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Intergenerational coresidence and the Covid-19 pandemic in the United States[☆]

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ABSTRACT

This paper investigates the relation between intergenerational coresidence and mortality from Covid-19 in 2020. Using a cross-section of U.S. counties, we show that this association is positive, sizeable, significant, and robust to the inclusion of several demographic and socio-economic controls. Furthermore, using evidence from past, pre-pandemic years, we argue that this positive, sizeable and significant association is somewhat specific to the Covid-19 pandemic.

1. Introduction

This research enquires into the impact of intergenerational coresidence on the mortality from Covid-19.

A specific aspect of Covid-19, which is common across countries worldwide, is the fact that it is particularly deadly for older persons (Verity et al., 2020). For instance, as of February 10th 2021, persons aged 65 or more accounted for 81% of the overall number of deaths from Covid-19 in the United States (Centers for Disease Control and Prevention, 2021c).

Contagion and mortality, however, are diffused unevenly across and within countries. This geographical variability may hinge on several factors like the healthcare system and policies, the age structure of the population and its density, culture, institutions and the like. A key institutional element that might differ significantly across and within countries is the family structure, whose impact on socio-economics outcomes has recently been the object of a copious literature in economics (Baudin et al., 2021; Browning et al., 2014; Doepke and Tertilt, 2016; Greenwood et al., 2017, among others). In this article, we argue that one aspect of the family structure, namely intergenerational coresidence – defined as families in which at least one elderly lives with at least one adult son/daughter – is relevant for the diffusion of, and the mortality from Covid-19.

The rationale behind our claim lies in the hypothesis that when coresiding with their adult children, the elderly are more exposed to unprotected social contacts. This happens for two reasons. First, it is reasonable to assume that young adults in the working force typically have more social contacts outside the family than the elderly (Harris, 2020; Malmgren et al., 2020). This implies that coresiding elderly might have more indirect social contacts – i.e. social contacts through their family members – than non-coresiding ones. Second, since preventive measures like masks and social distance are typically not implemented in the household (Lei et al., 2020; Li et al., 2020), those indirect social contacts will be unprotected.[1] All this suggests that intergenerational coresidence might foster contagion for the elderly. Since the fatality rate of Covid-19 is disproportionately huge for the

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[1] Intergenerational coresidence represents only one of the possible interactions between the elderly and their adult children. As underlined in the main text, a feature of intergenerational coresidence is that living in the same household makes the consistent use of preventive measures unrealistic. Another feature is that it is reasonably stable with respect to the evolution of the pandemic, while other forms of interactions (e.g. picking up grandchildren at school) may change as the pandemic unfolds.

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elderly, we expect intergenerational coresidence to be associated with higher mortality, in particular for the elderly.[2]

Using the available Census sample of 426 U.S. counties that represent 65% of the total American population in 2019, we show that intergenerational coresidence positively correlates with mortality for the elderly from Covid-19 in 2020. Quantitatively, a one percentage point increase in intergenerational coresidence is associated with more than 25 additional deaths from Covid-19 per 100,000 old persons, or, in absolute terms, 14,109 old individuals.

This association is robust to controlling for several confounders, such as population density, wealth and human capital, the number of hospital beds and residents in nursing homes, the unemployment rate, the percentage of votes for Trump in 2016, the percentage of Hispanics and Blacks, and geographical dummies. The association persists when tested on cumulative quarterly data. Furthermore, we tested that our results hold good for alternative definitions of intergenerational coresidence and alternative measurements of mortality from Covid-19.

In order to assess if the positive correlation with intergenerational coresidence is specific to mortality from the Covid-19 pandemic, we perform several other exercises. To start with, we show that intergenerational coresidence does not have a positive, sizeable and significant impact on the overall mortality rate in previous, non-pandemic years. We do so in two settings. First, in a cross-section analysis for 2019, that is more directly comparable to our benchmark. Second, in a balanced-panel of yearly data for 329 U.S. counties from 2005 to 2019 that represents 56% of the American population in 2019.[3]

Next, we turn to cause-specific mortality rates, using both the 2019 cross-section and the same panel of counties for the period 2005–2019. We show that there is no sizeable and significant positive association between intergenerational coresidence and mortality from cardiovascular diseases and cancer, largely the most important causes of mortality in the United States.[4] This points to the singularity of the Covid-19 positive mortality-intergenerational coresidence association. Interestingly, we find instead some evidence of a positive relationship between intergenerational coresidence and mortality rates due to pneumonia and influenza, two diseases that are similar to Covid-19 in terms of transmission and epidemiology.[5]

Our paper is closely related to the brand new literature on Covid-19 and intergenerational coresidence. The socio-economic determinants of intergenerational coresidence have been discussed by Costa (1997), Ruggles (2007) and, more recently, Kaplan (2012), Pensieroso and Sommacal (2014, 2019), Salcedo et al. (2012), among others. Bayer and Kuhn (2020) were the first to explore the possibility that intergenerational coresidence could be positively related to deaths from Covid-19. They use a sample of 24 countries (Australia plus some European and Asian countries) and show that intergenerational coresidence helps to explain cross-country differences in the case fatality rate of Covid-19. Aparicio Fenoll and Grossbard (2020) expand on their study by using a larger sample represented by 79 geographical units (E.U. countries and U.S. states). They show that there is a positive association between the fraction of young adults living with their parents and the cumulative number of deaths from Covid-19. In their analysis, this association is arguably stronger and more significant when the E.U. countries are excluded from the sample and the analysis is restricted to the U.S. states only. That intergenerational coresidence does not seem to be an important determinant of case fatality rates in the European Union is maintained also by Arpino et al. (2020).[6] On the contrary, in a mostly descriptive study, Mogi and Spijker (2021) analyse cross-country variation in the E.U. cumulative deaths between March and April 2020 and find that it is positively associated with social and/or cultural ties, including intergenerational coresidence, the average household size and the proportion of people having frequent social contacts.

Cross-country comparisons suffer from several known problems, going from how mortality and contagion are measured, to idiosyncratic differences like policy, culture, institutions and the like, to the trivial but significant complication represented by the reduced size of the sample. A first contribution of our paper is to overcome these problems by focusing on a more disaggregated geographical unit, the county, belonging to a single country, the United States. This way we reduce the heterogeneity of confounding factors that may pollute cross-country analysis, and avoid the small sample bias that makes results from a cross-state analysis in the United States less compelling.[7] A similar approach was followed by Desmet and Wacziarg (2022), who study the determinants of spatial variation in Covid-19 across U.S. counties. They find that contagion and mortality from Covid-19 correlates with several variables, including, in particular, measures of what they call 'effective' population density. Our work complements their analysis, for we focus on the intergenerational dimension of the household, and, as explained here below, we provide some element for an identification, based on historical comparisons. Furthermore, by using yearly data, focusing on mortality for both the elderly and the overall population, and using excess mortality among our robustness checks, we overcome several of the potential measurement issues in the previous literature as highlighted by Dowd et al. (2020).

A second contribution of this paper is to use past, pre-pandemic years to show that the positive correlation between mortality and intergenerational coresidence is somewhat specific to the Covid-19 pandemic. Although we do not fully venture into causal inference, we interpret this as a kind of placebo test suggesting that the positive correlation we find is not a statistical artefact.

The outburst of Covid-19 has determined a renewal of interest for the economics of pandemics. As stressed by Hauck (2018), the transmission of infectious diseases crucially depends on social interactions, which in turn depend on human behaviour. The economists' take on pandemics is that contrary to what is typically done in epidemiological models, human behaviour cannot be assumed as a given, for it is actually influenced by the presence and evolution of the infectious disease itself. Hence the need for an integration of epidemiological models (which explain the evolution of the contagion given human behaviour) and economic models (which show how the contagion and the

[2] Notice that our reasoning abstracts from another type of intergenerational coresidence, that between parents and small or school-age children. The transmission of Covid-19 from children to adults is still an unsettled issue (see Forbes et al., 2021, Wood et al., 2021).

[3] In Appendix B we also extend the analysis, with similar results, to a balanced-panel of decennial data for 240 U.S. counties for the period 1980–2010 that represents 48% of the American population in 2010.

[4] See Centers for Disease Control and Prevention (2021b).

[5] As additional exercise, in Appendix B, we investigate the relationship between intergenerational coresidence and mortality in the case of the 1918 Spanish influenza. This was an episode of pandemic due to a virus that transmitted via aerosols and salivary droplets like Covid-19, but which, contrary to Covid-19, was particularly deadly for prime-age persons, not the elderly (Beach et al., 2020; Garrett, 2008; Taubenberger and Morens, 2006). Accordingly, we surmise that in this case intergenerational coresidence is of lesser relevance to the morbidity of the virus, and hence its mortality, since most social contacts of prime-age adults typically happen outside the family circle. Using a sample of 422 U.S. cities that represent two-thirds of American urban population in 1910 from Clay et al. (2019), we find no evidence of a sizeable and significant positive association between intergenerational coresidence and either the excess mortality due to the Spanish influenza in 1918.

[6] Dowd et al. (2020) notice that Arpino et al. (2020) investigate the link between coresidence and mortality from Covid-19 using case fatality rates: the latter, however, is a measure of the lethality of the infection and may therefore not capture appropriately mortality. The same argument applies to Bayer and Kuhn (2020).

[7] In the same spirit, using a sample of 300 communities making up the Los Angeles county, Harris (2021) finds that the transmission of Covid-19 is higher in multigenerational families.

different policies aimed at its mitigation influence social interactions). Examples of such integrated models include Adda (2016), Brotherhood et al. (2020), Burzyński et al. (2021), Eichenbaum et al. (2020), Favero et al. (2020) and the papers in the special 2021 issue on the economics of epidemics in the *Journal of Mathematical Economics* surveyed by Boucekkine et al. (2021). Although we do not contribute explicitly to this literature, our work suggests that successful integrated models should take the family structure into account.

Understanding the interplay between family structure and a pandemic episode might have significant policy implications. For instance, our work is relevant in the debate brought about by the *Great Barrington Declaration* in October 2020 on the "focused protection" of the elderly. In the light of our results, age-targeted lockdowns, as proposed for instance by Favero et al. (2020) to mitigate the economic impact of the Covid-19 pandemic, might be more or less effective depending on the degree of intergenerational coresidence.

On the whole, our work suggests that the explicit consideration of family structure might result in more accurate economic and epidemiological models of pandemics, thereby contributing to better inform policy decisions.

The paper is organized as follows. In Section 2, we provide a theoretical discussion of the link between intergenerational coresidence and mortality, explaining the specificity of Covid-19. In Section 3, we present our empirical analysis on Covid-19. In Section 4, we discuss the relationship between intergenerational coresidence and all-causes and cause-specific mortality in past, pre-pandemic years. Finally, in Section 5, we discuss the robustness of our results to different definitions of intergenerational coresidence and alternative measures of mortality from Covid-19. Section 6 concludes.

2. A simple model of intergenerational coresidence and mortality

In this Section, we rationalize in a reduced-form model the impact of intergenerational coresidence on mortality from a viral disease that transmits through aerosols and saliva droplets. The model is intended as a roadmap to interpret and qualify our cross-section analysis on Covid-19.[8]

The probability of contagion, π, is a function of three elements: the age of the agent, $\iota = y, o$, where y stands for young, and o for old; the intergenerational coresidence status, κ, where $\kappa = h$ (for 'household') when there is coresidence, and $\kappa = a$ (for 'alone') when the young and the old live apart; and the contacts outside home, c. Hence,

$$\pi^{\iota,\kappa} = \begin{cases} f(c^{\iota}) & \text{for } \kappa = a \\ f(c^{\iota}, c^{-\iota}) & \text{for } \kappa = h \end{cases} \tag{1}$$

We assume that π is increasing in both arguments. The idea behind $c^{-\iota}$ is that through coresidence, external contacts are indirectly shared among members of the household.

It is reasonable to assume that $c^{y} > c^{o}$, i.e. the number of external contacts of the young is superior with respect to the number of external contacts of the old, due to a more intense social life (working, leisurely activities ...). Hence, for the young (old) the number of indirect contacts brought by coresidence with the old (young) represents a marginal (important) increase with respect to their overall number of external contacts.

Accordingly, we shall have

$$\pi^{o,h} > \pi^{o,a}, \tag{2}$$

$$\pi^{y,h} \cong \pi^{y,a}. \tag{3}$$

Thus, coresidence increases the probability of contagion for the old, but not for the young.

[8] Since this empirical analysis is mainly static, integrating intergenerational coresidence in a (dynamic) SIR-type epidemiological model (Avery et al., 2020; Hethcote, 2000) falls beyond our scope.

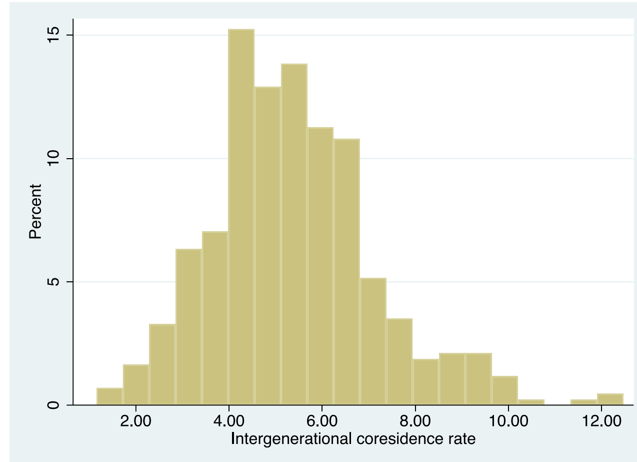

Fig. 1. Intergenerational coresidence rate, distribution. 426 U.S. counties, 2019.

There are N^{ι} susceptible individuals of type ι in the economy, $N^{\iota,h}$ of whom are coresiding with their offspring/parent. Accordingly, the share of infected individuals of type ι, I^{ι}, will be

$$I^{\iota} = \frac{N^{\iota,h}}{N^{\iota}}\pi^{\iota,h} + \frac{N^{\iota} - N^{\iota,h}}{N^{\iota}}\pi^{\iota,a}. \tag{4}$$

Assuming that the lethality rate from the disease is α^{ι}, the overall death rate of the age group ι associated with the disease reads

$$\delta^{\iota} = \alpha^{\iota} I^{\iota}. \tag{5}$$

The overall death rate for the adult population then is

$$\delta = \sum_{\iota \in [y,o]} \phi^{\iota}\delta^{\iota}, \tag{6}$$

where ϕ^{ι} is the share of group ι in the population.

In this model, higher coresidence has an asymmetric impact by age, for it implies a higher contagion among the coresiding old, but not among the coresiding young. This higher contagion among the coresiding old translates into a sizeable increase of their death rate, provided that α^{o} is high enough. For a pandemic that is particularly deadly for the old, like Covid-19, we shall typically have a high α^{o}. Hence, we expect that coresidence will have a positive effect on mortality of the elderly. This will translate into higher overall mortality depending on ϕ^{o}, according to Eq. (6).[9]

3. Intergenerational coresidence and mortality from Covid-19 in 2020

Using the (2019) U.S. Census data (Ruggles et al., 2021), we build county-level intergenerational coresidence rates, defined as the percentage of households in which there is an elderly parent (65 years old or more) living with at least one adult child (18–64).

Our definition catches two elements that are key in our story: first, the family dimension, limiting the efficacy of preventive measures like masks and social distance; and second, the demographic dimension,

[9] On the contrary, when the pandemic is particularly lethal for the young but not for the old, like the Spanish influenza, we shall have a low α^{o}, and we expect intergenerational coresidence to have little effect on the overall mortality rate. The reasons why the Spanish influenza was not extremely lethal for the old are still debated in the medical literature. Short et al. (2018) suggests that previous infections might have made them immune to the virus. We investigate the association between intergenerational coresidence and mortality from the Spanish influenza in Appendix B.

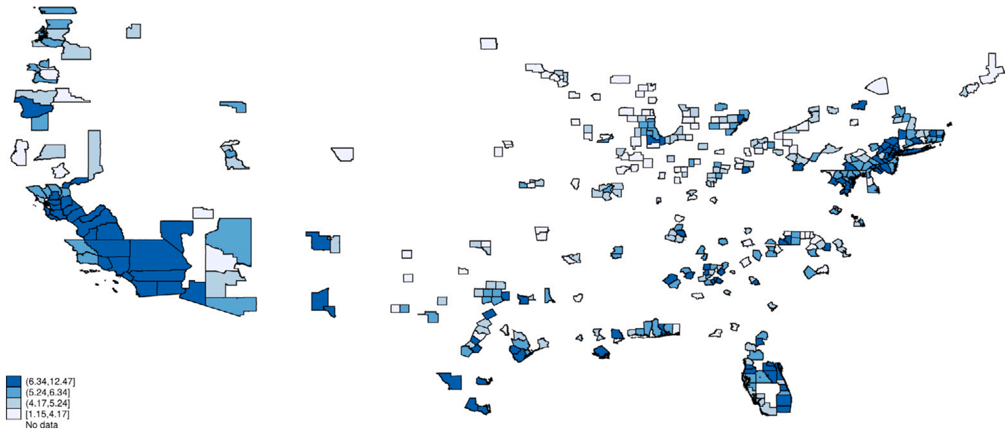

Fig. 2. Intergenerational coresidence rate, geography. 426 U.S. counties, 2019.

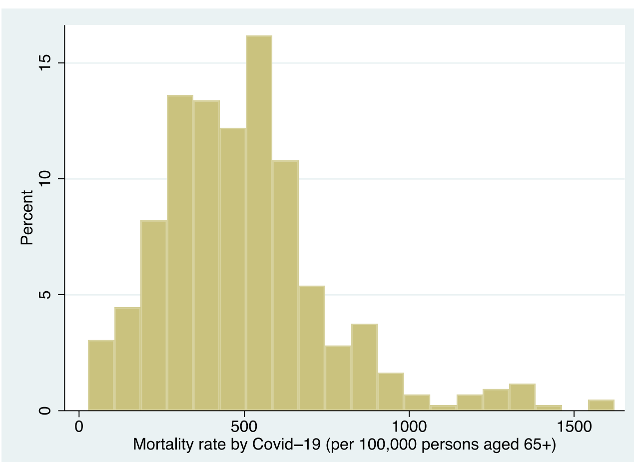

Fig. 3. Incidence of mortality from Covid-19 among persons aged 65+ (deaths per 100,000 persons), distribution. 426 U.S. counties, 2020.

or the presence of old individuals for which Covid-19 is particularly lethal.[10]

In Fig. 1, we show the distribution of the intergenerational coresidence rate at the county level in 2019. It ranges from 1.2% to 12.5%, with a median (mean) value of 5.3% (5.37%).

In Fig. 2, we show the geographic variability of the intergenerational coresidence rate at the county level in 2019. The top quartile of the distribution is concentrated mostly in California, Florida, New Jersey, New York, and Texas.

We build annual mortality rates from Covid-19 for 2020 using county-level data from Centers for Disease Control and Prevention (2021a). We restrict the sample to the 426 U.S. counties available in the 2019 U.S. Census.[11]

In Fig. 3, we show the incidence of mortality from Covid-19 in 2020 among 100,000 old persons, *i.e.* persons aged more than 64 years (65+).

We observe that there is wide variation across counties, with the mortality rate from Covid-19 for the old ranging from 27.2 to 1622.1 deaths per 100,000 old persons. The median (mean) mortality rate is 480.8 (498.3).

In Fig. 4, we show the geographic variability of the mortality rate from Covid-19 for the old at the county level in 2020. The top quartile of the distribution is mostly concentrated in Illinois, Indiana, New Jersey, New York, Pennsylvania, and Texas.

Comparison of Figs. 3 and 4 gives the visual impression of a positive (unconditional) correlation between intergenerational coresidence and mortality from Covid-19 for the old at the county level. This is confirmed by the scatter plot of the two variables in Fig. 5.

We then run the following regression:

$$\delta^o_{i,2020} = \beta_0 + \beta_1 h_{i,2019} + \boldsymbol{\beta_2} \mathbf{X}_{i,2019} + \beta_3 z_{j,2019} + \boldsymbol{\beta_4} \mathbf{D} + \epsilon_i. \quad (7)$$

In Eq. (7), δ^o is the mortality rate for the elderly, h is the intergenerational coresidence rate, and $\mathbf{X}$, z and $\mathbf{D}$ are controls. Subscripts i and j stand for county and state, respectively. The county-level controls in vector $\mathbf{X}$ include several potential confounders: (i) the share of college graduates in the adult population (25 years old or more), a measure of human capital and income; (ii) the percentage of households who are proprietor of their own house, a proxy for wealth; (iii) the number of nursing home residents per 100,000 persons; (iv) the unemployment rate, another proxy for income and economic conditions; (v) the density of the population, to discriminate between family structure per se and density; (vi) the percentage of votes for Trump in the 2016 Presidential election, supposedly catching potential mistrust in the public sector, and hence in public recommendations against the pandemic; (vii) the percentage of Hispanics and the percentage of Blacks, catching some ethno-cultural specificity. The state-level control z stands for the number of hospital beds per 100,000 persons. The variable $\mathbf{D}$ is a vector of geographical dummies computed alternatively at the Census division or the State level. They stand for generic idiosyncrasies at the geo-political level, including the policy response to the pandemic. When the regression includes state dummies, the state-level controls are turned off, *i.e.* $\beta_3 = 0$.[12]

Controls were mostly chosen to catch possible omitted variables, i.e. variables that can affect both intergenerational coresidence and mortality. The level of human capital might affect the comprehension of diseases and the intake of preventive measures to contrast them.[13]

[10] Alternative definitions are discussed in Section 5.

[11] We use all available counties. Limiting the analysis to the metropolitan counties as defined according to the National Center of Health Statistics (NCHS)'s 2013 classification (Ingram and Franco, 2014) does not change the results. Notice that this would excludes from the sample only 15 micropolitan counties, representing less than 6% of the population.

[12] In order to control for possible co-morbidity factors linked to chronic diseases, we have also introduced the incidence of diabetes among the controls. While this reduces the sample size, results do not change appreciably. These and all the other results mentioned but not explicitly reported in the text are available upon request.

[13] Our results also hold good using alternative measures of human capital, namely the average years of schooling and the percentage of high school dropouts, for individuals aged more than 25.

Fig. 4. Incidence of mortality from Covid-19 among persons aged 65+ (deaths per 100,000 persons), geography. 426 U.S. counties, 2020.

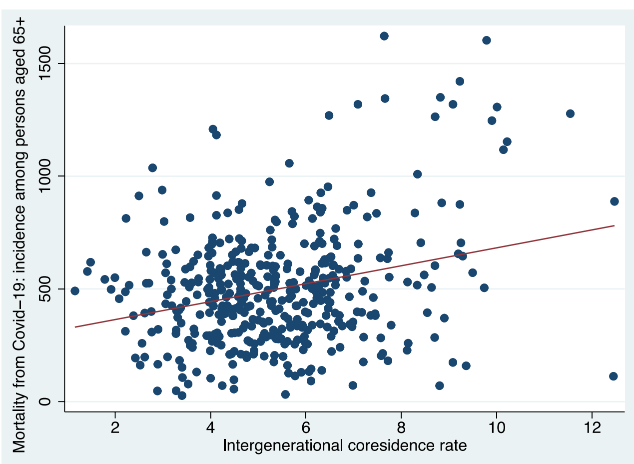

Fig. 5. Intergenerational coresidence and mortality from Covid-19 among persons aged 65+ (deaths per 100,000 persons), unconditional correlation. 426 U.S. counties, 2020.

Furthermore, human capital is a major determinant of income, which, together with wealth and the employment status should obviously improve living conditions and the access to medical services.[14] The latter also depends on the number of hospital beds, a stand-in for the availability of health-care facilities in the state, while the number of deaths in nursing homes have been an important share of the overall death toll from Covid-19 (Cronin and Evans, 2020).[15] Finally, cultural variables may have some explanatory power. Covid-19 hit disproportionately ethnic minorities, Blacks and Hispanics in particular (Woolf et al., 2022), while the higher resilience of Hispanics in terms of mortality is a known fact in the epidemiological literature (Fenelon, 2013; Hummer et al., 2000, among others). Moreover, a populist *credo* might have lowered the adherence of a non-negligible part of the population to the proposed measures of public health. For what concerns the impact of these variables on intergenerational coresidence, the economic and demographic literature mentioned in the Introduction suggests that income, employment status, wealth, and cultural norms are all major determinants of intergenerational coresidence.

Table 1
Regression results. Dependent variable: mortality rate from Covid-19 among persons aged 65+. 426 U.S. counties, 2020. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks; density. State-level controls include: number of hospital beds.

	(1)	(2)	(3)	(4)
% Int. cores.	54.54***	23.14***	53.98***	25.28***
	(7.532)	(6.409)	(8.464)	(7.544)
% Hispanics		9.66***		11.88***
		(1.091)		(1.234)
County-level controls	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No
Census division FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Observations	426	426	426	426
Adjusted R-squared	0.507	0.618	0.554	0.684

Robust standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 1 reports results from regressing the mortality rate from Covid-19 among old persons on intergenerational coresidence. Columns 1–4 capture different specifications of Eq. (7): columns 1 and 2 use fixed effects at the Census division level, while columns 3 and 4 use state fixed effects; columns 2 and 4 add the percentage of Hispanics as a control to columns 1 and 3, respectively. In all the specifications, intergenerational coresidence is positively associated with mortality from Covid-19. As to the magnitude of this positive association, we note first that the geographical level at which fixed effects are computed (division vs state) have a small impact. Since public health policy decisions may have been taken at a more disaggregated level than the census division, we shall focus on the analysis with state dummies. Second, we have isolated the percentage of Hispanics from the other controls to single out the peculiar strong effect that this sub-group of the population turns out to have in our regressions. Adding the percentage of Hispanics as a control, indeed, reduces the effect of intergenerational coresidence on mortality from Covid-19 by more than a half. Nonetheless, such an impact remains quite sizeable. Our benchmark regression in column 4 shows that an increase in the intergenerational coresidence rate of 1 percentage point is associated with about 25 more deaths from Covid-19 per 100,000 (old) persons, or an increase of about 5% with respect to the mean mortality rate of the elderly.[16] In absolute terms, this corresponds to 14,109 individuals.[17]

[14] Notice that we control for human capital, unemployment and wealth in our benchmark regression, but not for income, because of multicollinearity. Results are however robust to introducing income as an additional control.

[15] Our results also hold good by replacing the number of hospital beds with the percentage of health workers.

[16] The mean mortality rate is about 498.

[17] This number is obtained by multiplying the coefficient of the regression, which is expressed in per-100,000-old-persons terms, by the number of elderly

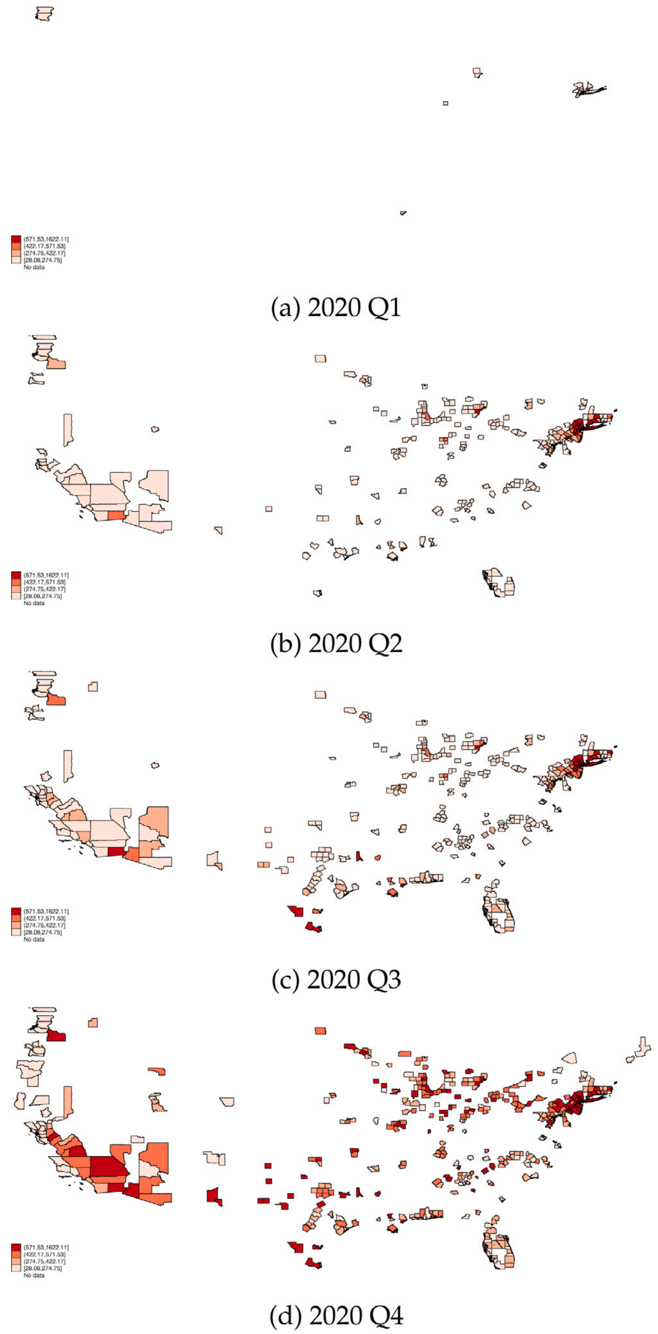

Fig. 6. Incidence of mortality from Covid-19 among persons aged 65+ (deaths per 100,000 persons), geography. U.S. counties, quarterly cumulative data, 2020. Quarter 1 (Q1): 48 counties; Quarter 2 (Q2): 284 counties; Quarter 3 (Q3): 364 counties; Quarter 4 (Q4): 426 counties.

It might also be interesting to understand the time dynamics of Covid-19 spreading across counties. Our theoretical argument, indeed, assumes that social contacts are unprotected both outside and inside the household. While this might be the case at the beginning of the pandemic, it is likely that this assumption becomes less compelling as the pandemic unfolds: social contacts outside the household become less and less regular, and the use of protective measures more widespread, due to public policy and individual prudence. Accordingly, we expect the positive relationship between intergenerational coresidence and mortality from Covid-19 to be stronger in the early phases of the pandemic.

To assess whether this was actually the case, we look at the quarterly cumulative mortality from Covid-19 (Centers for Disease Control and Prevention, 2021a). In Fig. 6, we show the geographic variability of the cumulative mortality rate from Covid-19 for the old at the county level in the four quarters of 2020. From a visual inspection of the graphs, we notice that deaths from Covid-19 were quite limited in the first quarter (Q1) of 2020 and concentrated in few counties only. In the second quarter (Q2), the disease spread across the U.S. territory, with higher incidence in the north-east. In Q3 and Q4, we witness an overall diffusion across the counties.

In order to assess the temporal pattern of the association between intergenerational coresidence and mortality from Covid-19, we run our regression (7) on the quarterly data. In Table 2, we show the results of this regression for the second and the third quarter.[18] In accordance with our intuition, the magnitude of the positive association between intergenerational coresidence and mortality from Covid-19 decreases over time, though it remains sizeable and significant. Looking at column 4 (8), which represents our benchmark specification, we see that in the second (third) quarter, a 1 percentage point increase in intergenerational coresidence implies about 48 (34) additional deaths from Covid-19 per 100,000 elderly, which corresponds to 24% (13.6%) of the mean mortality rate of the elderly.[19] As reported in column (4) of Table 1, at the end of 2020, a 1 percentage point increase in intergenerational coresidence implies about 25 additional deaths from Covid-19 per 100,000 elderly, which corresponds to 5% of the mean mortality rate of the elderly.

In the light of these results, one may be tempted to restrict the benchmark analysis to cumulative mortality in the second quarter only. This might not be the most suitable approach, however, because focusing on the early phase of the pandemic might also make the analysis more susceptible to the possible randomness of the initial infection spread: Covid-19 might have preponderantly stricken counties with high intergenerational coresidence only by chance. Carrying out an yearly analysis, as we do, mitigates this concern. Furthermore, as an additional robustness check, we run our benchmark regressions excluding the New York City counties, which were among the first to be harshly hit by the pandemic and have very high intergenerational coresidence. Results are shown in Table 3 and are qualitatively similar to the benchmark regression of Table 1.

To wrap up, we find a sizeable and significant positive association between intergenerational coresidence and mortality from Covid-19, after controlling for several confounders. This holds true both at the yearly and the quarterly level. We are now going to discuss whether this association is specific to the Covid-19 pandemic.

4. Intergenerational coresidence and mortality in pre-pandemic years

In this Section, we investigate the association between intergenerational coresidence and mortality in the recent non-pandemic past. The idea is to verify whether the significant and sizeable positive correlation we found between Covid-19 mortality and intergenerational coresidence is somewhat specific to the Covid-19 pandemic. In other words, we are using past, non-pandemic years as a sort of placebo test.[20]

in the population (55,811,000), and dividing the result by 100,000. Data on the population from the World Bank https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS, retrieved on August 26th 2022.

[18] We do not show the cumulative analysis for the fourth quarter because this corresponds to the 2020 year, and for the first quarter because the sample size is limited to 48 counties.

[19] The mean mortality rate of the elderly is 204 in the second quarter and 252 in the third one.

[20] In Appendix B, we extend the analysis further in the past, by considering the association between intergenerational coresidence and overall mortality in

Table 2
Cumulative quarterly data, regression results. Dependent variable: mortality rate from Covid-19 among persons aged 65+. 364 (284 for Q2) U.S. counties, 2020. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks; density. State-level controls include: number of hospital beds.

	Quarter 2				Quarter 3			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Int. cores.	54.74***	45.63***	61.58***	48.83***	54.77***	33.89***	56.15***	34.24***
	(7.830)	(8.927)	(8.125)	(8.411)	(7.167)	(7.115)	(7.200)	(7.116)
% Hispanics		2.89**		5.81***		6.88***		9.36***
		(1.131)		(1.155)		(1.049)		(1.076)
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No	Yes	Yes	No	No
Census division FE	Yes	Yes	No	No	Yes	Yes	No	No
State FE	No	No	Yes	Yes	No	No	Yes	Yes
Observations	284	284	284	284	364	364	364	364
Adjusted R-squared	0.669	0.678	0.740	0.773	0.597	0.668	0.651	0.750

Robust standard errors in parentheses
***p < 0.01, **p < 0.05, *p < 0.1

Table 3
Regression results. Dependent variable: mortality rate from Covid-19 among persons aged 65+. 421 U.S. counties (excluding New York City) , 2020. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks; density. State-level controls include: number of hospital beds.

	(1)	(2)	(3)	(4)
% Int. cores.	49.34***	16.04**	46.13***	16.42**
	(7.876)	(6.200)	(8.937)	(7.364)
% Hispanics		9.90***		12.09***
		(1.105)		(1.267)
County-level controls	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No
Census division FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Observations	421	421	421	421
Adjusted R-squared	0.462	0.590	0.519	0.665

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1

Table 4
Regression results. Dependent variable: overall mortality rate among persons aged 65+. 426 U.S. counties, 2019. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks, density. State-level controls include: number of hospital beds.

	(1)	(2)	(3)	(4)
% Int. cores.	−36.45***	−18.23	−19.19	−6.21
	(10.691)	(12.993)	(12.928)	(14.656)
% Hispanics		−5.60***		−5.37**
		(1.919)		(2.255)
County-level controls	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No
Census division FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Observations	426	426	426	426
Adjusted R-squared	0.660	0.668	0.712	0.717

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

4.1. Mortality and intergenerational coresidence since 2005

We first look at the relationship between mortality of the old and intergenerational coresidence in 2019, i.e. the year before the outburst of the pandemic. All the explanatory variables in the regression are measured in 2019 as in Section 3. What changes here is that mortality in 2019 is independent of the diffusion of Covid-19. Table 4 shows the results. The coefficient of intergenerational coresidence is mostly negative and not significant.[21] Interestingly, and differently from the Covid-19 regressions, the coefficient associated with the percentage of Hispanics now has a negative sign, in line with the well-known mortality advantage of the Hispanic population.

As a second exercise, we enlarge the time window of the analysis to the interval 2005–2019. Using county-level mortality rates from Centers for Disease Control and Prevention (2021a) and Census data from Ruggles et al. (2021), we build a balanced panel of 329 counties, for a total of 4,935 observations.[22] To control for time-invariant, county-specific characteristics that may affect mortality rates, we apply a Fixed Effect estimator, with year dummies, to the following relationship:

$$\delta^o_{i,t} = \beta_0 + \beta_1 h_{i,t} + \boldsymbol{\beta_2}\mathbf{X}_{i,t} + \beta_3 z_{j,t} + \epsilon_{i,t}, \quad (8)$$

where all the variables have the same meaning as in Eq. (7).[23] Results are reported in Table 5. The association between intergenerational coresidence and mortality of the old turns out to be positive, but not significant and quantitatively negligible.[24] This first placebo exercise suggests that a sizeable, significant, positive association between intergenerational coresidence and mortality for the old seems to be specific to the Covid-19 pandemic.

4.2. Mortality and intergenerational coresidence by type of disease

To further investigate the matter, we are now going to look at the association between intergenerational coresidence and mortality of the old in pre-pandemic years by type of disease. In particular, we select three causes of mortality: (1) mortality from circulatory diseases, (2) mortality from cancer and (3) mortality from influenza and pneumonia. The rationale behind this comparison is that circulatory diseases and cancer are major causes of mortality,[25] while only influenza and

the decades between 1980 and 2010, and during the Spanish influenza. Results conform to our main conclusions.

[21] To grasp the quantitative magnitude of the coefficient, notice that the mean mortality rate is about 3948.

[22] The analysis is restricted to the counties available in the Census. Annual Census data exist from the year 2000. However, it is not possible to retrieve observations by county for the years 2001–2004.

[23] We exclude the percentage of votes for Trump in the 2016 Presidential elections from the controls.

[24] The mean mortality rate is 4662.

[25] They represent about 54% of overall mortality for the elderly in 2019.

Table 5
Regression results. Fixed effect panel. Dependent variable: overall mortality rate among persons aged 65+. 329 U.S. counties, 2005–2019. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of blacks; density. State-level controls include: number of hospital beds.

	(1)	(2)
% Int. cores.	1.52	0.96
	(4.412)	(4.287)
% Hispanics		3.94
		(5.266)
County-level controls	Yes	Yes
State-level controls	Yes	Yes
County FE	Yes	Yes
Year FE	Yes	Yes
Observations	4,935	4,935
Counties	329	329
Adjusted R-squared	0.730	0.730

Robust standard errors in parentheses.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

pneumonia are transmitted via aerobic contagion, thereby making them more directly comparable to Covid-19. We shall investigate the matter both in a cross-section analysis for 2019 and in the 2005–2019 panel.

In Table 6 we show the results from the 2019 cross section analysis. The association between intergenerational coresidence and mortality of the old turns out to be always positive and significant only for influenza and pneumonia. In the benchmark specification of column 12, a 1 percentage point increase in intergenerational coresidence implies about 3.5 additional deaths from influenza and pneumonia per 100,000 elderly, which corresponds to about 5% of the mean mortality rate of the elderly (from influenza and pneumonia).[26] The magnitude of the effect of coresidence on mortality from influenza and pneumonia is thus close to the one from Covid-19. As to the mortality from cancer, the association with intergenerational coresidence is always negative, mostly non-significant and of a small magnitude (with respect to the mean).[27] Finally, the association between mortality from circulatory diseases and intergenerational coresidence is positive but mostly non-significant and of a small magnitude (with respect to the mean).[28]

Table 7 displays the results obtained running Eq. (8) on 2005–2019 panel data for the three diseases: the coefficient of intergenerational coresidence is never significant and quite small (with respect to the mean).[29]

To sum up, our placebo regressions provide some evidence of a positive, significant and sizeable association between intergenerational coresidence and mortality only in the 2019 cross-section analysis for influenza and pneumonia, diseases whose transmission is similar to Covid-19.

5. Robustness

In this Section, we study the robustness of our yearly analysis on Covid-19 to alternative definitions of the dependent and independent variables in Eq. (7).

5.1. Alternative mortality measures

As a first exercise, we enquire into different measurements of mortalities from Covid-19.

Our benchmark analysis focuses on the mortality of elderly persons. One may wonder to what extent our results hold good when we extend the reference age cluster to include the whole population. This gives an appreciation of the overall magnitude of the association between intergenerational coresidence and mortality from Covid-19, and makes our analysis more directly comparable to the literature.

To do so, we regress mortality from Covid-19 in the whole population (i.e. without imposing any age restriction) over the same set of variables described in Section 3, plus the percentage of persons aged more than 64, to control for the demographic structure of the population.[30] Results are reported in Table 8.

The coefficient associated with intergenerational coresidence is positive and significant. From the benchmark specification of column 4, a one percentage point increase in intergenerational coresidence is associated with 6.6 additional deaths from Covid-19 per 100,000 persons. The corresponding coefficient from the benchmark regression of Section 3 is 25.28. Multiplying these coefficients by the respective reference populations,[31] and dividing by 100,000 one gets the variations of mortality induced by changes in coresidence in the two groups in absolute – an hence directly comparable – terms. These amount to 14,109 and 21,668 individuals for the old and the whole population, respectively. This allows to assess how much of the association between overall Covid-19 mortality and intergenerational coresidence is driven by the elderly. It turns out that the elderly, who represent barely 17% of the population, represents instead more than 65% of the increase in the number of deaths due to a one percentage point increase in intergenerational coresidence. Dividing the increase in the number of deaths due to a one percentage point increase in intergenerational coresidence by the overall number of deaths from Covid-19 in 2020 gives the semi-elasticity of mortality from Covid-19 with respect to intergenerational coresidence. This amounts to 6.17%, and is directly comparable to Aparicio Fenoll and Grossbard (2020)'s cross-country analysis. The authors find that one extra percentage point in the share of young individuals living with their parents is associated with additional deaths from Covid-19 ranging between 2.4% and 4%.

Possible measurement errors in the computation of mortality from Covid-19 might be a concern for our benchmark analysis. There is indeed a widespread feeling in the literature that mortality from Covid-19 might be poorly estimated by official figures (see for instance Ackley et al., 2022). One way to take this concern into account in our regression analysis is to consider excess, as opposed to measured mortality as dependent variable. Excess mortality is typically estimated as the difference between actual mortality and some forecasted value based on past mortality. In the regressions, we use the excess mortality series estimated by Ackley et al. (2022) at the U.S. county level for the whole population. Results are reported in Table 9 and show conclusively that intergenerational coresidence is positively correlated with excess mortality from Covid-19. Looking at the benchmark specification in column 4, a one percentage point increase in intergenerational coresidence is associated with about 9 additional excess deaths, or an increase of 7.8% with respect to the mean excess mortality rate.[32]

[26] In 2019, the mean mortality rate of the elderly from influenza and pneumonia was about 65.

[27] The 2019 mean mortality rate for the elderly from cancer is 811.

[28] The 2019 mean mortality rate for the elderly from circulatory diseases is 1307.

[29] The mean mortality rate for the elderly is 1515, 935, 92 for circulatory diseases, cancer and influenza and pneumonia, respectively.

[30] In a robustness exercise available upon request, we control for the percentage of persons aged more than 79, instead of 64. Results do not change appreciably.

[31] In 2019 in the United States, the population over 65 was 55,811,000 individuals, while the overall population amounted to 328,300,000. Source: the World Bank https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS, retrieved on August 26th 2022.

[32] In our sample, the mean excess mortality rate is 119.

Table 6
Regression results. Dependent variable: mortality rate from circulatory diseases among persons aged 65+, column (1)–(4); mortality rate from cancer among persons aged 65+, column (5)–(8); mortality rate from influenza and pneumonia among persons aged 65+, column (9)–(12). 426 (297 for column (9)–(12)) U.S. counties, 2019. County-level controls include: percentage of people aged more that 64; percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks, density. State-level controls include: number of hospital beds.

	Circulatory				Cancer				Influenza and Pneumonia			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
% Int. cores.	8.43	11.67*	8.00	9.36	−9.47***	−4.35	−6.46*	−2.16	3.46***	4.02***	3.56***	3.56***
	(5.757)	(6.345)	(7.078)	(7.381)	(2.602)	(2.995)	(3.336)	(3.377)	(1.144)	(1.377)	(1.266)	(1.367)
% Hispanics		−1.00		−0.56		−1.57***		−1.78***		−0.17		0.00
		(1.038)		(1.089)		(0.411)		(0.537)		(0.184)		(0.178)
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
Census division FE	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
State FE	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Observations	426	426	426	426	426	426	426	426	297	297	297	297
Adjusted R-squared	0.502	0.503	0.574	0.573	0.528	0.546	0.580	0.597	0.253	0.253	0.415	0.412

Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 7
Regression results. Fixed effect panel. Dependent variable: mortality rate from circulatory diseases among persons aged 65+, column (1)–(2); mortality rate from cancer among persons aged 65+, column (3)-(4); mortality rate from influenza and pneumonia among persons aged 65+, column (5)–(6). County-level controls include: percent of college graduates (over 25); percent of dwelling owners; number of nursing home residents; percent of unemployed; percent of blacks, density. State-level controls include: number of hospital beds. 329 (325 for column (5)–(6)) U.S. counties, 2005–2019.

	Circulatory		Cancer		Influenza and Pneumonia	
	(1)	(2)	(3)	(4)	(5)	(6)
% Int. cores.	−2.99	−2.98	0.99	0.61	1.16	1.45
	(2.824)	(2.790)	(1.355)	(1.360)	(1.017)	(1.195)
% Hispanics		−0.09		2.67*		−1.65
		(3.570)		(1.487)		(1.924)
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,935	4,935	4,935	4,935	4,106	4,106
Counties	329	329	329	329	325	325
Adjusted R-squared	0.747	0.747	0.666	0.666	0.277	0.279

Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 8
Regression results — robustness I. Dependent variable: mortality rate from Covid-19 (all ages). 426 U.S. counties, 2020. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks; density; percentage of elderly (65+). State-level controls include: number of hospital beds.

	(1)	(2)	(3)	(4)
% Int. cores.	10.97***	5.81***	10.85***	6.60***
	(1.506)	(1.360)	(1.774)	(1.610)
% Hispanics		1.69***		2.09***
		(0.205)		(0.242)
County-level controls	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No
Census Division FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Observations	426	426	426	426
Adjusted R-squared	0.558	0.644	0.605	0.700

Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 9
Regression results — robustness II. Dependent variable: excess mortality rate from Covid-19 (all ages). 426 U.S. counties, 2020. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks; density; percentage of elderly (65+). State-level controls include: number of hospital beds.

	(1)	(2)	(3)	(4)
% Int. cores.	13.98***	7.14***	14.90***	9.04***
	(1.977)	(1.903)	(2.307)	(2.146)
% Hispanics		2.24***		2.88***
		(0.288)		(0.330)
County-level controls	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No
Census Division FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Observations	426	426	426	426
Adjusted R-squared	0.520	0.599	0.571	0.668

Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 10
Regression results — robustness III. Dependent variable: mortality rate from Covid-19 among persons aged 65+. 426 U.S. counties, 2020. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks; density. State-level controls include: number of hospital beds.

	(1)	(2)	(3)	(4)
% Int. cores. (18–34)	126.51***	40.09**	114.42***	45.00**
	(23.802)	(18.911)	(28.850)	(21.012)
% Hispanics		10.35***		12.57***
		(1.041)		(1.184)
County-level controls	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No
Census division FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Observations	426	426	426	426
Adjusted R-squared	0.475	0.610	0.522	0.676

Robust standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

5.2. Alternative definitions of intergenerational coresidence

In this paper, we have defined the intergenerational coresidence rate as the percentage of households in which there is an elderly parent (65 years old or more) living with at least one adult child (18–64).

To ensure that our empirical results are not driven by possible idiosyncrasies linked to this definition, we have run the same analysis presented in Table 1 using an alternative definition of intergenerational coresidence, namely the percentage of households in which there is an elderly parent (65 years old or more) living with at least one young adult child (18–34). With respect to the benchmark, this definition focuses more on the relatively young age of the adult child, while still catching the importance of having elderly parents. As shown in Table 10, results are qualitatively similar, and even stronger from a quantitative point of view.

Aparicio Fenoll and Grossbard (2020) use yet another definition of the intergenerational coresidence rate, namely the fraction of young adults (18–34) living with their parents. Notice that this definition, like ours, catches the family link within the household, but, differently from ours, does not focus on the old age of the parents. We believe that our definition is more suitable to the purpose of this paper. For robustness, however, we have rerun our main regressions using Aparicio Fenoll and Grossbard (2020)'s definition. Results are shown in Table 11 and are in line with our benchmark findings in Table 1, for they show a positive and significant association between intergenerational coresidence and mortality from Covid-19. Since this definition does not focus on the old age of the parents, the coefficients are much smaller than in our benchmark analysis of Table 1, as expected.

The above-mentioned definitions catch coresidence among at least two generations, but are silent about how many additional generations may be actually involved. To investigate whether this may be an issue, we employ the definition of multigenerational household available from U.S. Census data (Ruggles et al., 2021 and select multigenerational households with three or more generations, and in which there is at least one elderly. Results are similar qualitatively and even stronger from a quantitative point of view, as can be witnessed by a look at Table 12.[33]

6. Conclusions

In this paper, we investigate whether intergenerational coresidence may have been a mechanism fostering the transmission of Covid-19 to the elderly strata of the population. We present evidence that intergenerational coresidence is positively associated with mortality from Covid-19 in a sample of 426 American counties in 2020. The effect is statistically significant, and quantitatively sizeable. A one percentage point increase in the intergenerational coresidence rate is associated with 25 more deaths per 100,000 elderly persons due to Covid-19, that is, in absolute terms, 14,109 individuals. Results are robust to the inclusion of several socio-economic confounders, and the consideration of different measures of mortality and intergenerational coresidence.

The value added of our research is twofold. First, we are able to establish the existence of a robust, positive correlation between intergenerational coresidence and mortality from Covid-19 in a larger, more homogeneous sample relative to what is currently done in the literature. We show that this correlation is particularly strong for the elderly strata of the population.

Second, we use history as a loose form of identification. In particular, we rely on historical comparisons with pre-pandemic years (2005–2019) as a sort of placebo test, where no a-priori obvious correlation between intergenerational coresidence and mortality of the elderly is expected in non-pandemic years. We run this placebo analysis for both all-cause and cause-specific mortality. We show that a positive, sizeable, significant association between intergenerational coresidence and mortality seems indeed to be specific to the Covid-19 pandemic only.

Although we focus on smaller geographical units than most of the literature (counties vs states/countries), still by construction our analysis remains eminently macro. This macro perspective makes it more difficult to fully capture all the potential confounders, like for instance the health status of elderly, cultural factors such as religion, and psycological attitudes. To delve deeper into the relationship between family structure and the mortality from Covid-19 or related pandemics, one would need individual mortality data, matched with individual characteristics such as, age, living arrangements, social contacts, and other relevant demographic and socio-economic features. This would allow, for instance, to better enquire into those interactions between the elderly and their family members other than intergenerational coresidence, such as informal childcare by non-coresiding grandparents. In addition, our analysis shows that the percentage of Hispanics is strongly and positively correlated with both intergenerational coresidence and mortality from Covid-19, while being mostly negatively correlated with mortality from other causes and in other periods. Using individual-level data would allow to carry out the study for this sub-group of the population, thereby shedding more light on these correlations.

Our research has potential policy implications worthy of further investigation. For instance, it suggests that lockdowns targeted to specific demographic clusters (e.g. the elderly) might be less effective to mitigate the mortality from infectious diseases like Covid-19, in places where intergenerational coresidence is particularly high. In this sense, our work speaks to the debate between the *Great Barrington Declaration*, which suggests the "focused protection" of the elderly, and the *John Snow memorandum*, which underlines its unfeasibility.

Furthermore, on the ground of our analysis, one may wonder whether intergenerational coresidence should be taken into account in the ongoing debate over school closures during pandemics. In particular, the cost-to-benefit ratio from school closures might be different depending on whether intergenerational coresidence is high or low and whether it involves only two or more generations. These and other possible policy implications are left for future research.

[33] All the above definitions catch the extensive margin of integenerational coresidence, i.e. how many households have at least one elderly coresiding with at least one adult child. For the sake of simplicity, we abstract from the intensive margin of intergenerational coresidence, i.e. how many adult children live with how many elderly parents. As long as the intensity of coresidence correlates positively with the coresidence rate, this is a conservative assumption, for it implies that we are underestimating the impact of coresidence on mortality from Covid-19. In our sample, this is actually the case: the correlation coefficient between our measure of intergenerational coresidence and average family (household) size is 0.51 (0.52) and is statistically significant at the 1% level.

Table 11
Regression results — robustness IV. Dependent variable: mortality rate from Covid-19 among persons aged 65+. 426 U.S. counties, 2020. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks; density. State-level controls include: number of hospital beds.

	(1)	(2)	(3)	(4)
% Int. cores. (Aparicio Fenoll and Grossbard)	12.89***	4.80***	13.02***	4.13***
	(1.558)	(1.545)	(1.832)	(1.591)
% Hispanics		9.18***		11.74***
		(1.126)		(1.280)
County-level controls	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No
Census division FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Observations	426	426	426	426
Adjusted R-squared	0.535	0.616	0.572	0.676

Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 12
Regression results — Robustness V. Dependent variable: mortality rate from Covid-19 among persons aged 65+. 426 U.S. counties, 2020. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; number of nursing home residents; percentage of unemployed; percentage of votes for Trump in the 2016 Presidential election; percentage of blacks; density. State-level controls include: number of hospital beds.

	(1)	(2)	(3)	(4)
% Int. cores. (multigen)	99.62***	41.50***	107.88***	51.08***
	(14.186)	(12.471)	(15.697)	(13.911)
% Hispanics		9.49***		11.38***
		(1.063)		(1.229)
County-level controls	Yes	Yes	Yes	Yes
State-level controls	Yes	Yes	No	No
Census division FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Observations	426	426	426	426
Adjusted R-squared	0.516	0.619	0.575	0.687

Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Data availability

Data will be made available on request.

Appendix A. Data

A.1. Mortality variables

Data for all mortality rates were retrieved from Centers for Disease Control and Prevention (2021a). For the Covid-19 analysis, we constructed mortality rates per 100,000 persons using the 2019 county-level population. Excess mortality rates were obtained from Ackley et al. (2022).

A.2. Explanatory variables

Person and household-level data on family structure, demographic and socio-economic variables were taken from the U.S. Census (Ruggles et al., 2021). For the years 2005–2019, we used the 1% sample of the American Community Survey. For the year 2000 and 1980 we used the 5% sample. For the year 1990 we used the 1% sample.

Data were aggregated at the county level by constructing a 5-digit identifier using the Federal Information Processing Standard (FIPS) county code classification. Group quarters and fragments were excluded from the analysis. Households are identified using the 1970, 1990 and 2000 definition (Ruggles et al., 2021).

The number of hospital beds per 100,000 persons is measured at the state level and was obtained from the American Hospital Association.[34]

The number of occupied nursing home beds per 100,000 persons comes from the Brown University Center for Gerontology and Healthcare Research and the National Institute on Ageing available at www.ltcfocus.org.

Density was constructed using (i) county-level areas (in square miles) from 2010 retrieved on March 12th 2021 from https://github.com/ykzeng/covid-19.git and (ii) population estimates from Centers for Disease Control and Prevention (2021a).

Data on the percentage of votes for Trump in the 2016 Presidential elections were retrieved in June 2021 from https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/VOQCHQ.

A.3. Spanish influenza

The analysis of the Spanish Influenza pandemic was carried out using mortality rates from Clay et al. (2019). Data were merged with 1% sample from the 1910 American Census available in IPUMS (Ruggles et al., 2021). Group quarters and fragments were excluded from the sample. Data were aggregated at the city level.

Excess mortality rates were calculated as in Clay et al. (2019), that is as the difference between observed mortality and predicted mortality from a city-specific linear trend for the period 1915–1925, excluding 1918 (the pandemic year).

Appendix B. The far past

B.1. Mortality and coresidence from 1980: Panel of decennial censuses

In this Section, we further extend our panel analysis of Section 4.1 on overall mortality to the period 1980–2010. Using decennial Census data, we construct a balanced panel of 240 counties, for a total of 960 observations. Results are presented in Table 13, and show a negative, significant association between intergenerational coresidence and overall mortality.

B.2. Mortality in 1918: the spanish influenza pandemic

The outburst of the Covid-19 pandemic has renewed the interest for the Spanish influenza, on which there already exists a copious historical literature (see Crosby, 2003 and the references therein). Beach et al. (2020) provide a detailed review of differences and similarities between Covid-19 and the Spanish influenza, while Barro et al. (2020) analyse

[34] http://ghdx.healthdata.org/record/united-states-hospital-beds-1000-population-state

Table 13
Regression results. Fixed effect panel. Dependent variable: overall mortality rate among persons aged 65+. 240 U.S. counties, 1980–2010. County-level controls include: percentage of college graduates (among persons aged 25+); percentage of dwelling owners; percentage of unemployed; percentage of blacks; density.

	(1)	(2)
% Int. cores.	−54.85***	−35.67*
	(17.835)	(20.048)
% Hispanics		−11.67**
County-level controls	Yes	Yes
State-level controls	Yes	Yes
County FE	Yes	Yes
Year FE	Yes	Yes
Observations	960	960
Number of FIPS	240	240
Adjusted R-squared	0.647	0.651

Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

the long-term macroeconomic consequences of the Spanish influenza in terms of GDP and consumption decline. Several studies analyse the determinants of within-country and cross-country variation of mortality rates during this pandemic episode. In particular, cross-sectional studies have shown that poverty, illiteracy and pollution contributed to the severity of the pandemic (Clay et al. (2019), Clay et al. (2018) Grantz et al. (2016), Chowell et al. (2014) among others). Markel et al. (2007) and Bootsma and Ferguson (2007) find that preventive measures such as quarantine and lockdown had a (small) negative impact on mortality.

In this Section, we look at the experience of the 1918 Spanish influenza, which is a pandemic episode with transmission features similar to Covid-19, but a different epidemiological impact by demographic cluster (Beach et al., 2020). Indeed, it witnessed an unusual age-specific incidence of mortality, with a peak for individuals aged 18–40 (Taubenberger and Morens, 2006). Accordingly, we do not expect a sizeable, positive and significant association between intergenerational coresidence and mortality from the Spanish influenza.

In order to investigate whether this is the case, we build a cross-section of 423 American cities, using city-level mortality data from Clay et al. (2019) and U.S. 1910 Census data from Ruggles et al. (2021). As a measure of mortality, we use the (computed) excess mortality rate allegedly due to the Spanish influenza from Clay et al. (2019).[35] We computed city-level intergenerational coresidence rates from the Census.

Fig. 7 shows the relative frequency of the intergenerational coresidence rate in 1910. The distribution is slightly skewed to the right. It ranges from 0% to 29%; the median (mean) is 8.9 (9.5). A glance at Figs. 1 and 7 suggests that intergenerational coresidence was on average higher and more volatile in 1910 than in 2019.

Fig. 8 plots the relative frequency of the excess mortality rate in 1918. It shows considerable variation across cities. Excess mortality ranges from −144.7 to 1788, with median (mean) 541.1 (567.5).

Given the data at our disposal, Eq. (7) becomes

$$\delta_{i,1918} = \beta_0 + \beta_1 h_{i,1910} + \boldsymbol{\beta_2} \mathbf{X}_{i,1910} + \epsilon_i. \quad (9)$$

In Eq. (9), δ is the excess mortality rate, h is the intergenerational coresidence rate, $\mathbf{X}$ is a vector of controls and i stands for city. In this regression, the controls in vector $\mathbf{X}$ include: (i) the demographic structure, represented by share of old persons (65 years old or more) in the population; (ii) the illiteracy rate; (iii) the percentage of households who are proprietor of their own house, a proxy for wealth; (iv) density;

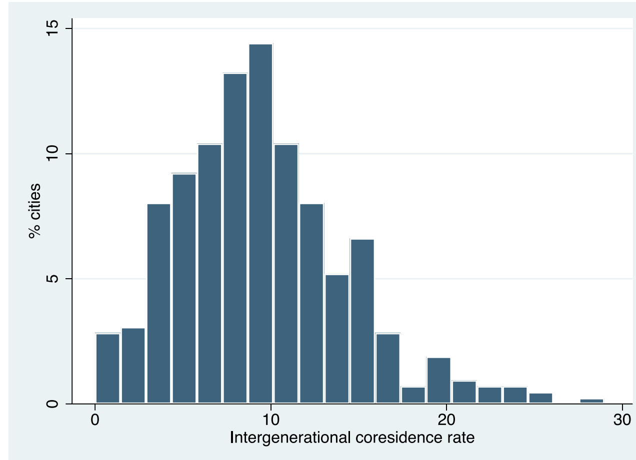

Fig. 7. Intergenerational coresidence rate. 423 American cities, 1910.

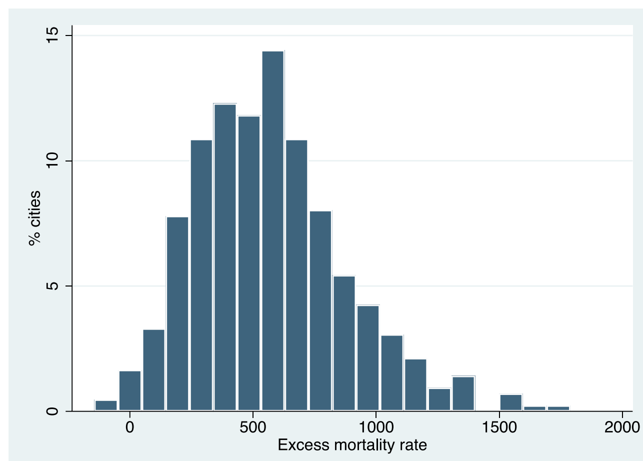

Fig. 8. Excess mortality rate (per 100,000 persons). 423 American cities, 1918.

(v) percentage of health workers; (vi) percentage of Blacks; (vii) percentage of Hispanics; (viii) percentage of employment in agriculture; (ix) unemployment rate; (x) geographical dummies.[36]

Results are presented in Table 14. They show that intergenerational coresidence rate is not significantly associated with the excess mortality rate. Furthermore, the point estimate in the benchmark specification in column 4 is quite small, 0.6% of the sample mean. This may be interpreted as a consequence of its peculiar epidemiological pattern, in which, contrary to what experienced during the Covid-19 pandemic, adults aged between 18 and 40 were disproportionately hit.

The comparison of these results with those obtained in the analysis of the Covid-19 pandemic suggests that intergenerational coresidence might be a mechanism fostering the transmission of this type of viral diseases from the young (adults) to the elderly. This translates into

[35] This variable is expressed in per 100,000 persons terms. City-level data on the number of casualties directly caused by the Spanish influenza are not available for our sample.

[36] Due to the lack of data, we could not include the number of hospital beds and the number of nursing home residents among the controls. Furthermore, all controls are available only for 422 cities.

Table 14
Regression results. Dependent variable: excess mortality rate from Spanish Influenza. 422 U.S. cities, 1918. City-level controls include: percentage of persons aged 65+; percentage of dwelling owners; percentage of illiterates; unemployment rate; percentage of employment in agriculture; percentage of Blacks; density; percentage of healthcare workers.

	(1)	(2)	(3)	(4)
% Int. cores.	2.57	2.48	3.26	3.17
	(5.131)	(5.105)	(5.023)	(4.968)
% hispanics		−17.51		−20.04
		(11.814)		(14.085)
City-level controls	Yes	Yes	Yes	Yes
Census division FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Observations	422	422	422	422
Adjusted R-squared	0.230	0.232	0.299	0.301

Robust standard errors in parentheses.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

higher observed mortality only when the disease is particularly deadly for the elderly.

References

Ackley, Calvin A, Lundberg, Dielle J, Ma, Lei, Elo, Irma T, Preston, Samuel H, Stokes, Andrew C, 2022. County-level estimates of excess mortality associated with COVID-19 in the United States. SSM-Population Health 17, 101021.

Adda, Jérôme, 2016. Economic activity and the spread of viral diseases: Evidence from high frequency data. Q. J. Econ. 131 (2), 891–941.

Aparicio Fenoll, A., Grossbard, S., 2020. Intergenerational residence patterns and COVID-19 fatalities in the EU and the US. Econ. Hum. Biol. 39, 100934.

Arpino, Bruno, Bordone, Valeria, Pasqualini, Marta, 2020. Reply to dowd and others: Dangerous to overemphasize the importance of specific COVID-19 risk factors based on (unadjusted) macro-level analyses. Proc. Natl. Acad. Sci. 117 (42), 25977–25978.

Avery, C., Bossert, W., Clark, A., Ellison, G., Ellison, S.F., 2020. An economist's guide to epidemiology models of infectious disease. J. Econ. Perspect. 34, 79–104.

Barro, Robert J., Ursúa, José F., Weng, Joanna, 2020. The coronavirus and the great influenza pandemic: Lessons from the "Spanish flu" for the coronavirus's potential effects on mortality and economic activity. Working Paper Series 26866, National Bureau of Economic Research.

Baudin, Thomas, Rock, Bram De, Gobbi, Paula, 2021. Economics and family structures. Discussion Paper 16516, CEPR.

Bayer, Christian, Kuhn, Moritz, 2020. Intergenerational ties and case fatality rates: A cross-country analysis. Discussion Paper 14519, CEPR.

Beach, Brian, Clay, Karen, Saavedra, Martin H., 2020. The 1918 influenza pandemic and its lessons for COVID-19. Working Paper Series 27673, National Bureau of Economic Research.

Bootsma, Martin C.J., Ferguson, Neil M., 2007. The effect of public health measures on the 1918 influenza pandemic in US cities. Proc. Natl. Acad. Sci. 104 (18), 7588–7593.

Boucekkine, R., Carvajal, A., Chakraborty, S., Goenka, A., 2021. The economics of epidemics and contagious diseases: An introduction. J. Math. Econom. 93, 1–8.

Brotherhood, Luiz, Kircher, Philipp, Santos, Cezar, Tertilt, Michèle, et al., 2020. An economic model of the Covid-19 pandemic with young and old agents: Behavior, testing and policies. Discussion Paper 175, CRC TR 224 - University of Bonn and University of Mannheim.

Browning, M., Chiappori, P.A., Weiss, Y., 2014. Economics of the Family. Cambridge University Press, Cambridge, UK.

Burzyński, Michał, Machado, Joel, Aalto, Atte, Beine, Michel, Goncalves, Jorge, Haas, Tom, Kemp, Francoise, Magni, Stefano, Mombaerts, Laurent, Picard, Pierre, et al., 2021. Covid-19 crisis management in Luxembourg: Insights from an epidemionomic approach. Econ. Hum. Biol. 43, 101051.

Centers for Disease Control and Prevention, 2021a. Compressed mortality database - CDC wonder. https://wonder.cdc.gov/mortsql.html.

Centers for Disease Control and Prevention, 2021b. Leading causes of death. https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm.

Centers for Disease Control and Prevention, 2021c. Provisional COVID 19 death counts by sex age and state. https://data.cdc.gov/NCHS/Provisional-COVID-19-Death-Counts-by-Sex-Age-and-S/9bhg-hcku.

Chowell, Gerardo, Erkoreka, Anton, Viboud, Cécile, Echeverri-Dávila, Beatriz, 2014. Spatial-temporal excess mortality patterns of the 1918–1919 influenza pandemic in Spain. BMC Infect. Dis. 14 (1), 1–12.

Clay, Karen, Lewis, Joshua, Severnini, Edson, 2018. Pollution, infectious disease, and mortality: Evidence from the 1918 Spanish influenza pandemic. J. Econ. Hist. 78 (4), 1179–1209.

Clay, Karen, Lewis, Joshua, Severnini, Edson, 2019. What explains cross-city variation in mortality during the 1918 influenza pandemic? Evidence from 438 US cities. Econ. Hum. Biol. 35, 42–50.

Costa, D.L., 1997. Displacing the family: Union army pension and elderly living arrangements. J. Polit. Econ. 105, 1269–1292.

Cronin, Christopher J., Evans, William N., 2020. Nursing Home Quality, COVID-19 Deaths, and Excess Mortality. Technical Report, National Bureau of Economic Research.

Crosby, Alfred W., 2003. America's Forgotten Pandemic: The Influenza of 1918. Cambridge University Press.

Desmet, K., Wacziarg, R., 2022. Understanding spatial variation in COVID-19 across the United States. J. Urban Econ. 127, 103332.

Doepke, Matthias, Tertilt, Michèle, 2016. Families in macroeconomics. Handb. Macroecon. 2, 1789–1891.

Dowd, Jennifer Beam, Block, Per, Rotondi, Valentina, Mills, Melinda C, 2020. Dangerous to claim "no clear association" between intergenerational relationships and COVID-19. Proc. Natl. Acad. Sci. 117 (42), 25975–25976.

Eichenbaum, Martin S., Rebelo, Sergio, Trabandt, Mathias, 2020. Epidemics in the neoclassical and new Keynesian models. Working Paper 27430, National Bureau of Economic Research.

Favero, Carlo A., Ichino, Andrea, Rustichini, Aldo, 2020. Restarting the economy while saving lives under Covid-19. Discussion Paper 14664, CEPR.

Fenelon, Andrew, 2013. Revisiting the hispanic mortality advantage in the United States: The role of smoking. Soc. Sci. Med. 82, 1–9.

Forbes, Harriet, Morton, Caroline E, Bacon, Seb, McDonald, Helen I, Minassian, Caroline, Brown, Jeremy P, Rentsch, Christopher T, Mathur, Rohini, Schultze, Anna, DeVito, Nicholas J, et al., 2021. Association between living with children and outcomes from covid-19: Opensafely cohort study of 12 million adults in England. Bmj 372.

Garrett, Thomas A., 2008. Pandemic economics: The 1918 influenza and its modern-day implications. Fed. Res. Bank St. Louis Rev. 90 (March/April 2008), 75–93.

Grantz, Kyra H, Rane, Madhura S, Salje, Henrik, Glass, Gregory E, Schachterle, Stephen E, Cummings, Derek AT, 2016. Disparities in influenza mortality and transmission related to sociodemographic factors within chicago in the pandemic of 1918. Proc. Natl. Acad. Sci. 113 (48), 13839–13844.

Greenwood, Jeremy, Guner, Nezih, Vandenbroucke, Guillaume, 2017. Family economics writ large. J. Econ. Lit. 55 (4), 1346–1434.

Harris, Jeffrey E., 2020. Data from the COVID-19 epidemic in Florida suggest that younger cohorts have been transmitting their infections to less socially mobile older adults. Rev. Econ. Househ. 18 (4), 1019–1037.

Harris, Jeffrey E., 2021. Los Angeles county SARS-CoV-2 epidemic: Critical role of multi-generational intra-household transmission. J. Bioecon. 23 (1), 55–83.

Hauck, Katharina, 2018. The economics of infectious diseases. In: Oxford Research Encyclopedia of Economics and Finance. Oxford University Press.

Hethcote, Herbert W., 2000. The mathematics of infectious diseases. SIAM Rev. 42 (4), 599–653.

Hummer, Robert A, Rogers, Richard G, Amir, Sarit H, Forbes, Douglas, Frisbie, W Parker, 2000. Adult mortality differentials among Hispanic subgroups and non-Hispanic whites. Soc. Sci. Q. 459–476.

Ingram, Deborah D., Franco, Sheila J., 2014. 2013 NCHS Urban-Rural Classification Scheme for Counties, no. 2014. US Department of Health and Human Services, Centers for Disease Control and Prevention.

Kaplan, G., 2012. Moving back home: Insurance against labor market risk. J. Polit. Econ. 120, 446–512.

Lei, Hao, Xu, Xiaolin, Xiao, Shenglan, Wu, Xifeng, Shu, Yuelong, 2020. Household transmission of COVID-19-a systematic review and meta-analysis. J. Infect. 81 (6), 979.

Li, Wei, Zhang, Bo, Lu, Jianhua, Liu, Shihua, Chang, Zhiqiang, Peng, Cao, Liu, Xinghua, Zhang, Peng, Ling, Yan, Tao, Kaixiong, et al., 2020. Characteristics of household transmission of COVID-19. Clin. Infect. Dis. 71 (8), 1943–1946.

Malmgren, Judith, Guo, Boya, Kaplan, Henry G., 2020. Covid-19 confirmed case incidence age shift to young persons age 0-19 and 20-39 years over time: Washington state march-april 2020. Cold Spring Harbor Laboratory Press, MedRxiv.

Markel, Howard, Lipman, Harvey B, Navarro, J Alexander, Sloan, Alexandra, Michalsen, Joseph R, Stern, Alexandra Minna, Cetron, Martin S, 2007. Nonpharmaceutical interventions implemented by US cities during the 1918–1919 influenza pandemic. JAMA 298 (6), 644–654.

Mogi, Ryohei, Spijker, Jeroen, 2021. The influence of social and economic ties to the spread of COVID-19 in Europe. J. Popul. Res. 1–17.

Pensieroso, L., Sommacal, A., 2014. Economic development and the family structure: From *Pater Familias* to the nuclear family. Eur. Econ. Rev. 71, 80–100.
Pensieroso, L., Sommacal, A., 2019. Agriculture to industry: The end of intergenerational coresidence. Rev. Econ. Dyn. 34, 87–102.
Ruggles, S., 2007. The decline of intergenerational coresidence in the United States, 1850 to 2000. Am. Sociol. Rev. 72, 964–989.
Ruggles, S., Flood, S., Foster, S., Goeken, R., Pacas, J., Schouweiller, M., Sobek, M., 2021. Integrated Public Use Microdata Series: Version 11.0 [dataset]. University of Minnesota.
Salcedo, A., Schoellman, T., Tertilt, M., 2012. Families as roommates: Changes in U.S. household size from 1850 to 2000. Quant. Econ. 3, 133–175.
Short, Kirsty R, Kedzierska, Katherine, van de Sandt, Carolien E, 2018. Back to the future: Lessons learned from the 1918 influenza pandemic. Front. Cell. Infect. Microbiol. 8, 343.
Taubenberger, Jeffery K., Morens, David M., 2006. 1918 Influenza: The mother of all pandemics. Revista Biomed. 17 (1), 69–79.
Verity, Robert, Okell, Lucy C, Dorigatti, Ilaria, Winskill, Peter, Whittaker, Charles, Imai, Natsuko, Cuomo-Dannenburg, Gina, Thompson, Hayley, Walker, Patrick GT, Fu, Han, et al., 2020. Estimates of the severity of coronavirus disease 2019: A model-based analysis. Lancet Infect. Dis. 20 (6), 669–677.
Wood, Rachael, Thomson, Emma, Galbraith, Robert, Gribben, Ciara, Caldwell, David, Bishop, Jennifer, Reid, Martin, Shah, Anoop SV, Templeton, Kate, Goldberg, David, et al., 2021. Sharing a household with children and risk of COVID-19: A study of over 300 000 adults living in healthcare worker households in Scotland. Arch. Dis. Child..
Woolf, Steven H., Masters, Ryan K., Aron, Laudan Y., 2022. Changes in Life Expectancy Between 2019 and 2020 in the US and 21 Peer Countries. JAMA Netw. Open 5 (4), e227067.