Long-Term Care Facilities as a Risk Factor for Death Due to COVID-19

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

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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.

[1] Neil Gandal, Tel Aviv University, School of Economics, and CEPR (gandal@tauex.tau.ac.il)
Matan Yonas, Tel Aviv University, School of Economics, (matany@mail.tau.ac.il)
Michael Feldman, Tel Aviv University, School of Computer Science, (michal.feldman@cs.tau.ac.il)
Ady Pauzner, Tel Aviv University, School of Economics, (pauzner@tauex.tau.ac.il)
Avraham Tabbach, Tel Aviv University, Law Faculty, (adtabbac@tauex.tau.ac.il)
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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 in these facilities are in poorer health than those outside of such facilities and they would have been likely to die even had they had not been in these facilities.

Each of these has 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 country-level data from Europe,[7] and controlling for the percentage of older adults in the population 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 COVID-19 mortality rates in European

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[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-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.

countries. This finding supports the thesis that living in long-term care facilities presents a significant mortality risk factor for older people contracting COVID-19.

Our results also provide a partial, preliminary explanation as to why the death rates from COVID-19 differ so widely among the European Countries. This issue needs to be explored in more depth once there is more detailed data available, including additional countries, regional level data, and more. Therefore, there is a need for future research on this question.

2. Analysis Using 33 European Countries

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.

Data

The data employed in the study are

- Deaths_cap = deaths from COVID-19 per million residents through mid-May 2020
- LTCB_cap = number of long-term care beds per million residents[9]
- Per_75 = the percentage of the population aged 75 and older[10]
- Pop_den = the population density: residents per square kilometer.

We included all European countries for which we have data on long-term beds per capita. We have data on thirty-three of the thirty-seven European countries with more than 600,000 residents.[11] Figure 1 shows a graph of deaths per capita in relation to long-term care beds per capita for these countries.[12] The figure shows that there is a large difference in the number of

[9] The European Health Information Gateway, which is part of the European Regional Office of the World Health Organization is the source for the data used in this study and for the definition of long-term care beds. Their definition for long-term care beds is “beds available for people requiring long-term care in institutions (other than hospitals.) The predominant service component is long-term care and the services are provided for people with moderate to severe functional restrictions.” The quote is from the European Health Information Gateway, https://gateway.euro.who.int/en/indicators/hfa_491-5101-number-of-nursing-and-elderly-home-beds/, which served as the data source for all countries except Portugal for this study. Data from Portugal is from Lopez el. al, 2028. Most of the data on beds from our data source is from 2015, the most recent year available. See the Appendix for details. See the source for the detailed explanation. Although the quality of the settings, and their structures may differ, the nature of the facilities included is well-defined by the agency.

[10] All of the results hold if we use “65 and older” or “70 and older” instead of “75 and older.” The “fit” of the regressions is best when we employ “75 and older.” Hence, we use this variable.

[11] Two small island countries, Iceland and Malta, were excluded from the analysis.

[12] While not all the country names not appear in Figure 2, all thirty-three observations are

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.

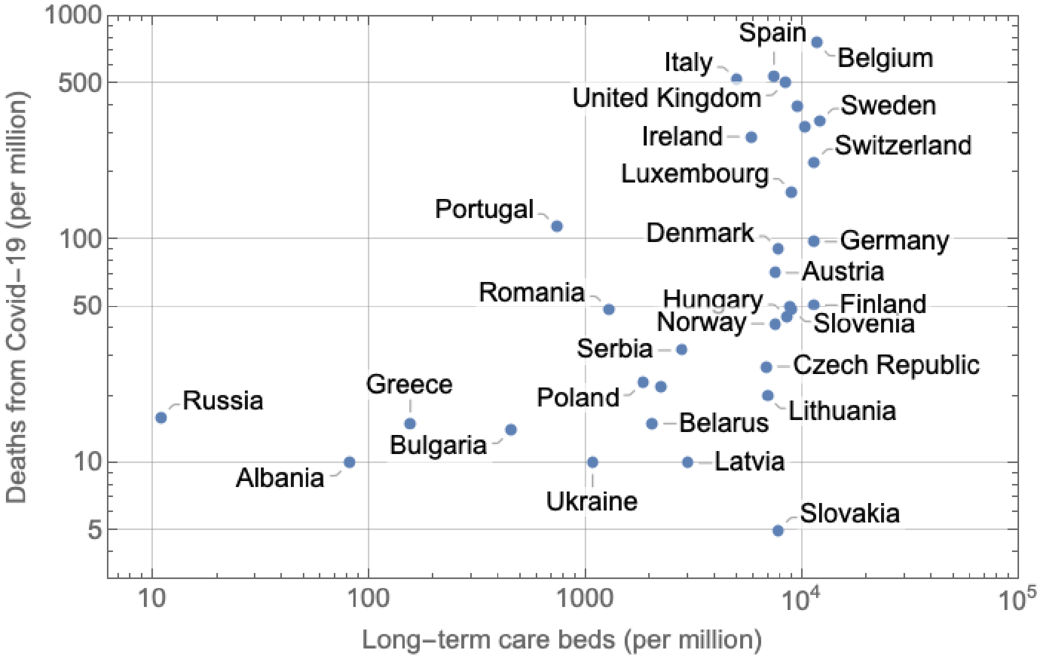

Figure 1: COVID-19 Deaths per capita in relation to long-term care beds per capita: 33 countries: logarithmic scale.

Descriptive Statistics are shown in Table 1.

Table 1: Descriptive Statistics (N=33, All European Countries for which there are data)

Variable	Mean	Std. Error	Minimum	Maximum
Deaths per capita	149.1	196.3	5.0	760.0
Beds per capita	6,008.9	4,029.9	11.2	12,140.0
Per_75	0.088	0.017	0.06	0.12
Population Density	120.2	97.2	8.4	412.5

In Table 2 below, we show the correlations among the above variables for the thirty-three European countries which are shown in Figure 1. The Table shows that long-term beds per capita is positively correlated with COVID-19 deaths per capita (0.46.) The table also shows that deaths per capita are positively correlated with the percentage of the population aged 75 and over (correlation 0.27) and with the population density (correlation 0.61).

Included in the figure.

Table 2: Correlations among the Variables for 33 European Countries

	Deaths/capita	Beds/capita	75+/capita
Deaths per capita	1.00		
Beds per capita	0.46	1.00	
Per_75	0.27	0.23	1.00
Population Density	0.61	0.41	0.07

We now turn to the Econometric Analysis.

Econometric Analysis

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,) and the percentage of the population aged 75 and older (Per_75), both of which are exogenous.[13] We also include COVID-19 cases per capita (Cases_cap) in the equation. The first equation is thus

1. $Deaths\_cap = \beta_0 + \beta_1 * LTCB\_cap + \beta_2 * Per\_75 + \beta_3 * Cases\_cap + \varepsilon$,
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. $Cases\_cap = \alpha_0 + \alpha_1 * LTCB\_cap + \alpha_2 * Per\_75 + \alpha_3 * pop\_den + \alpha_4 * Tests\_cap + \xi$,
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

[13] 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.

3. Tests_cap = $\gamma_0 + \gamma_1$*Cases_cap + μ, 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:[14]

4. Deaths_cap = $\varphi_0 + \varphi_1$*LTCB_cap+ φ_2*Per_75 + φ_3*pop_den + ω

Hence, we can estimate equation (4) using ordinary squares, and the estimates will be unbiased.[15]

From Figure 1, it appears that the variance of the dependent variable increases with the number of long-term care beds, which is indicative of heteroscedasticity. When we estimate (4) with a linear model, we indeed find, using the Breusch-Pagan test, that constant variance of the noise factor is rejected in favor of heteroscedasticity.[16] The estimates for the linear model are shown in column one in Table 3. But these estimates have biased standard errors and hence, this specification is not appropriate.

There are two common solutions in the case of heteroskedasticy. One alternative is to use a multiplicative heteroskedastic linear regression (MHLR) by modeling the variance as an exponential function of the specified variables using maximum likelihood estimation. A second solution is to use a functional form with all of the variables in natural logarithms, i.e., a log/log specification. We employ both options.

In column two Table 3, we estimate (4) using a multiplicative heteroskedastic linear regression (MHLR) by modeling the variance as an exponential function of long-term care

[14] 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.

[15] If tests per capita was completely exogenous, we could also estimate equation (1) via Instrumental Variables estimation, with Tests per capita as an instrument for Cases per capita, but this is not likely the case.

[16] The Breusch-Pagan test rejects constant variance of the noise factor if the Chi-squared statistic is large. In our case, the first column of Table 3 shows that with the linear model, the Chi-squared statistic equals 9.16 and the p-value equals 0.003. Hence, constant variance is rejected at the 99 percent level in favor of heteroscedasticity.

beds per capita using maximum likelihood estimation.[17] In this case, we find that the estimated coefficients for both long-term beds per capita and population density are positive and statistically significant. The estimated coefficient on long-term beds per capita is statistically significant at the 95 percent level of confidence, while the estimated coefficient on population density is statistically significant at the 99 percent level of confidence. The coefficient on the percent of the population seventy-five years and above is positive, but not statistically significant.

In column three of Table 3, 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 beds per capita, natural logarithm of population density per capita, and the natural logarithm of the percent of the population 75 and older as explanatory variables. In this case, the Breusch-Pagan hypothesis of constant variance of the noise term cannot be rejected. Consequently, this specification, is also appropriate.

Similar to the specification in column 2 of Table 3, the results in column three show that the estimated coefficients for both long-term beds per capita and population density are positive. They are also both statistically significant at the 95 percent level of confidence. The coefficient on the percent of the population seventy-five years and above again is positive, but not statistically significant.[18]

The coefficient of the natural logarithm of beds per capita is an elasticity. Thus, the 0.29 coefficient from the third regression in Table 3 means that a one percent increase in the number of beds per capita is associated with a 0.29 percent increase in deaths per capita.

In summary, controlling for the population density and the proportion of adults aged 75 and older, long-term care beds per capita is positive and statistically significant at the 95% level of confidence in explaining the differences in the deaths per capita in Europe using either the

[17] The Likelihood Ratio test indicates that heteroscedasticity is present and that there is heteroscedasticity only for LTCB per capita.

[18] Part of Russia is in Asia. Russia has far fewer beds per capita than any other country in the data and it also has a very low density per capita. If we drop Russia from the analysis, the results are stronger. For example, without Russia, the estimated coefficients for both long-term beds per capita and population density are both statistically significant at the 99 percent level of confidence in the third regression in Table 3. Further, the estimated coefficient on "the percent of the population over 75" is statistically significant as well at the 90% level in the third regression in Table 3. Additionally, the adjusted R squared is higher in that regression.

MHLR or the Log/Log model. Thus our preliminary results suggest that long-term care beds per capita emerges as a risk factor for death from COVID-19.

Table 3: Estimates from Equation (4)[19]

	Linear Model	MHLR Model	Log/Log Model
Beds_capita	0.010 (0.0075)	0.012** (0.0064)	0.29** (0.14)
Per_75	1980.55 (1601.81)	1251.48 (922.66)	1.45 (1.03)
Pop_den	1.02*** (0.30)	1.05*** (0.32)	0.49** (0.24)
Breusch-Pagan Test	Chi2=7.62**		Chi2=1.20
R squared adj.	0.39		0.29
N = observations	33	33	33

3. The Regions in Italy

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 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.[20]

[19] Standard Errors in parentheses: ***= significant at 99% level, **= significant at the 95% level, and *= significant at the 90% level.
[20] The small number of regions without the northern counties (N=12) is, of course, insufficient to perform regressions.

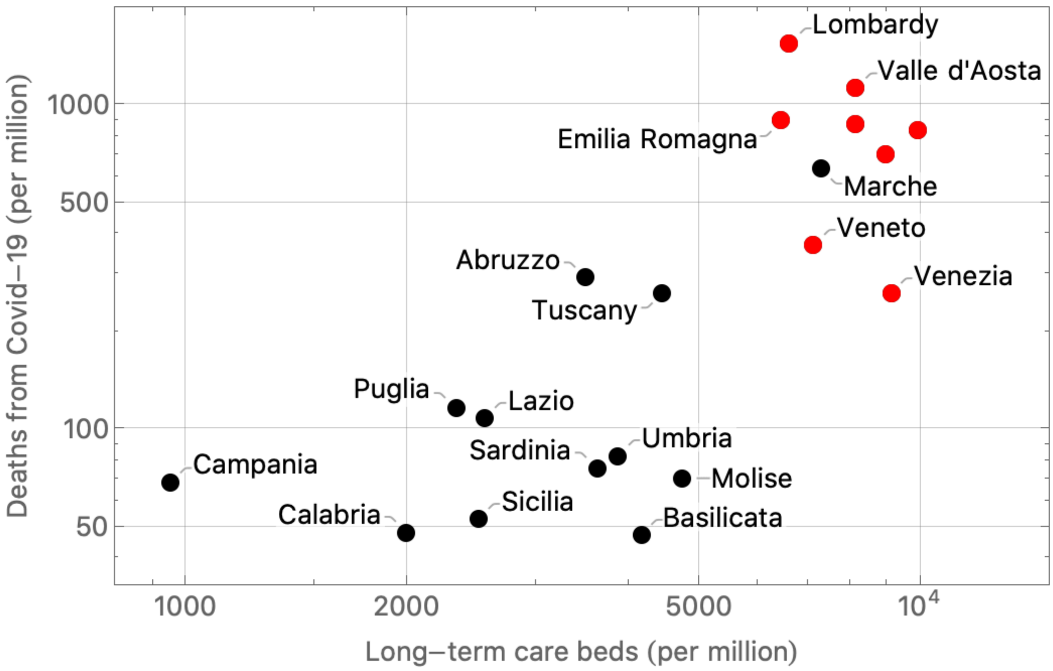

Figure 2: COVID-19 Deaths per capita in relation to long-term care beds per capita, Italian counties, northern counties in "red" (logarithmic scale.)

4. Discussion and Further Work

Controlling for the proportion of adults "aged 75 and older," and the population density, the number of long-term care beds per capita is positive and statistically significant in explaining the differences in the deaths per capita for countries in Europe. This suggests that the structural features of such settings are associated with death from COVID-19. In European countries with fewer (respectively, more) long-term care beds per capita, the death rate from COVID-19 is lower (respectively, higher.) These findings are, of course, very preliminary, but they nonetheless 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 and more detailed data concerning long-term care facilities may be available in the next few months, allowing us to continue and improve our analysis.

References

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Appendix A:

Data Sources

Description	Source	Comment
Long-term care beds by country	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
Coronavirus death statistics by country	https://www.worldometers.info/coronavirus/	Data as of May 13, 2020
Demography statistics by countries	https://www.cia.gov/library/publications/the-world-factbook/docs/rankorderguide.html	Year2020 (Est.)
Mobility data	https://www.google.com/covid19/mobility/	Data as of May 9, 2020
Age Groups	https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS	2019 Revision
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): Table 2: Ten Years after the Creation of the Portuguese National Network for Long-Term Care in 2006: Achievements and Challenges. Health Policy.	Data as of 2016
Italy regional Coronavirus statistics	https://statistichecoronavirus.it/regioni-coronavirus-italia/toscana/	Data as of May15, 2020
Countries density	https://covid.ourworldindata.org/data/owid-covid-data	Year 2020 (Est.)
Age group distribution (75+)	https://population.un.org/wpp/Download/Standard/Population/	Year 2020 (Est.)