita	0.43	1.00			
Per_75	0.13	0.52	1.00		
Population Density	0.54	0.22	0.25	1.00	
Hospital Beds per capita	-0.09	0.61	0.21	-0.22	1.00
Mobility	0.52	-0.19	-0.01	0.49	-0.54

We now turn to the Econometric Analysis.

3 Econometric Model

The first structural equation has COVID-19 Deaths per capita (Deaths_cap) on the left-hand side. On the right side we include long-term care beds per capita (LTCB_capita,) the percentage of the population aged 75 and older (Per_75), and hospital beds per capita (Hosp_cap,) all of

which are exogenous.[17] We also include COVID-19 cases per capita (Cases_cap) in the equation. The first equation is thus

1. $\text{Deaths\_cap} = \beta_0 + \beta_1 * \text{LTCB\_cap} + \beta_2 * \text{Per\_75} + \beta_3 * \text{Hosp\_cap} + \beta_4 * \text{Cases\_cap} + \varepsilon,$

where ε is the error term.

Cases per capita is endogenous and likely depends on the two exogenous variables in Equation 1, as well as on population density (pop_den), which is also exogenous, and on tests performed for COVID-19 per capita (Tests_cap,) which itself may be endogenous. The second structural equation is thus

2. $\text{Cases\_cap} = \alpha_0 + \alpha_1 * \text{LTCB\_cap} + \alpha_2 * \text{Per\_75} + \alpha_3 * \text{pop\_den} + \alpha_4 * \text{Tests\_cap} + \xi,$

where ξ is the error term.

Tests per capita depends on exogenous variables like institutional features of the country, and government policy, which we can reasonably assume are uncorrelated with the other exogenous variables and can be viewed as part of the error term. But tests per capita is also likely a function of Cases per capita, that is, more cases lead to more tests. Thus, the third structural equation is

3. $\text{Tests\_cap} = \gamma_0 + \gamma_1 * \text{Cases\_cap} + \mu,$

where μ is the error term.

We are interested in the association between long-term care beds per capita (LTCB_cap) and deaths per capita (deaths_cap.) Since the number of long-term care beds per million residents is exogenous, we can solve for the reduced form of the above three-equation structural model. We can then estimate the relevant "reduced form" equation with Deaths per capita as the left-hand side variable:[18]

4. $\text{Deaths\_cap} = \varphi_0 + \varphi_1 * \text{LTCB\_cap} + \varphi_2 * \text{Per\_75} + \varphi_3 * \text{pop\_den} + \varphi_4 * \text{hosp\_cap} + \omega$

[17] We would have liked to include the percent of the population with two or more preexisting conditions in the older people in the population as an explanatory variable, but we do not have data on this variable. It seems reasonable to assume that this variable is uncorrelated with the exogenous variables used in our analysis.

[18] There are also reduced form regressions for Cases per capita and Tests per capita as a function of the same exogenous variables in equation 4. But we are interested in the association between long-term care beds per capita and death per capita.

Hence, we can estimate equation (4) using ordinary least squares, and the estimates will be unbiased.

From Figures 1a and 1b, it appears that the variance of the dependent variable increases with the number of long-term care beds. Hence, we use robust standard errors, which is the way to address heteroscedasticity.

3.1 Analysis and Results: 32 European Countries

In Column 1 of Table 3a, we estimate a linear model using equation (4.) In this case, we find that the estimated coefficients on long-term beds per capita and population density are positive and statistically significant at the 95 percent level of confidence. The estimated coefficient on the percent of the population 75 and older is positive, but not statistically significant. The coefficient on Hospital Beds per capita is negative and statistically significant at the 95 percent level of confidence.

In column 2 of Table 3a, we estimate (4) using a log/log model. The regression uses the natural logarithm of deaths per million residents from COVID-19 as the dependent variable and the natural logarithm of LTCB per capita, the natural logarithm of population density, the natural logarithm of the percent of the population 75 and older, and the natural logarithm of hospital beds per capita as explanatory variables.

Similar to the specification in Column 1 of Table 3a, the results in column 2 show that the estimated coefficients for both long-term beds per capita and population density are positive and both are statistically significant, in this case at the 99 percent level of confidence. The coefficient on the percent of the population seventy-five years and over is positive, but not statistically significant, while the coefficient on hospital beds per capita is negative and statistically significant at the 99 percent level of confidence. Thus the results are qualitatively similar to those using the linear model in Column 1 of the table.

The table also shows that the four factors in the log/log model explain 68 percent of the variation in the death rate for European countries (versus 54 percent for the linear model.) This is a very high percentage for such a small number of factors. Hence, we believe that the fit of this model is quite good. While both the linear model and the log/log model provide qualitatively similar results, the log/log model is our preferred specification since it provides a much better fit.

To get a sense of how much of the variation in deaths rate LTCB per capita alone explains, we make the following calculation. When we run the log/log model in Column 2 of Table 3a without LTCB per capita, i.e., we include the other three factors, the model explains 43 percent of the variation in the death rates among countries. By adding LTCB per capita, the model explains 68 percent of the variation in the death rates in the death rates among countries. Thus, LTCB per capital explains an additional 44 percent of the variation in death rates![19]

Robustness Analysis

GDP per capita might lead to more deaths if wealthier countries find it more difficult to social distance due to economic activity, which in turn might lead to more infections and deaths. The ideal way to address this is to include a variable on "mobility" in the regression. Our mobility index was calculated by taking the average of the following "Google mobility" indices (I) "Residential", (II) "Workplace", (III) "Transit", and (IV) "Retail & Recreation".

LTCB per capita could be a function of wealth, such that wealthier countries will have more beds. If this were driving our results this would imply that GDP per capita is positively correlated with deaths per capita. While, it seems clear that increases in GDP per capita will not directly lead to an increase in the death rate, our story suggests that it is not wealth itself but the behavior of wealthier countries (specifically in terms of their treatment of older people) that drives our outcomes.

Nevertheless, we added GDP per capita as well as Mobility to the regression and report the results in column 3 of table 3a.[20] We find that our results are again qualitatively unchanged. In particular, the estimated coefficient on LTCB beds per capita is positive and statistically significant at the 97 percent level of confidence. The estimated coefficients on mobility and GDP per capita are positive, but not statistically significant.

Thus, even after controlling for GDP per capita, and mobility, as well as the other factors, LTCB per capita is positively associated with death per capita and the effect is statistically significant.[21]

[19] The calculation is (68-43)/57=0.44, where 57 percent is the amount of unexplained variation without LTCB per capita in the regression.

[20] We do not have data for Albania so there are 31 observations in the regression in column 4. The correlation between mobility and LTCB is virtually zero (0.03.) Other indices of mobility give similar results.

[21] Additional health (risk) factors that are associated with mortality from COVID-19 (like diabetes and obesity) explain virtually none of the variation in the death rates from COVID-19 among European countries – and their estimated coefficients are not significantly different from zero. Adding them to the

Table 3a: Estimates from Equation (4): 32 European Countries[22]

	Linear Model (1)	Log/Log (2)	Log/Log (3)
LTCB_capita	**0.012** (0.0055)**	**0.58***(0.086)**	**0.40**(0.17)**
Per_75	1716.0 (1543.6)	1.36 (1.12)	1.18 (1.20)
Pop_den	0.97** (0.37)	0.67***(0.11)	0.57***(0.17)
Hosp_cap	-0.030** (0.014)	-1.76***(0.33)	-1.50***(0.42)
GDP_cap			0.55 (0.40)
Mobility			0.39 (0.81)
R^2	0.54	0.68	0.70
N	32	32	31

3.2 Results: 50 US States and Washington D.C.

We now turn to the results using the data on U.S. States. In Column 1 of Table 3b, we estimate a linear model using equation (4.) In this case, we find that the estimated coefficients on long-term care beds per capita and population density are positive and statistically significant at the 99 percent level of confidence. The estimated coefficient on the percent of the population 75 and older is negative, but not statistically significant. The coefficient on Hospital Beds per capita is negative and statistically significant at the 99 percent level of confidence.

In column 2 of Table 3b, we estimate (4) using a log/log model. Similar to the specification in Column 1 of Table 3a, the results in column 2 show that the estimated coefficients for both long-term beds per capita and population density are positive and both are statistically significant, again at the 99 percent level of confidence. The coefficient on the percent of the population seventy-five years and over is negative, but not significant, while the coefficient on hospital beds per capita is negative and statistically significant at the 99 percent level of confidence. Thus the results are qualitatively similar to those using the linear model in Column 1 of the table.

The table also shows that the four factors in the log/log model explain 50 percent of the variation in the death rate for U.S. States (versus 39 percent for the linear model.) While both the linear

regression does not affect the estimated coefficient on LTC Beds. We do not include these regressions in the paper, but they are available from the authors upon request.

[22] ROBUST Standard Errors in parentheses: ***= significant at 99% level, **= significant at the 95% level, and *= significant at the 90% level.

model and the log/log model provide qualitatively similar results, as in the case of Europe, the log/log model is our preferred specification since it provides a much better fit.

Similar to our analysis of the European countries, we calculate how much of the variation in the death rate can be attributed to LTCB per capita. When we run the log/log model in Column 2 of Table 3b without LTCB per capita, i.e., we include just the other three factors, they explain 29 percent of the variation in the death rates among US states. By adding LTCB per capita, the model explains 50 percent of the death rates among US states. Thus, LTCB explains an additional 42 percent of the variation in death rates among U.S. States![23]

Robustness Analysis

We again include GDP per capita (for each State) and Mobility in the log/log regression, third Column in Table 3b. We find that our results are again qualitatively unchanged regarding the association between LTCB per capita and deaths from COVID-19 per capita. In particular, the estimated coefficient on LTCB beds per capita is again positive and statistically significant at the 99 percent level of confidence.

The coefficient on GDP per capita is negative, but not statistically significant. Interestingly, in the case of the U.S., the coefficient on mobility is positive and statistically significant. Because mobility is both correlated with deaths and population density, population density is no longer significantly associated with death per capita.

But, of course, our main research question involves the association between LTCB per capita and overall deaths per capita. In the case of the U.S. States, like the European countries, we find that even after controlling for GDP per capita, and mobility, as well as the other factors, LTCB per capita is positively associated with death per capita and the effect is statistically significant.[24] Hence, we are confident that our results are robust.

[23] The calculation is (50-29)/50=0.50, where the 50 percent in the denominator is the amount of unexplained variation without LTCB per capita in the regression.

[24] Again, additional health (risk) that are associated with mortality from COVID-19 (like diabetes and obesity) explain virtually none of the variation in the death rates from COVID-19 among U.S. States – and their estimated coefficients are not significantly different from zero. Adding them to the regression does not affect the estimated coefficient on LTC Beds. We do not include these regressions in the paper, but they are available from the authors upon request.

Table 3b: Estimates from Equation (4): US States and Washington D.C.

	Linear Model (1)	Log/Log (2)	Log/Log (3)
LTCB_capita	**0.13*** (0.035)**	**1.71***(0.52)**	**1.73***(0.54)**
Per_75	-1588.50 (3056.1)	-1.82 (1.17)	-2.28 (1.37)
Pop_den	0.023*** (0.0052)	0.31***(0.12)	0.16(0.10)
Hosp_cap	-0.25*** (0.068)	-1.72***(0.61)	-0.50(0.68)
GDP_cap			-0.64 (0.52)
Mobility			1.91*** (0.43)
R^2	0.39	0.50	0.64
N	51	51	52

4. Discussion and Further Work

Controlling for the proportion of adults "aged 75 and older," the population density, and hospital beds per capita, the number of long-term care beds per capita is positive and statistically significant in explaining the differences in the total COVID-19 deaths per capita for European countries and for US States. This suggests that the structural features of such settings are associated with death from COVID-19. In European countries and U.S. States with more long-term care beds per capita, the death rate from COVID-19 is higher. These findings raise policy implications. In particular, efforts should be geared to protecting older adults living in long-term care settings. Policy makers might even consider alternative dwelling options during the epidemic period, such as encouraging residents to live with their families whenever possible. It appears that additional regional and county data concerning long-term care facilities may be available in the next few months, allowing us to continue and improve our analysis.[25]

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[25] In Appendix C, we examine regional data for the one European country for which we have data at the regional level: Italy.

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Appendix A:

Data Sources

Description	Source	Notes
European Long-term care beds	https://gateway.euro.who.int/en/indicators/hfa_491-5101-number-of-nursing-and-elderly-home-beds/visualizations/#id=19556&tab=table	DK 2011, BE and NL 2012, DE and ES 2013, IE, LU and UK 2014, the rest 2015
European COVID-19 deaths	https://www.worldometers.info/coronavirus/	Data as of May 13, 2020
European Demographic statistics	https://www.cia.gov/library/publications/the-world-factbook/docs/rankorderguide.html	Year2020 (Est.)
Italy regional long-term care beds	http://dati-anziani.istat.it/index.aspx?lang=en&SubSessionId=83aaf6dc-879c-457e-abe0-ce4781c6f43a	Data as of 2016
Portugal long-term care beds	Lopes, H., Mateus, C, Hernández-Quevedo, C. (2018)[26]	Data as of 2016
Italy regional COVID-19 statistics	https://statistichecoronavirus.it/regioni-coronavirus-italia/toscana/	Data as of May15, 2020
European Population density by Country	https://covid.ourworldindata.org/data/owid-covid-data	Year 2020 (Est.)
European population 75 and older by Country	https://population.un.org/wpp/Download/Standard/Population	Year 2020 (Est.)
European Hospital Beds by Country	https://data.oecd.org/healthcqt/hospital-beds.htm https://datarepository.wolframcloud.com/resources/OECD-Data-Hospital-Beds-Per-Country	2016, as reported by the Wolfram Data Repository
U.S.A population 75 and older	https://www.census.gov/data/tables/time-series/demo/popest/2010s-counties-detail.html	Year 2019 (Est.)
U.S.A hospital beds	https://www.kff.org/health-costs/issue-brief/state-data-and-policy-actions-to-address-coronavirus/?utm_source=web&utm_medium=trending&utm_campaign=covid-19	Data as of 2018
U.S.A Long-term care beds	https://www.kff.org/other/state-indicator/number-of-nursing-facility-residents/[27]	Data as of 2017
US COVID-19 deaths & population density	https://github.com/CSSEGISandData/COVID-19	As of June 18
Mobility data	https://www.google.com/covid19/mobility/	Data through May 9, 2020 Data through June 18

[26] Ten Years after the Creation of the Portuguese National Network for Long-Term Care in 2006: Achievements and Challenges. Health Policy.
[27] Kaiser Family Foundation analysis of Certification and Survey Provider Enhanced Reports data

Appendix B:

Correlation of the Variables in Levels (European Countries, N=32)[28]

	Deaths per cap	LTCB per cap	Per_75	Population Density	Hosp Beds per cap
Deaths per capita	1.00				
LTCB per capita	0.45	1.00			
Per_75	0.24	0.17	1.00		
Population Density	0.60	0.38	0.03	1.00	
Hospital Beds per capita	-0.39	-0.04	-0.15	-0.13	1.00
Mobility	0.55	0.03	0.19	0.35	-0.42

Correlation of the Variables in Levels (US States + DC, N=51)

	Deaths per cap	LTCB per cap	Per_75	Population Density	Hosp Beds per cap
Deaths per capita	1.00				
LTCB per capita	0.31	1.00			
Per_75	0.10	0.41	1.00		
Population Density	0.38	-0.02	-0.09	1.00	
Hospital Beds per capita	-0.12	0.60	0.17	0.57	1.00
Mobility	0.61	-0.23	-0.01	0.03	-0.49

[28] We do not have data on mobility from Albania. Hence, correlations with mobility are for 31 European countries

Appendix C: Italian Regional Data

For research purposes, having data on long-term care beds per capita for regions within a country, and not just for the country as a whole, is ideal, as there is more similarity in other (unobserved) aspects within a country than among countries. The one European country that did have such regional data available was Italy. This information also existed for us to break down the data for Italy into the smaller sub-regions, which we denote as "counties." The correlation of deaths per capita and long-term care beds per capita is 0.70 when all counties are included. Since the northern part of Italy had many more deaths per capita, the correlation between COVID-19 deaths and living in long-term care facilities was again calculated excluding the northern counties. The result of 0.74 was very close to that of the country as a whole. This suggests that even when excluding the northern regions of Italy from consideration, there is strong positive relationship between mortality rates per capita and long-term care beds per capita. See Figure 2, which shows the data for Italian counties.

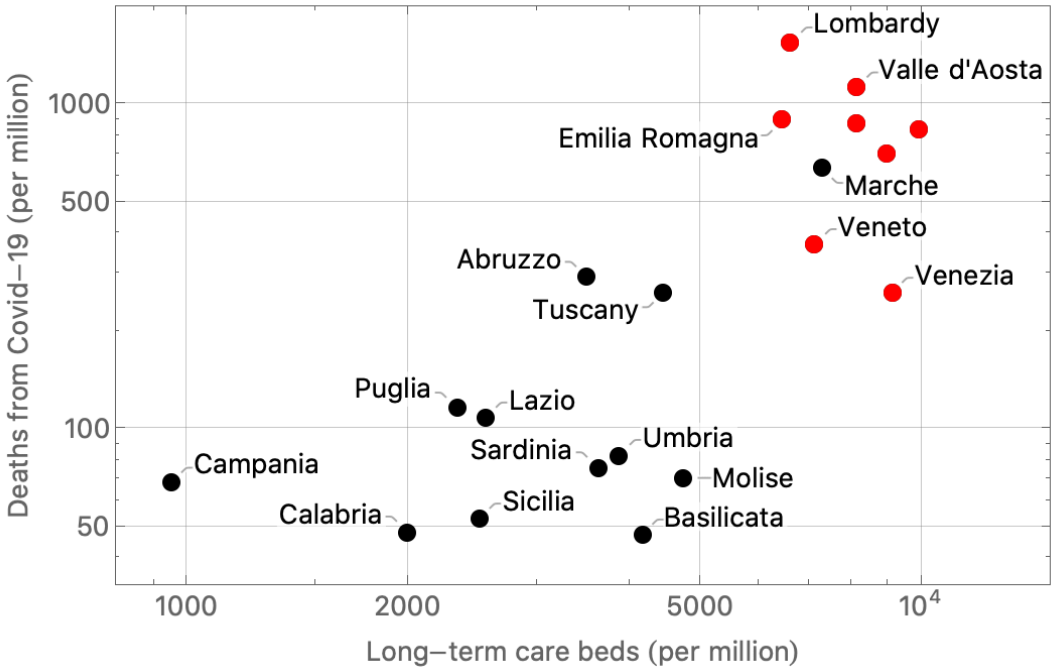

Figure 2: COVID-19 Deaths per capita in relation to long-term care beds per capita, Italian counties, northern counties in "red" (logarithmic scale.)