

1 **Risk factors for mortality of residents in nursing homes with Covid-**  
2 **19: a retrospective cohort study**

3 Clara Suñer PhD\*<sup>1</sup> & Dan Ouchi MsC\*<sup>1</sup>, Miquel Àngel Mas MD<sup>2,3</sup>, Rosa Lopez Alarcon<sup>4</sup>, Mireia Massot Mesquida<sup>7</sup>,  
4 Eugènia Negredo PhD<sup>1,5,6</sup>, Núria Prat, MD<sup>7</sup>, Josep Maria Bonet-Simó MD<sup>7</sup>, Marta Expósito Izquierdo MD<sup>7</sup>, Irene  
5 Garcia Sánchez MD<sup>7</sup>, Sara Rodoreda Noguerola MD<sup>7</sup>, Ramon Miralles MD<sup>2,3</sup>, Montserrat Teixidó Colet PhD<sup>7</sup>,  
6 Joaquim Verdaguer Puigvendrelló MD<sup>7</sup>, Norma Henríquez, PhD<sup>7</sup>, Michael Marks PhD<sup>8,9</sup>, Jordi Ara PhD<sup>7</sup> & Oriol  
7 Mitjà PhD<sup>1,5,10</sup>

8

9 \*Contributed equally

10 1. Fight AIDS and Infectious Diseases Foundation, Badalona, Badalona, Spain

11 2. Direcció Clínica Territorial de Cronicitat Metropolitana Nord, Institut Català de la Salut, Barcelona, Catalonia,  
12 Spain

13 3. Geriatrics Department, Hospital Universitari Germans Trias i Pujol, Badalona, Spain;

14 4. Direcció d'Organització i Sistemes d'Informació. Gerència Territorial Metropolitana Nord. Institut Català de la  
15 Salut, Barcelona, Catalonia, Spain

16 5. Infectious Diseases Department, Hospital Universitari Germans Trias i Pujol, Badalona, Spain

17  
18 6. Centre for Health and Social Care Research (CESS), Faculty of Medicine, University of Vic - Central University  
19 of Catalonia, Barcelona, Spain

20  
21 7. Direcció Atenció Primària Metropolitana Nord, Institut Català de la Salut, Barcelona, Catalonia, Spain

22 8. Clinical Research Department, London School of Hygiene & Tropical Medicine, London, United Kingdom

23 9. Hospital for Tropical Diseases, London, United Kingdom

24 10. Lihir Medical Centre- InternationalSOS, Lihir Island, Papua New Guinea

25

26

27

28 Corresponding author: Oriol Mitjà, [omitja@flsida.org](mailto:omitja@flsida.org), Hospital Germans Trias i Pujol, Carretera  
29 Canyet s/n, 08916, Badalona, Spain

30

## 31 **Abstract**

### 32 *Background and Objectives*

33 Nursing homes have shown remarkably high Covid-19 incidence and mortality. We aimed to  
34 explore the contribution of structural factors of nursing home facilities and the surrounding district  
35 to all-cause and Covid-19-related deaths during a SARS-CoV-2 outbreak.

### 36 *Methods*

37 Retrospective cohort study of Covid-19 mortality at the facility level in nursing homes in Catalonia  
38 (North-East Spain). The investigated factors included characteristics of the residents (age, gender,  
39 comorbidities, and complexity and/or advanced disease), structural features of the nursing home  
40 (total number of residents, residents who return home during the pandemic, and capacity for  
41 pandemic response, based on an ad hoc score of availability of twelve essential items for  
42 implementing preventive measures), and sociodemographic profile of the catchment district  
43 (household income, population density, and population incidence of Covid-19). Study endpoints  
44 included all-cause death and Covid-19-related death (either PCR-confirmed or clinical suspicion).

### 45 *Results*

46 The analysis included 167 nursing homes that provide long-term care to 8,716 residents. Between  
47 March 1 and June 1, 2020, 1,629 deaths were reported in these nursing homes; 1,089 (66.9%) of  
48 them were Covid-19-confirmed. The multivariable regression showed a higher risk of death  
49 associated with a higher percentage of complex patients (HR 1.09; 95%CI 1.05-1.12 per 10%  
50 increase) or those with advanced diseases (1.13; 1.07-1.19), lower capacity for implementing  
51 preventive measures (1.08; 1.05-1.10 per 1-point increase), and districts with a higher incidence  
52 of Covid-19 (2.98; 2.53-3.50 per 1000 cases/100,000 population increase). A higher population  
53 density of the catchment area was a protective factor (0.60; 0.50- 0.72 per log<sub>10</sub> people/Km<sup>2</sup>  
54 increase).

### 55 *Conclusion*

56 Presence of residents with complex/advance disease, low capacity for pandemic response and  
57 location in areas with high incidence of Covid-19 are risk factors for Covid-19 mortality in nursing  
58 homes and may help policymakers to prioritize preventative interventions for pandemic  
59 containment.

60

## 61 **Introduction**

62 Six months after the first outbreak of the novel coronavirus disease (Covid-19), the global death  
63 toll associated with the pandemic amounted to nearly half a million [1]. To date, various authors  
64 have reported on the major role of long-term care (LTC) facilities, such as nursing homes, in  
65 spreading SARS-CoV-2 to the most vulnerable populations during the Covid-19 pandemic [2].  
66 This group has experienced an extremely high death toll and also has overwhelmed local health

67 systems. In some countries, LTC residents account for more than 50% of deaths attributed to  
68 Covid-19. In Catalonia (North-East Spain), the government reported approximately 1,810 deaths  
69 among residents of LTC facilities between March 15 and April 15 [3].

70 To date, large variations in Covid-19 death rates across LTC facilities have been observed.  
71 Whether the high death rates are linked to the structural features of such settings or the poorer  
72 health of individuals in these facilities compared to those living elsewhere is still unclear. Because  
73 of the different policy implications of the relative influence of these features, there is a need to  
74 deepen into the determinants of SARS-CoV-2 spread and mortality in LTC facilities [4,5].

75 Potential risk factors of the residential setting are a communal living area, multiple residents in a  
76 single room, care provided by multiple caregivers – who may work across multiple different  
77 facilities, shortage of healthcare resources (e.g., tests, and personal protective equipment), limited  
78 access to skilled healthcare professionals, and the lack of specific guidance for managing the  
79 outbreak in the residential setting [2,3,6]. In addition to these setting-specific risk factors, the  
80 higher death rates are likely associated primarily with older age, high levels of multi-comorbidity,  
81 disability, and immune senescence of old-age [5,7–9]. Finally, some authors have identified risk  
82 factors associated with the characteristics of the population in the catchment area, such as the mean  
83 household income or the population density [10,11].

84 We aimed to assess whether living in a nursing homes for LTC is associated with an increased risk  
85 of death from Covid-19 beyond the risk associated with age and chronic health conditions. We  
86 used data from nursing homes, including residents' health characteristics, structural features, and  
87 the demographic and epidemiological profile of the district where the nursing home is located, to  
88 investigate the association between potential risk factors at the facility level and mortality in the  
89 residential setting during the SARS-CoV-2 outbreak in Spain.

## 90 **Methods**

### 91 *Study setting and participants*

92 This was a retrospective cohort study of Covid-19 mortality risk factors in the residential setting  
93 in Catalonia (North-East Spain). The study included clinical, mortality, and structural information  
94 corresponding to all public and private nursing homes in the administrative health region  
95 *Metropolitana Nord* (population 1,986,032 people) in Barcelona, Spain between March 1 and June  
96 1, 2020, during the Covid-19 outbreak. Skilled nursing facilities (i.e., intermediate care) and  
97 mental health facilities were excluded from the analysis.

98 On March 1, 2020, the Department of Health of Catalonia launched a comprehensive disease  
99 control program to minimize Covid-19 spread and mortality among residents in nursing homes.  
100 The containment strategy was implemented in all LTC facilities in the study area and involved 64  
101 primary care teams that reported daily information regarding the epidemiological status of each

102 nursing home. The primary care teams provided preventive epidemiological recommendations,  
103 including the partition of communal living areas, isolation of suspected cases and contacts,  
104 guidance on personal protective measures to nursing home workers. In the advent of a confirmed  
105 or suspected case of Covid-19, the teams also conducted systematic screening of close  
106 contacts—or all residents, in centers with high incidence—using real-time reverse transcription–  
107 polymerase chain reaction (rt-PCR) from nasopharyngeal swabs.

108 The study protocol was approved by the institutional review board of Hospital Germans Trias  
109 Pujol.

### 110 *Data collection*

111 Demographic and clinical data of residents were extracted from electronic medical records using  
112 a standardized data collection form [12]. The structural and organizational features of each nursing  
113 home were gathered at facility assessment visits by the study team. The demographic and  
114 epidemiological profile of the nursing home district was retrieved from the Statistical Institute of  
115 Catalonia. Deaths were identified from the Mortality Registry of the Department of Health of  
116 Catalonia. All data were handled according to the General Data Protection Regulation 2016/679  
117 on data protection and privacy for all individuals within the European Union and the local  
118 regulatory framework regarding data protection.

### 119 *Definitions*

120 Variables regarding the residents' health characteristics in each nursing home included  
121 demographic characteristics (i.e., age and gender), and clinical characteristics (i.e., number of  
122 comorbidities and percentage of residents with high dependence in activities of daily living,  
123 defined as a Barthel score < 50 [13]). We also recorded the percentage of residents identified on  
124 electronic medical records as complex chronic patients (CCP) and patients with advanced chronic  
125 disease (ACD) by their primary care teams, according to clinical guidelines of the Catalan Health  
126 Department [14]. These guidelines define CCP based on their clinical condition (e.g.  
127 multimorbidity, disability, difficult symptom control) and/or social environment (e.g., lack of  
128 support from family or caregivers, isolated household). Patients with ACD are those with advanced  
129 and irreversible chronic conditions that limit their life expectancy to approximately 12 months.  
130 Comorbidities were codified according to the ICD-10 system and included dementia, asthma or  
131 chronic obstructive pulmonary disease, hypertension, type-1 diabetes mellitus, type-2 diabetes  
132 mellitus, chronic kidney disease, cerebrovascular disease, cardiovascular disease.

133 Structural features of nursing homes were characterized according to their capacity for pandemic  
134 preparedness and response (SNQ12 score) and other relevant organizational variables such as  
135 current number of residents and percentage of residents who return home to live with their relatives  
136 due to the pandemic. The capacity of the nursing home for pandemic preparedness and response  
137 was assessed using an *ad hoc* set of 12 essential items that yields a score, called SNQ12 (*sine qua*

138 *non* conditions for implementing the measures) [15]. The score indicates the number of unmet  
139 requirements, which ranges from 0 (all requirements are met) to 12 (all requirements are unmet).  
140 The requirements are related to three areas: 1) personal protective equipment (PPEs) (adequate  
141 supply, routine use, and use for waste management and cleaning/disinfection), 2) surveillance and  
142 communication (routine monitoring of symptom onset by non-healthcare professionals and  
143 communication of symptoms to occupational health services), and 3) cleaning and waste  
144 management (regular hand washing before and after contact with Covid-19 patients or their  
145 contacts, adequate laundry procedures, cleaning and disinfection of surfaces, use of an adequate  
146 disinfectant, adequate disposal of used PPEs) (Appendix Figure 1).

147 The district demographic and epidemiological profile was assessed and defined using the  
148 household income and density of population in the municipality, and the population incidence of  
149 Covid-19 in the post code district (lowest administrative division) where the nursing home is  
150 located.

151 Deaths were classified as Covid-19-related when individuals had a positive rt-PCR or a clinical  
152 suspicion of Covid-19. Clinical suspicion of Covid-19 was defined based on the national  
153 guidelines available at the time as individuals with clinical features of acute respiratory disease of  
154 sudden onset and any severity, primarily characterized by fever, cough, and shortness of breath.  
155 Other symptoms such as odynophagia, anosmia, dysgeusia, muscular pain, diarrhea, chest pain, or  
156 headache could also be considered suggestive of SARS-CoV-2 at the physician's discretion.

### 157 *Statistical Analysis*

158 Continuous and categorical variables were presented as the mean and standard deviation (SD) (or  
159 median and interquartile range [IQR], defined by 25<sup>th</sup> and 75<sup>th</sup> percentiles) and number (%),  
160 respectively. The excess deaths were defined as the difference between deaths reported in 2020  
161 and the median of 2016-2019 for the same months of the year; the Covid-19 contribution to the  
162 excess deaths was computed by the difference between confirmed or suspected Covid-19 deaths  
163 and all-cause mortality. In our primary analysis to determine the risk factors associated with  
164 mortality, we used univariate and multivariate Poisson regression models at facility level.  
165 Variables for the multivariate model were treated as linear, and were chosen using an Akaike  
166 Information Criteria (AIC)-based backward stepwise procedure. Results were presented as the  
167 hazard ratio (HR) and the 95% confidence interval (CI). In a secondary analysis, we grouped the  
168 nursing homes according to their characteristics using cluster analysis based on k-nearest neighbor  
169 classifier [16,17]. The resulting clusters (phenogroups) were described in a heatmap that represents  
170 the intensity of each characteristic based on the difference (below or above) between the average  
171 of the given cluster and that of the overall sample. We used a random forest classifier and the Gini  
172 measure of importance [18] to determine the weight of each variable in each cluster. The  
173 significance threshold was set at a two-sided alpha value of 0.05. All analyses and plots were  
174 performed using R version 3.6 [19].

## 175 **Results**

### 176 *Characteristics of the nursing homes*

177 The analysis included 167 nursing homes providing long-term care to 8,716 residents. Table 1  
178 summarizes the characteristics of the nursing homes included in the analysis. The mean age was  
179 87.1 years, 56.6% of them were classified as CCPs and/or ACD patients, and 82.1% were identified  
180 as highly dependent. The median SNQ12 score was 1.4 unmet preventative items, reflecting an  
181 overall high level of pandemic preparedness. The individual demographic, clinical, and  
182 epidemiological characteristics of included residents are summarized in the Appendix Table 1.

### 183 *Mortality*

184 Between March 1 and June 1, 2020, a total of 1,629 deaths were reported in the nursing homes  
185 included in the analysis. Of these, 1,089 (66.9%) were registered as Covid-19 deaths in the  
186 mortality registry of the Department of Health. The cause of the death of the remaining 671 deaths  
187 could not be confirmed. Overall, the excess deaths in the analyzed nursing homes compared with  
188 the same period in the four previous years were estimated to be 971 deaths; Covid-19-confirmed  
189 deaths accounted for 89.2% of all excess mortality (Figure 1). At the nursing home level, the  
190 median (IQR) mortality rate was 14.3 (7.6 – 26.1) deaths/100 residents/3-month study period for  
191 all-cause death, and 3.9 (0.0 – 18.4) for Covid-19 confirmed deaths.

### 192 *Risk factors for mortality*

193 According to the multivariate analysis, the risk of Covid-19 related deaths was higher in nursing  
194 homes with a higher percentage of CCP patients (hazard ratio 1.09; 95%CI 1.05-1.12 per 10 units  
195 increase) or ACD patients (1.13; 1.07-1.19 per 10 units increase), lower capacity for pandemic  
196 preparedness and response (1.08, 1.05-1.10 per unit increase) and located in areas with high  
197 incidence of Covid-19 (2.98; 2.53-3.50 per 1000 cases/100,000 population increase) (Table 2).  
198 The risk factors of all-cause death were the same as those of Covid-19 related death. For Covid-  
199 19-related deaths, the univariate analysis revealed a higher risk of death in nursing homes with a  
200 high percentage of residents who returned home to live with their relatives. This variable was  
201 selected in the stepwise method, but it was not significantly associated with Covid-19-related  
202 deaths in the multivariate analysis. The only variable associated with lower all-cause deaths was  
203 living in high-density population areas (0.60; 0.50- 0.72 per log 10 people/km<sup>2</sup>). The risk factors  
204 significantly associated to all-cause death were the same as those of Covid-19 related death (Table  
205 2).

### 206 *Comparison of characteristics among nursing home clusters*

207 The cluster analysis based on the k-nearest neighbor classifier identified eight groups of nursing  
208 homes that were significantly different from each other. Resident health characteristics, structural

209 features, and sociodemographic factors were stratified according to each cluster. Figure 2  
210 illustrates the intensity of each characteristic (i.e., the extent of the difference between the mean  
211 of a given cluster and that of the entire sample) in the resulting clusters and the contribution of  
212 each characteristic to their definition. Key characteristics of each cluster were as follows:

213 Nursing homes in **cluster 1** were placed in low densely populated areas with high population  
214 incidence of Covid-19, and high household income; **cluster 2** were facilities with a high proportion  
215 of CCP and ACD patients, and located in areas with low population incidence of Covid-19; **cluster**  
216 **3** had low proportion of CCPs and highly dependent residents; **cluster 4** had higher number of  
217 residents than the median, although with a very low proportion of CCPs; nursing homes in this  
218 cluster were placed in areas with low household income; **cluster 5** had low proportion of ACD  
219 patients and dependent residents, and had higher number of residents that returned home with their  
220 relatives; **cluster 6** were placed in areas with high household income and low population incidence  
221 of Covid-19; **cluster 7** had high proportion of CCP and ACD patients; nursing homes in this cluster  
222 were located in densely populated areas; **cluster 8** had a high SNQ12 score—indicating very  
223 limited capacity for pandemic preparedness and response—and high proportion of CCPs and older  
224 residents than the median.

### 225 *Association of nursing home clusters with mortality*

226 The mortality rate in each cluster is shown in Figure 3. During the study period, the median (IQR)  
227 proportion of all-cause deaths and Covid-19-related deaths in the eight nursing home clusters was  
228 12.3% (7.6 - 26.1) and 3.9% (0.0 - 18.4), respectively. Clusters 1, 4, and 8 had a greater all-cause  
229 mortality rate than the median. Correspondingly, clusters 1, 7, and 8 had a greater Covid-19-related  
230 mortality rate than the median.

231

## 232 **Discussion**

233 To our knowledge this is the first study on risk of mortality at a facility level of residents with  
234 Covid-19 in nursing homes. Our analysis revealed that a ten percent increase in the proportion of  
235 residents with complex or advanced diseases increased the mortality risk by 9% and 13%,  
236 respectively; a 1-point increase in the 12-points score of unmet measures for containing SARS-  
237 CoV-2 spread increases the mortality risk by 8%, and an increase in population incidence of 1000  
238 Covid-19 cases per 100,000 population increases the mortality risk by 198%. Location in a highly  
239 densely populated area was the only factor associated with a reduced mortality rate, which might  
240 be related to improved access to hospitals with intensive care units in urban areas, as previously  
241 suggested [20].

242 The clustering of nursing homes according to their residents' profile and structural capacities  
243 provided a global perspective of the type of nursing homes that might be more susceptible to

244 Covid-19 mortality in the advent of future outbreaks. Consistently with our regression analysis,  
245 clusters with greater mortality than the median (cluster numbers 1,4,7, and 8) were all located in  
246 neighborhoods with high incidence of Covid-19. These results align with previous studies that  
247 reported a significant relationship between LTC mortality and Covid-19 incidence in the  
248 catchment area [5,10,11]. The increasing evidence on the influence of the local incidence of Covid-  
249 19 on mortality underscores the paramount importance of early detection—and response  
250 to—SARS-CoV-2 entry into facilities—often with new residents, staff, or visitors—for preventing  
251 uncontrolled outbreaks in this setting [5,21]. These finding also suggests that population efforts to  
252 contain Covid-19 incidence may also contribute to reducing Covid-19 deaths at their local nursing  
253 homes

254 The multiple regression and cluster analysis were also consistent regarding the importance of the  
255 capacity of the nursing home for pandemic preparedness and response. Although most nursing  
256 homes showed low SNQ12 scores—indicating few unmet needs for applying containment  
257 measures—facilities in cluster 8, characterized by higher SNQ12 scores (mean of 5 unmet items  
258 over a total of 12 essential requirements) than the median, experienced high mortality levels.

259 Finally, our multivariate analysis revealed a significant relationship between higher percentages  
260 of CCP and/or ACD patients and increased mortality risk. According to local clinical guidelines,  
261 CCP and ACD patients are characterized by high clinical complexity and the presence of an  
262 advanced—often terminal—disease, respectively [14], suggesting an increased likelihood of death  
263 in the advent of any infection or acquired disease. Interestingly, cluster no. 2, characterized by the  
264 higher health risk of its residents, had similar mortality than clusters 4, 5, and 6, with a more  
265 favorable resident health profile. These conflicting results suggest that the mechanisms driving  
266 mortality risk in nursing homes are complex and may depend on the conjunction of various factors.

267 Our analysis had the intrinsic limitations of retrospective studies, particularly regarding data  
268 completeness. Owing to the overload of the healthcare system during the investigated period, a  
269 large number of deaths could not be tested for SARS-CoV-2 PCR and remained unconfirmed. We  
270 were unable to gather information regarding the worker profiles in each nursing home. Unlike  
271 skilled nursing homes aimed at intermediate care or mental health resources, which tend to be  
272 coordinated by the healthcare authorities, non-specialized nursing homes aimed at long-term stay  
273 are a case-mix of organizational models. Hence, the inclusion of the characteristics of the work  
274 team profile (e.g., skills, resident/worker ratio, and presence of physicians) might have provided  
275 interesting insights regarding the capacity of the residence to cope with the outbreak [22].

276 Our results raise important policy implications by suggesting structural factors of the nursing  
277 homes and their surrounding districts that are important drivers of Covid-19-related mortality in  
278 this setting. Identification of facilities with low capacity for pandemic response, located in areas  
279 with high incidence of Covid-19 and low density of population (e.g., rural areas) could help public  
280 health officers to identify facilities where preventative interventions need to be prioritized. The



281 presence of complex patients and those with advanced chronic diseases also increased mortality  
282 risk, though these factors alone seem not to explain mortality trends at facility level. Efforts should  
283 be geared to protecting older adults living in the highest risk facilities.

284

## 285 **Disclosures**

### 286 *Contributors*

287 CS, DO, MAM, RLA and OM designed the study. DO, MAM, RLA, EN, MMM, NPG, JMB-S,  
288 MEI, IGS, SRN, RM, MTC, JVP, NH, JA collected the data. CS, DO, MM, OM analyzed the data.  
289 CS, DO, OM interpreted the data. CS, DO, OM wrote the manuscript. All authors reviewed and  
290 approved the final version of the manuscript.

291

### 292 *Declaration of interests*

293 We declare no competing interests.

294

### 295 *Acknowledgments*

296 The authors would like to thank Gerard Carot-Sans for providing medical writing support during  
297 the preparation of the manuscript.

298

### 299 *Funding*

300 Crowdfunding campaign YoMeCorono (<https://www.yomecorono.com/>), and Generalitat de  
301 Catalunya.

302

303

## 304 **References**

- 305 1. World Health Organization (WHO). Coronavirus disease (COVID-19) situation report - 163  
306 [Internet]. 2020 [cited 2020 Jul 24]. Available from: [https://www.who.int/docs/default-](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200701-covid-19-sitrep-163.pdf?sfvrsn=c202f05b_2)  
307 [source/coronaviruse/situation-reports/20200701-covid-19-sitrep-](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200701-covid-19-sitrep-163.pdf?sfvrsn=c202f05b_2)  
308 [163.pdf?sfvrsn=c202f05b\\_2](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200701-covid-19-sitrep-163.pdf?sfvrsn=c202f05b_2)
- 309 2. Trabucchi M, De Leo D. Nursing homes or besieged castles: COVID-19 in northern Italy.  
310 *The Lancet Psychiatry*. 2020 May 1;7(5):387–8.
- 311 3. Rada AG. Covid-19: The precarious position of Spain’s nursing homes. *BMJ*. 2020 Apr  
312 20;369.
- 313 4. Lau-Ng R, Caruso LB, Perls TT. COVID-19 Deaths in Long-Term Care Facilities: A  
314 Critical Piece of the Pandemic Puzzle. *Journal of the American Geriatrics Society*.  
315 Blackwell Publishing Inc.; 2020. p. jgs.16669.
- 316 5. McMichael TM, Currie DW, Clark S, Pogosjans S, Kay M, Schwartz NG, et al.  
317 Epidemiology of covid-19 in a long-term care facility in King County, Washington. *N Engl*  
318 *J Med*. 2020 May 21;382(21):2008–11.
- 319 6. Seshadri S, Concannon C, Woods JA, McCullough K, Dumyati G. “It’s like Fighting a War  
320 with Rocks:” Nursing Home Healthcare Workers’ Experiences During COVID-19. *Infect*  
321 *Control Hosp Epidemiol*. 2020 Aug 5;1–7.
- 322 7. Liu K, Chen Y, Lin R, Han K. Clinical features of COVID-19 in elderly patients: A  
323 comparison with young and middle-aged patients. *J Infect*. 2020 Jun 1;80(6):e14–8.
- 324 8. Amblàs-Novellas J, Santa Eugènia SJ, Vela E, Clèries M, Contel JC. What Lies Beneath :  
325 Clinical and Resource-use Characteristics of Institutionalized Older People . A  
326 Retrospective , Population-based Cohort Study in Catalonia. *BMC Geriatr*. 2020;1–17.
- 327 9. D’Adamo H, Yoshikawa T, Ouslander JG. Coronavirus Disease 2019 in Geriatrics and  
328 Long-Term Care: The ABCDs of COVID-19. *J Am Geriatr Soc*. 2020;68(5):912–7.
- 329 10. Sugg MM, Spaulding T, Lane S, Runkle JD, Harden S, Hege A, et al. Mapping community-  
330 level determinants of COVID-19 transmission in nursing homes: A multi-scale approach.  
331 *Sci Total Environ*. 2020;752:141946.
- 332 11. White EM, Kosar CM, Feifer RA, Blackman C, Gravenstein S, Ouslander J, et al. Variation  
333 in SARS-CoV-2 Prevalence in U.S. Skilled Nursing Facilities. *J Am Geriatr Soc*. 2020;1–  
334 7.
- 335 12. Catalan Health Service. eCAP [Internet]. 2018. [cited 2020 May 9]. Available from:  
336 [https://salutweb.gencat.cat/ca/ambits\\_actuacio/linies\\_dactuacio/tecnologies\\_informacio\\_i\\_](https://salutweb.gencat.cat/ca/ambits_actuacio/linies_dactuacio/tecnologies_informacio_i_comunicacio/ecap/)  
337 [comunicacio/ecap/](https://salutweb.gencat.cat/ca/ambits_actuacio/linies_dactuacio/tecnologies_informacio_i_comunicacio/ecap/)
- 338 13. Seematter-Bagnoud L, Lécureux E, Rochat S, Monod S, Lenoble-Hoskovec C, Büla CJ.

- 339 Predictors of functional recovery in patients admitted to geriatric postacute rehabilitation.  
340 Arch Phys Med Rehabil. 2013 Dec;94(12):2373–80.
- 341 14. Catalan Ministry of Health. Health Plan for Catalonia 2016-2020. A person-centred system:  
342 public, universal and fair. 2016.
- 343 15. Pla d'acció per la gestió de persones en l'àmbit residencial i l'assistència sanitària en  
344 situació de pandèmia per COVID-19. Barcelona Serv Català la Salut. 2020;
- 345 16. Levine JH, Simonds EF, Bendall SC, Davis KL, Amir EAD, Tadmor MD, et al. Data-Driven  
346 Phenotypic Dissection of AML Reveals Progenitor-like Cells that Correlate with Prognosis.  
347 Cell. 2015 Jul 3;162(1):184–97.
- 348 17. Blondel VD, Guillaume JL, Lambiotte R, Lefebvre E. Fast unfolding of communities in  
349 large networks. J Stat Mech Theory Exp. 2008 Oct 9;2008(10):P10008.
- 350 18. Breiman L. Random forests. Mach Learn. 2001;45:5–32.
- 351 19. R Core Team. R: A language and environment for statistical computing [Internet]. R  
352 Foundation for Statistical Computing, Vienna, Austria. 2017 [cited 2020 May 25].  
353 Available from: <https://www.r-project.org>
- 354 20. Ciminelli G, Garcia-Mandicó S. Mitigation Policies and Emergency Care Management in  
355 Europe's Ground Zero for COVID-19. SSRN Electron J. 2020;
- 356 21. Centers for Disease Control and Prevention (CDC). Discontinuation of Transmission-Based  
357 Precautions and Disposition of Patients with COVID-19 in Healthcare Settings (Interim  
358 Guidance) [Internet]. 2020 [cited 2020 Jul 27]. Available from:  
359 <https://www.cdc.gov/coronavirus/2019-ncov/hcp/disposition-hospitalized-patients.html>
- 360 22. Gorges RJ, Konetzka RT. Staffing Levels and COVID -19 Cases and Outbreaks in US  
361 Nursing Homes. J Am Geriatr Soc. 2020 Aug 28;jgs.16787.

362

363

364 **Tables**

365 **Table 1. Characteristics of nursing homes**

	<b>Total</b> <b>(N = 167)</b>
<b>Average resident profile</b>	
Age of residents, in years	87.1 (2.1)
Percentage of male residents	26.4 (9.6)
Number of comorbidities	1.5 (0.6)
Percentage of CCPs	46.1 (17.3)
Percentage of ACD patients	10.5 (8.9)
Percentage of dependent residents*	82.1 (9.5)
<b>Structural features</b>	
SNQ12 score	1.4 (1.7)
Current number of residents	46.2 (29.8)
Percentage of residents who return home	1.4 (3.0)
<b>District demographic and epidemiological profile</b>	
Mean household income, in Euro	36099.6 (5527.5)
Density of population per km <sup>2</sup> , in log <sub>10</sub>	17.9 (9.5)
Population incidence of Covid-19	0.9 (0.3)

366  
 367 Data are mean (SD). CCP=complex chronic patient. ACD=advanced chronic disease. SNQ12=number of unmet  
 368 epidemic and infection control preparedness requirements (0-12). \*Barthel score < 50.  
 369

370 **Table 2. Estimated effect of long-term care facilities' features in all deaths and Covid-19 related deaths.**

	All-cause deaths			Covid-19-related deaths		
	Univariate analysis	Multivariate analysis		Univariate analysis	Multivariate analysis	
	Hazard Ratio (95% CI)	Hazard Ratio (95% CI)	p-value	Hazard Ratio (95% CI)	Hazard Ratio (95% CI)	p-value
<b>Average resident profile</b>						
Age of residents in each facility †	0.99 (0.83-1.18)	..		0.99 (0.97-1.01)	..	
Percentage of male residents	1.01 (1.03-1.05)	..		1.00 (0.95-1.05)	..	
Number of comorbidities †	1.15 (1.08-1.22)*	..		1.35 (1.25-1.46)*	..	
Percentage of CCPs	1.04 (1.02-1.06)*	1.04 (1.02-1.06)	0.0015	1.10 (1.06-1.11)*	1.09 (1.05-1.12)	<0.0001
Percentage of ACD patients	1.09 (1.05-1.13)*	1.09 (1.04-1.13)	0.0002	1.15 (1.10-1.20)*	1.13 (1.07-1.19)	<0.0001
Percentage of dependent residents	1.03 (1.01-1.07)	..	..	1.00 (0.95-1.05)	..	..
<b>Structural features</b>						
SNQ12 §	1.06 (1.04-1.08)*	1.04 (1.03-1.07)	<0.0001	1.11 (1.09-1.14)*	1.08 (1.05-1.10)	<0.0001
Current number of residents†	1.00 (0.99-1.01)	..	..	1.00 (0.98-1.02)	..	..
Percentage of residents who return home	1.03 (0.91-1.14)	..	..	1.17 (1.01-1.31)*	..	..
<b>Sociodemographic profile</b>						
Mean household income, in Euro‡	0.95 (0.90-1.02)	..	..	0.95 (0.86-1.04)	..	..
Density of population, log10 people/km² §	0.84 (0.74-0.95)*	0.67 (0.59-0.77)	<0.0001	0.91 (0.77-1.08)	0.60 (0.50-0.72)	<0.0001
Population incidence of Covid-19	1.67 (1.48-1.87)*	1.79 (1.59-2.03)*	<0.0001	2.72 (2.33-3.18)*	2.98 (2.53-3.50)*	<0.0001

371

372 CCP= complex chronic patient; ACD= advanced chronic disease; Dependent resident=Barthel score < 50; SNQ12=  
373 number of unmet essential items for implementing preventive measures (0-12).

374

375 Hazar ratios and 95% CI are shown.

376 HR represents the estimated effect for an increase of 10 units, unless otherwise indicated.

377 † HR for an increase in 1 unit.

378 ‡ HR for an increase of 10,000€/annum in mean household income.

379 § HR for an increase in 1 log10 people/km².

380 || HR for an increase in incidence of Covid-19 of 1,000 cases/100,000 population.

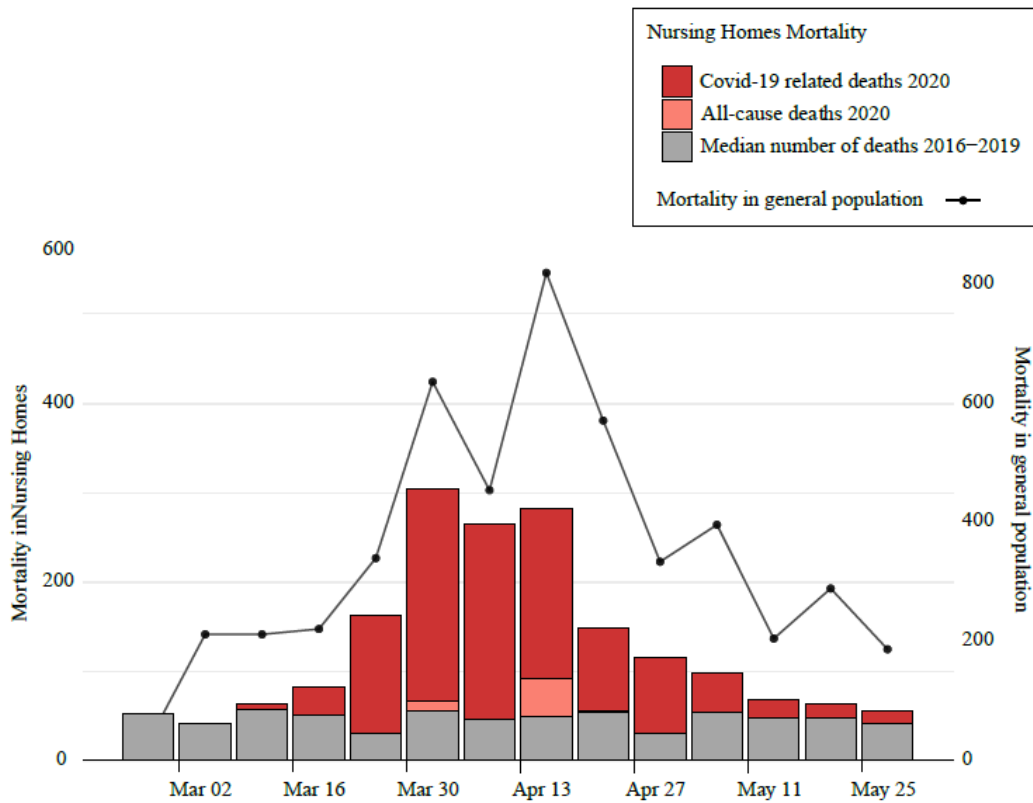
381 \*p-value for univariate analysis <0.05

382

383 **Figure Legends**

384 [Figures are presented herein in low resolution for rapid assessment; it will be formatted  
385 adequately before submission]

386

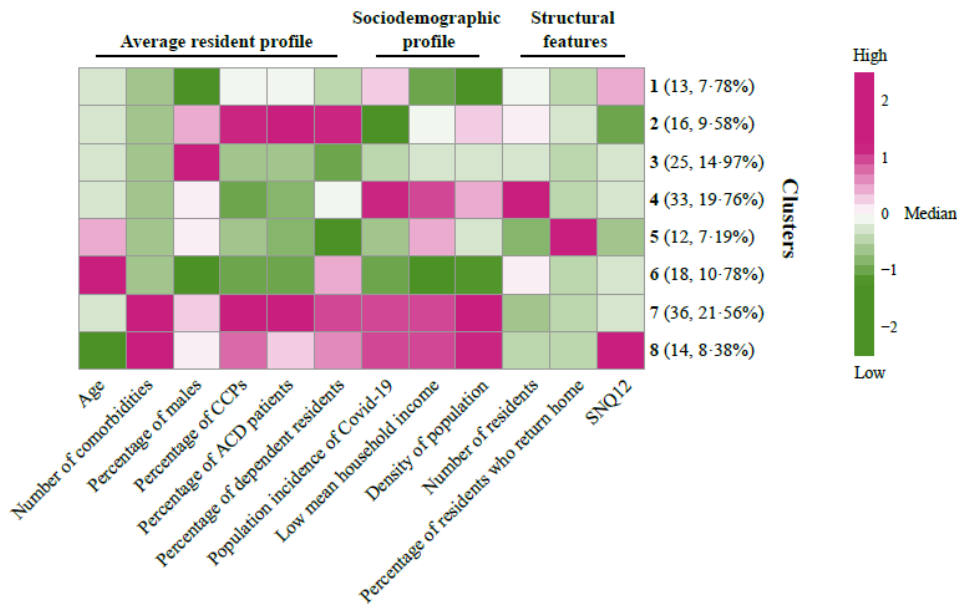


387

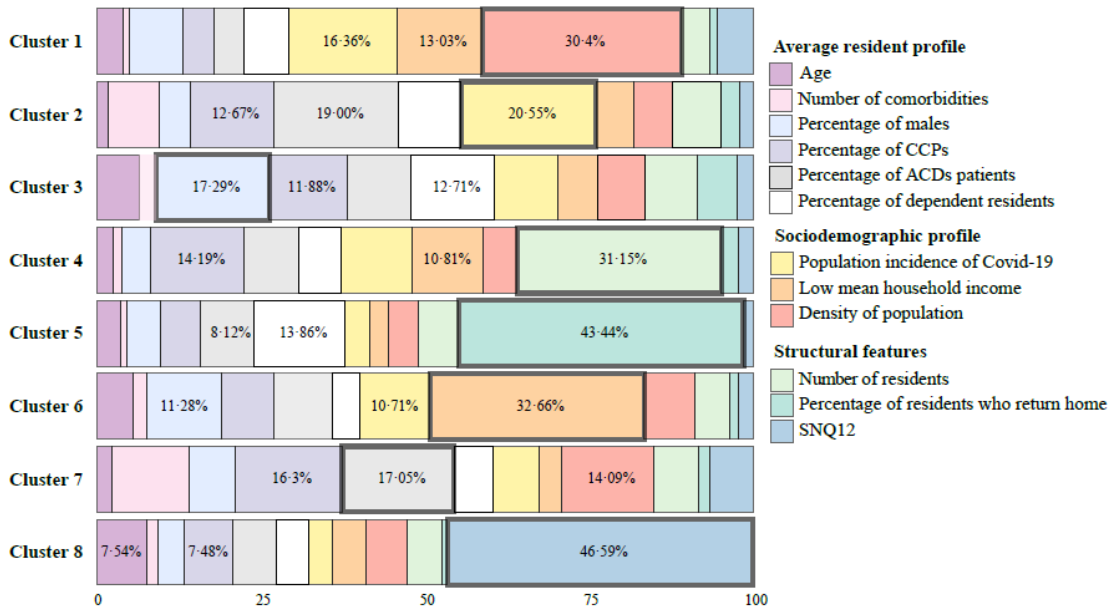
388 **Figure 1. Excess mortality of 2020 relative to the average of the past four years (2016-2019).** Bars show the  
 389 number of weekly deaths reported in 2020 in all nursing homes included in the analysis over the study period. Deaths  
 390 reported in 2020 have been classified as Covid-19 confirmed and unconfirmed, which include deaths of individuals  
 391 with suspected Covid-19 diagnosis. The median number of deaths for the same weeks in the previous 4 years (2016-  
 392 2019) is shown in grey. The continuous line shows the death toll attributed to Covid-19 in the general population of  
 393 the catchment area.

394

A



B

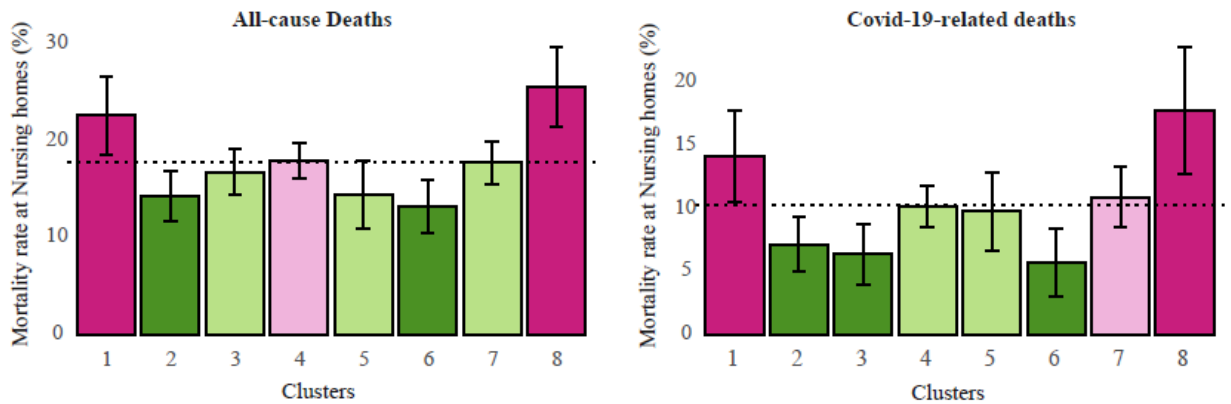


395

396

397 **Figure 2. Heatmap of nursing home clusters.** (A) Heatmap of nursing home clusters. For each characteristic (x-  
 398 axis), the extent of the difference between the mean of a given cluster and the median of the entire sample is illustrated  
 399 with the following color code: green tones indicate a mean of the cluster below the median of the entire sample,  
 400 whereas purple tones indicate a mean of the cluster above the median of the entire sample. In both cases, more intense  
 401 colors represent greater differences between the cluster and the whole sample. For each cluster, the number of nursing  
 402 homes is indicated (n, % of total). Appendix Figure 1 provides further details regarding the mean (SD) of the  
 403 characteristics in each cluster. (B) Contribution of variables to each cluster. Percentage is shown for the three variables  
 404 with greater weight. Black squares highlight the most important variable.

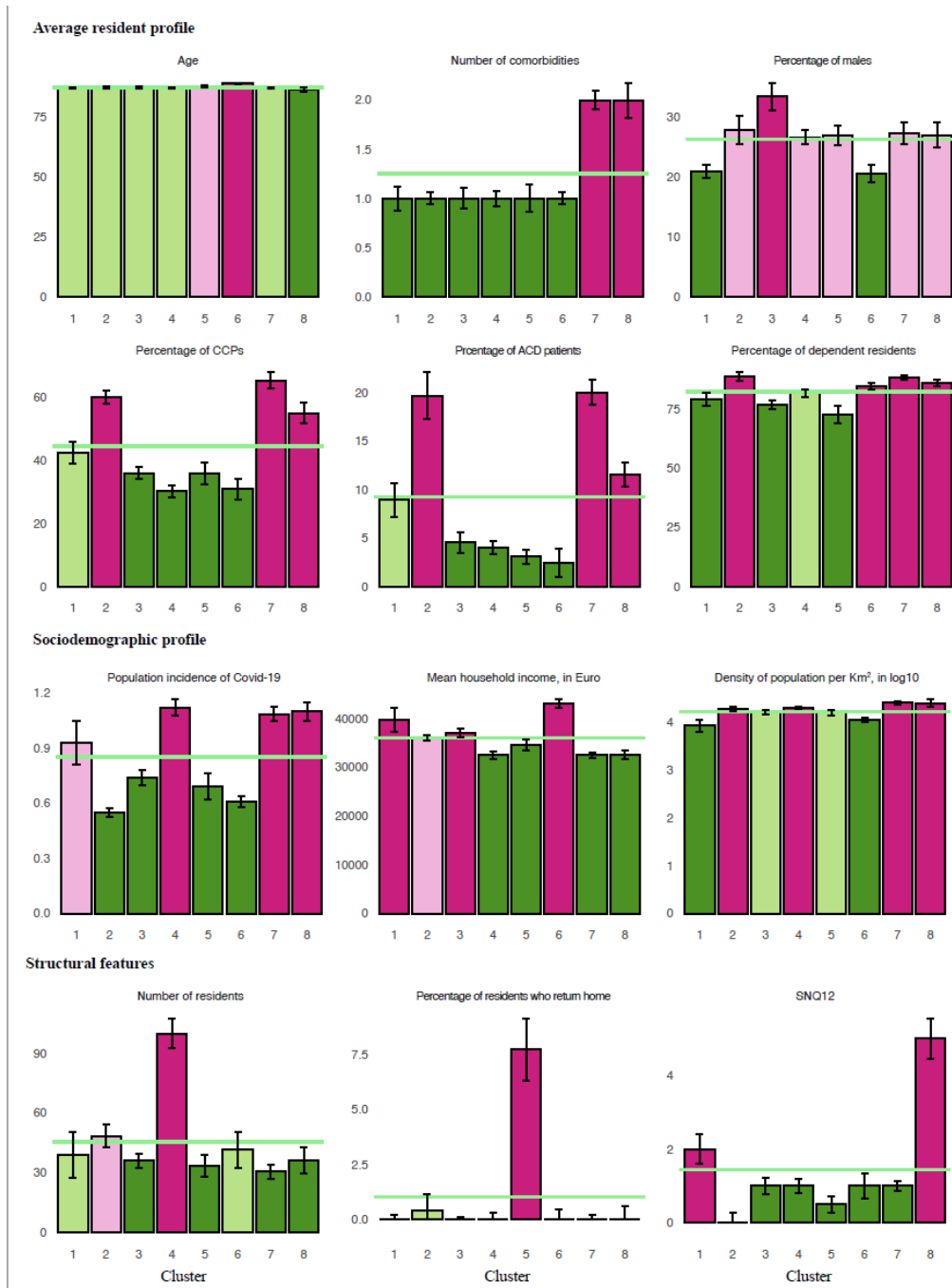




406  
407

408 **Figure 3. Mortality at the cluster level for all-cause deaths and Covid-19 related deaths.** The dotted line shows  
409 the median mortality rate for the entire sample. Bars show the mean mortality rate of each cluster; error lines represent  
410 the standard error of the mean (SEM). Red and green indicate mean cluster mortality higher and lower than the total  
411 median, respectively. For both colors, light tones indicate that the SD of the cluster encompasses the overall median,  
412 whereas intense tones indicate that the whole SD range is above (red) or below (green) the total median.

413



414

415

416 **Appendix Figure 1. Characteristics among nursing home clusters.** For each cluster (x-axis), barplots show the  
 417 mean (SD) of a given characteristic. The median of the entire sample is shown with a green line. The extent of the  
 418 difference between the mean of a given cluster and the median of the entire sample is illustrated with the following  
 419 color code: green tones indicate a mean of the cluster below the median of the entire sample, whereas purple tones  
 420 indicate a mean of the cluster above the median of the entire sample. In both cases, more intense colors represent  
 421 greater differences between the cluster and the whole sample.

422

423

424

425

426

427

428