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Individual and Spatial Determinants of Mortality During the Covid-19 Pandemic: The Case of Belgium in 2020

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ABSTRACT

The Covid-19 pandemic marked the year 2020. In Belgium, it led to a doubling in deaths, mainly grouped into two periods. This article aims to compare the relative importance of predictors and individual and spatial determinants of mortality during these two waves to an equivalent non-pandemic period and to identify whether and to what extent the pandemic has altered the sociodemographic patterns of conventional mortality. The analyses relate to all-cause mortality during the two waves of Covid-19 and their equivalent in 2019. They are based on matching individual and exhaustive data from the Belgian National Register with tax and population census data. A multi-level approach combining individual and spatial determinants was adopted. Mortality patterns during and outside the pandemic are very similar. As in 2019, age, sex, and household composition significantly determine the individual risk of dying, with a higher risk of death among the oldest people, men, and residents of collective households. However, their risk of death increases during the Covid period, especially in the 65–79 age group. Spatial information is no more significant in 2020 than in 2019. However, a higher risk of death is observed when the local excess mortality index or the communal proportions of single-person households or disadvantaged people increase. While the Covid pandemic did not fundamentally alter conventional mortality patterns, it did amplify some of the pre-existing differences in mortality.

1 | Introduction

The Covid-19 pandemic was the deadliest episode in the history of Belgium since the Second World War, incurring more than 33,000 deaths between 2020 and 2022. Regardless of the method used to count deaths[1], which varies from country to country, the mortality rate from Covid-19 in 2020 was exceptionally high in Belgium (Bustos Sierra et al. 2020; Sánchez-Páez 2022). Two waves of excess mortality were identified in 2020 (Figure 1). The first ran from mid-March to the end of April 2020, and the second from mid-October to the end of December 2020. Both were characterised by a doubling in the number of deaths compared with a non-pandemic situation (the monthly average of deaths observed between 2016 and 2019). This translates into a loss of 1 year of life expectancy at birth in Belgium between 2019 and 2020 (Bourguignon et al. 2022), one of the most important in the world (Aburto et al. 2021; Islam et al. 2021).

Many studies focused on the spatial or individual determinants of Covid-19 mortality (Bonnet et al. 2024; Chang et al. 2022; Gerken et al. 2022; Konstantinoudis et al. 2022). However, there

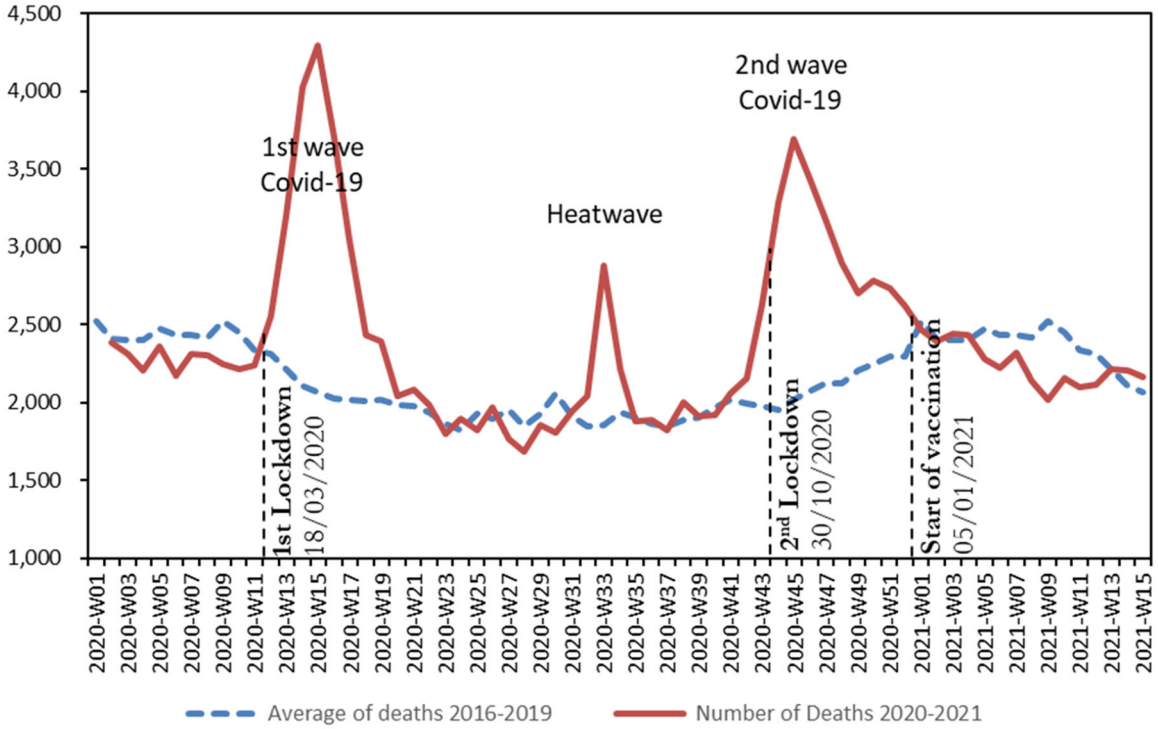

FIGURE 1 | Trends in excess mortality linked to Covid-19 in Belgium. *Source:* Statbel, authors' calculations.

still is a need to understand the relative importance of spatial versus individual determinants of Covid-19 mortality (Bonnet et al. 2024; Konstantinoudis et al. 2022). This article contributes to current knowledge by looking at Covid-19-related mortality with both individual and spatial determinants and assessing whether it follows the usual mortality trends or defines its own path. Thanks to register-based data, we investigate the role of individual and spatial factors—selected through an analysis of the existing literature—on mortality in 2020, using a comparative approach with 2019, and we rank their relative importance. We also observe how these results vary from wave to wave and for different large age groups.

2 | Background

2.1 | Individual Determinants

Studies agree that the risk of mortality from Covid-19 significantly increases with age, particularly in high-income countries (Bauer et al. 2021; Guilmoto 2020; Islam et al. 2021; Pifarré i Arolas et al. 2021; Williamson et al. 2020). This association is conspicuous in Belgium, particularly during the first wave of the pandemic, and after 65 (Bourguignon et al. 2022). This can be explained by health status: as age increases, health status deteriorates (Bambra et al. 2020). Moreover, the risk of contamination and death linked to Covid-19 is greater in people with co-morbidities such as cardiovascular disease, diabetes, cancer, and lung disease (Atkins et al. 2020; Burström and Tao 2020). During the second wave, the gradient of excess mortality by age in Belgium persists but is less clear-cut, with a convergence between the populations aged 75–84 and 85 and more (Bourguignon et al. 2022).

In addition, household composition may have impacted the risk of dying from Covid-19, given the importance of interpersonal contact in transmitting the virus. According to a study of people over 65 living at home in England (Nafilyan et al. 2021), living in a multigenerational household is associated with a higher risk of death (compared with a two-adult household). Another study in Los Angeles in the United States showed a positive association between household size and Covid-19 mortality (Varshney et al. 2022). In the case of Stockholm, the risk of dying from Covid-19 was higher for elderly people living with working age adults than for those living alone (Brandén et al. 2020).

In many countries, residential institutions for the elderly were affected by an exceptionally high Covid-19 related mortality (Brandén et al. 2020; Kemenesi et al. 2020). In Belgium, during the first wave, they accounted for 50% of Covid-19 related deaths (Sciensano 2020) and 65% in Wallonia (the south region of Belgium), whereas only 1.3% of the Walloon population resides in such establishments (Hardy et al. 2021). For the whole country, the standardised mortality rate for people living in collective households in 2020 was 1.7 times higher than in 2015–2019 in the first wave and 1.5 times higher in the second wave (Bourguignon et al. 2022). This excess mortality is due to the residents' age and state of health but also to the proximity in these residences between individuals and with carers (Davidson and Szanton 2020; Kemenesi et al. 2020). The health crisis highlighted structural weaknesses in Belgium, including a lack of resources (e.g., face masks) and staff that these establishments were experiencing (Hardy et al. 2021).

Covid-19 mortality was higher in men than in women at any age in most countries (Aburto et al. 2021; Ahrenfeldt et al. 2021), including Belgium (Gadeyne et al. 2021). In classic

mortality patterns, the gender gap changes over the life course: it increases until the age of 60–69, then gradually decreases to become very small after the age of 80 (Ahrenfeldt et al. 2021). Health inequalities between genders could explain this trend for older age groups.

The influence of nationality on the risk of death from Covid-19 is less univocal. People of foreign nationality were shown to be affected by higher excess mortality during the pandemic period than natives in Sweden, irrespective of age and socioeconomic characteristics (Drefahl et al. 2020), and in the United States and the United Kingdom (Abedi et al. 2021; Andrasfay and Goldman 2021; Williamson et al. 2020). In Italy, however, mortality patterns for migrants and non-migrants in 2020 did not differ significantly from those observed in the preceding years (Canevelli et al. 2020).

Several studies have shown that Covid-19 hit the disadvantaged social classes harder (Abedi et al. 2021; Andrasfay and Goldman 2021; Barhoumi et al. 2020; Chen and Krieger 2021; Mayer 2022; Williamson et al. 2020). Firstly, disadvantaged populations are characterised in Belgium by more widespread risk behaviours (smoking, poor dietary habits), less understanding of and adherence to health and hygiene measures to combat the disease, and limited access to and/or use of good quality healthcare (Gadeyne et al. 2021). Co-morbidities at an earlier age are more prevalent among the most disadvantaged populations, increasing the risk of dying from Covid-19 (Bambra et al. 2020; Williamson et al. 2020). Secondly, socially disadvantaged populations live more often in densely populated neighbourhoods and housing, which triggers higher risks of infection and mortality (Bambra et al. 2020; Barhoumi et al. 2020). Thirdly, working-age disadvantaged populations were over-represented among 'front-line' workers (e.g., health professionals, grocery store employees...), which have not benefited as much from the protective effects of containment and teleworking (Bambra et al. 2020; Barhoumi et al. 2020).

In Belgium, the few studies considering the social dimension of Covid-19 present variable results depending on the methodologies and social-positioning indicators used, but also according to the age group. Income is negatively associated with excess mortality among the elderly in Belgium in the first wave (Decoster et al. 2021). Conversely, when using income and level of education as indicators of social inequality, the highest levels of excess mortality were among the high-income men aged 25–64 and middle- and high-income men and women aged 65–84 (Gadeyne et al. 2021). Excess mortality is visible among all social groups[2] based on an excess mortality index[3] calculated for the two Covid-19 waves in 2020 (Bourguignon et al. 2022). However, the most disadvantaged social group shows the highest level of excess mortality, with a visible social gradient that is more marked for the population aged 40–79 than for those aged 80 and over, especially in the second wave. The difference in life expectancy loss in 2020 remains limited between social groups: 1 year for the most disadvantaged social group versus 0.7 year for the most advantaged one (Bourguignon et al. 2022).

2.2 | Spatial Determinants

Like other epidemics, Covid-19 has a particular spatial structure (Amdaoud et al. 2021). Certain characteristics of the place of residence can impact the individual risk of dying from Covid-19. The relationship between the space and COVID-19 mortality is multiple, diverse and complex (Bonnet et al. 2024). Many characteristics of the region—such as the environment, the spatial organisation, the socioeconomic composition of the population, and the services available in the close environment (Śleszyński 2021; Sun et al. 2021) can be related to the spread of a virus. Through the literature, we highlight three main elements that are particularly important in the spread of the virus and the mortality consequent to its contamination.

First, *population density* and the area's nature (urban, periurban, rural) play a significant role in the spread of the virus (Fonseca-Rodríguez et al. 2021). A crowded environment is associated with a higher risk of spreading the disease. In the United States, among the seven most affected states, the most densely populated counties had the highest contamination rates (Abedi et al. 2021). In France, the departments with the highest urbanisation rates experienced the highest excess mortality during the first wave of Covid-19 (Pilkington et al. 2021). In addition to the characteristics and density of the area, the contagious nature of Covid-19 means that the closer an area is to a source of contamination, the greater the probability that it will be affected by the epidemic (Amdaoud et al. 2021), especially among people with low immune systems like the elderly. Spread by contagion has been observed in France's departments (Levratto et al. 2020) and in China's provinces (Kang et al. 2021). Containment has proved to be an effective solution to limit this contagion, as highlighted in France (Gaudart et al. 2021). In New York and Chicago, the 'cold spots' identified based on diagnosed cases were distinguished by their ability to maintain physical distancing (Maroko et al. 2020). The density at the household level also matters in the spread of the virus as shown by the higher contamination in the neighbourhoods with a high proportion of overcrowded housing (Maroko et al. 2020).

Second, there are regional inequalities regarding healthcare access. If an area has a smaller and more dispersed healthcare system, this implies a lower or slower response capacity in critical situations. At the French departmental level, a strong association was found between high levels of excess mortality and poor primary care provision during the first wave of the epidemic (Pilkington et al. 2021).

Third, the social environment influences exposure to the virus and the probability of dying (Schlüter et al. 2022). Living in a socially disadvantaged neighbourhood (Riou et al. 2021; Vandentorren et al. 2022) is cited as a factor in infection and excess mortality. In Belgium, a significant association has been detected at the municipal level between the number of infections and social precariousness (Meurisse et al. 2022). Still, less is known about the relationship between living in a disadvantaged neighbourhood and mortality during the pandemic period, especially when controlling for individual socioeconomic positions.

2.3 | Research Questions and Hypotheses

A lot is known about the individuals' characteristics and the close environment that can impact mortality risk during the Covid period. But some questions remain unanswered: what elements matter the most? Are the associations between individual factors and mortality during Covid-19 still robust after controlling for spatial factors, and vice-versa? And what differences can we observe between the Covid period and a 'classic' period, as well as over the pandemic periods and across age groups?

This article has two objectives. Firstly, we aim to measure the relative importance of individual and spatial determinants for the first time by ranking their weight in mortality risk in 2020. Secondly, we investigate which characteristics are associated with excess mortality in the Covid-19 period. These two objectives are part of a comparative perspective. Firstly, the analyses compare two types of mortality patterns, 'classic' (2019) and 'pandemic' (2020). The analyses are carried out separately for each Covid wave in 2020, systematically compared with the two equivalent periods in 2019. Finally, the analyses cover the whole population and three major age groups (40–64, 65–79, 80 +), which may have been affected differently by the pandemic.

Our analyses and reflections are based on three hypotheses.

1. First, when we consider both individual and spatial determinants, we expect that mortality is mainly explained by some individual variables (age, sex, social group, etc.), both in an epidemic context and in a 'classic situation' (2019). Elderly, men, disadvantaged social groups and residents of collected households are expected to be more vulnerable groups and associated with higher excess mortality.
2. Even if spatial variables have a lower relative importance on mortality than some individual variables, we expect the role of the spatial factors to be larger in a pandemic context than in a 'classical situation (2019)', due to the infectious nature of the disease. Factors such as living in a dense or urban area, with high level of local precariousness, low access to healthcare centres and excess mortality in the neighbourhood are expected to be associated with higher risks of death.
3. Finally, the influence of both individual and spatial determinants on excess mortality in 2020 would be modified by the age group. We expect a higher effect of socioeconomic precariousness (at individual and spatial levels) for working-age adults. In contrast, the household type and density of the population at the local level would threaten older adults more (as they are more vulnerable to interpersonal contamination).

3 | Data and Methods

3.1 | Data

The study relies on an anonymised Register-based individual database (Demobel) that covers Belgium's entire legally domiciled population, that is, over 11 million individuals. Registration in these databases is compulsory. In theory, only illegal migrants, asylum seekers, and diplomatic personnel are not covered by this data source. The registration system in Belgium comes from the local level (municipalities) and then centralises information at the national level. The reliability of the Register data has improved over time and has been very good quality since the 1990s, even at the local level (Poulain and Herm 2013). This database, developed by the Belgian Statistical Office (Statbel), links the National Register, 2001 and 2011 censuses, and the tax register for 2002–2022. The National Register provides information on the sociodemographic characteristics (age, gender, type of household, place of residence, deaths, etc.) of individuals. The censuses and the tax register provide information on the socioeconomic characteristics of individuals (education, occupation, housing conditions, tax income). This database provides the date of death, which allows us to identify individuals who died during the two periods of Covid-related excess mortality in 2020 covered by our article.

Our approach is based on an analysis of all-cause mortality. Our analyses focus on the months marked by excess mortality associated with Covid-19: from March to May 2020 (first wave); from October to December 2020 (second wave). Over time, individual characteristics (except socioeconomic group) are measured each January 1st. They are time-varying: the closest available information was assigned to the population (e.g., 1st January 2020 for the survivors of the 1st wave and those who died in 2020; 1st January 2021 during the second wave for those who survived 2020).

Multilevel models include several covariates: five individual factors and six spatial factors. We chose these covariates based on the literature and their availability in the Belgian context. Table A1 (in the appendix) describes the variables, their source and their values in detail. **Individual variables** include (1) the age of individuals, (2) their sex, (3) the composition of their household, (4) their nationality, and (5) their social precariousness.

A multidimensional indicator of social precariousness captures the socioeconomic category of individuals based on four dimensions that traditionally enable individuals to be positioned socially (Cambois and Jusot 2007; Kunst and Mackenbach 1994): education, employment category, housing conditions and household income. While the correlation between these dimensions is high, they each play a different role in health status and mortality. Level of education measures cultural capital. It will determine attitudes toward preventative behaviours, use of healthcare, and access to healthcare. Income, employment category, and housing conditions refer more to material resources and standard of living (Cambois and Jusot 2007). This multidimensional index considers each individual's overall situation and has been divided into score quartiles: disadvantaged, low intermediate, high intermediate, and advantaged (Eggerickx et al. 2020). A fifth group was observed: the 'undetermined', for whom no information is available for at least two of the dimensions considered, either because they did not answer the questions or were not present at the time of the census (e.g., children born or immigrants arrived in after 2011).

While the household income comes from the 2017 tax returns, information about education, socio-professional category and housing characteristics are based on data from the 2011 Census. Implicitly, we assume that people's position on the three dimensions of the indicator has not changed over the observation period. This assumption is restrictive, but the income level partially makes it possible to correct this constraint. Secondly, the level of education changes very little beyond the age of 25. Finally, previous work (Eggerickx et al. 2021) shows that housing characteristics vary less for the elderly (i.e., the group most represented among those who died during the pandemic period) insofar as mobility beyond the age of 55 is relatively low.

Spatial variables refer to some characteristics of individuals' municipality of residence, or to the proportion of residents of the same municipality who share similar individual characteristics. First, we measure the *area's population density* through the municipality's population density and the position of the municipality of residence in the country's urban hierarchy. Urban hierarchy is based on the typology of urban residential complexes developed by Vanderstraeten and Van Hecke (2019). It distinguishes five types of places: the conurbation, suburbs (urbanised belt of around urban centre), ZMAs (*zones des migrants alternants*, areas outside cities with a substantial commuter population, small towns, and the rural environment (areas not classified within the urban hierarchy). Then, the proportion of isolated households (one person) is a good way to estimate the risk of spreading the disease within the household. Second, healthcare access will be assessed based on the distance to the nearest hospital. The distance between the municipality and the nearest hospital is calculated from the centroid of the individual municipalities of residence. It therefore does not include information on travel time which, in specific rural contexts in the south of Belgium, for example, can also indicate other inequalities in healthcare access. Third, we compute the *social environment* with the proportion of disadvantaged people in the municipality of residence. Finally, we calculated the level of excess mortality (i.e., mortality observed in 2020 compared to the average of 2016–2019) in all municipalities within 20 kilometres of the municipality of residence (including the municipality of residence) to represent the extent to which the immediate environment is affected by Covid-19. This last variable does not correlate highly with the other spatial variables and models without it were conducted. They confirmed that it does not capture the association between spatial characteristics and mortality.

3.2 | Methods

We aim firstly to identify the individual and spatial determinants of mortality (at the municipal level) during the Covid-19 pandemic. This implies that all individuals from the same municipality will present the same information on spatial determinants and that our data set presents a hierarchical structure. We thus model the individual probability of dying during each of the two waves of excess mortality during Covid-19 with a multilevel random-effects logistic model:

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + \beta X_{ij} + \beta X_j + u_{0j} \text{ where } u_{0j} \sim N\left(0, \sigma^2_{u0}\right) \quad (1)$$

where p_{ij} denotes the probability of an individual i residing in a municipality j dying during a Covid-19 wave; X_{ij} a vector of individual explanatory variables; X_j a vector of spatial explanatory variables; u_{0j} a random residual term at the level of the groups defined by the municipalities (this term groups together the unobservable random effects at the municipality level). Estimates at the individual level will be interpreted given that we control for spatial determinants, and vice-versa.

In total, 16 models are produced for the total population and three main age groups (40–64, 65–79, 80 +), for each of the two waves in 2020 and the two equivalent periods in 2019 in a comparative approach (Figure 2). Models for under-40's were not considered, as no excess mortality in this population was observed in 2020 in the descriptive analyses (Bourguignon et al. 2022).

Then, estimating the relative importance of the different explanatory variables involves analysing the marginal contributions of the predictors in reducing the unexplained variability of mortality, all other things being equal (for a fixed value of the other variables introduced into the model). For each explanatory variable, we calculated a partial pseudo-correlation (R) adapted to the logistic model (Bhatti 2006):

$$R = \pm\sqrt{\frac{Wald\ statistic - 2K}{-2LL_0}} \quad (2)$$

Where K is the number of degrees of freedom of the explanatory variable, and LL is the log-likelihood of the empty model without independent variables. In other words, the R-value estimates the contribution of each variable to explain the variance of the outcome, compared to the model without that variable. Partial pseudo-correlation is interpreted similarly as a correlation coefficient (between −1 and 1). In our case, the absolute value of the indicator will be used, as we are interested in the intensity of partial pseudo-correlations independently of their direction.

3.3 | Analysis of an Exhaustive Population

Our register-based data set is not a representative sample of Belgium's resident population but the total population residing in Belgium, which is included in the national register. Given the exhaustiveness of the data, this research does not fall within the inferential statistics framework, which should be used when the data constitute a sample and the results are expected to be generalised to a larger population (White and Gorard 2017). Thus, the b parameters derived from the regression models are not an estimate of the sample parameter to which a confidence level is assigned. These parameters represent the effect of an explanatory variable on the variable of interest in the population studied. In this way, we do not interpret using the tools of

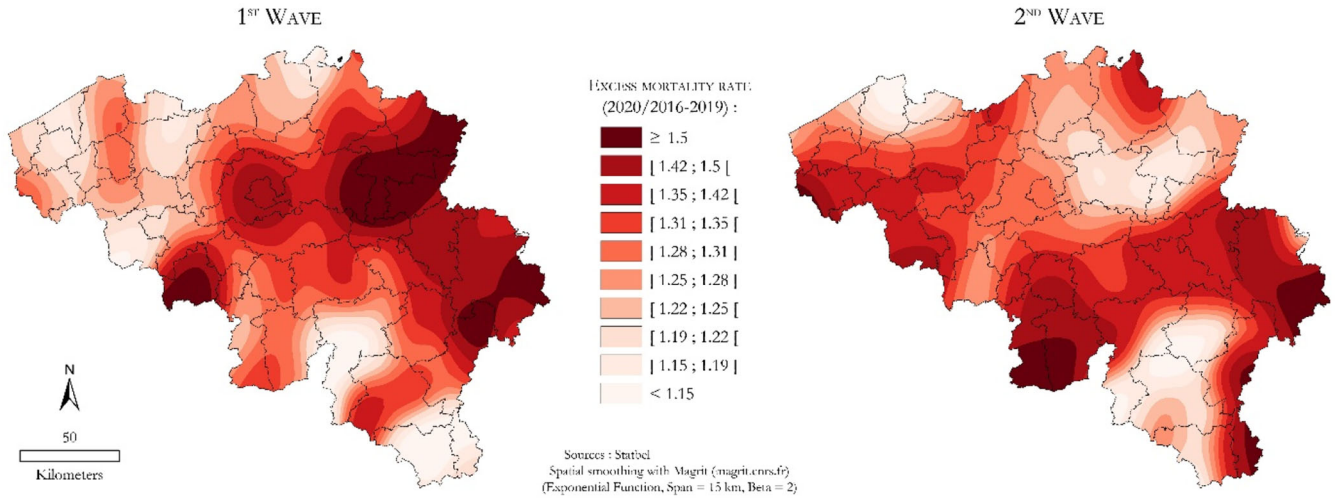

FIGURE 2 | Estimated multilevel models.

inferential statistics (*p*-value, confidence intervals). Instead, we systematically use the number of individuals and the proportion of deaths for each modality of each categorical variable. This sometimes means we can temper our comments, for example, if the analyses involve too small a group of individuals.

However, another school of thought would consider that inferential statistics tools might still be used in our case by assuming that there is a 'super-population' from which our study population is drawn or that the latter is one possible reality among others, and that elements of randomness exist in our data selection, such as the recorded time of a person's death being in or out the observation window, or the place of death that can be aleatory in the boundary regions. To respect the plurality of visions, we also present the confidence intervals of our estimates in the appendix (Table A5).

4 | Analysis

Mortality linked to Covid-19 was not uniform across Belgium. Some areas were affected earlier and/or more severely than others, revealing the presence of outbreaks, as in other countries (Figure 3). During the first wave, the main outbreaks were in the Mons region (south-west), the province of Limburg and eastern Flemish Brabant (north-east), a large part of the province of Liège and the north-east of the province of Luxembourg (centre-east) and the Brussels conurbation (centre). However, the geography of the excess mortality in the first wave differs greatly from that of the second wave, with outbreaks mainly located along international borders. Furthermore, to date, no clear link has been detected between the excess mortality linked to Covid-19 and other factors such as population density, the country's social geography or 'normal' mortality, particularly during the second wave (Bourguignon et al. 2021).

4.1 | Relative Importance of Variables

In 2020, during the two waves of the Covid-19 pandemic, the probability of dying was mainly influenced by individual factors such as age, household type and sex, the weight of spatial variables was very low overall, except for excess local mortality (Figure 4). Age is the factor with the greatest relative importance during the two waves in 2020. In the first wave, it was 2.5 times more important than the household composition and five times more important than sex. This finding is unsurprising and was also observed for mortality in 2019. More surprising is the low weight of certain individual variables, such as social group and nationality, both during and outside the pandemic.

4.2 | Relative Importance of Variables by Age Group

There are differences between the age groups. Among 40–64-year-olds, age and gender retain their high relative weight, while that of household composition declines. Conversely, spatial determinants – the proportion of disadvantaged or one-person households in the municipality, population density, and local excess mortality—are better positioned in the ranking than for older age groups, even though their relative weight remains low. The variables ranking changes for older people (aged 65–79 or 80 and over). During the first wave of the Covid-19 pandemic, household composition had the highest weight, followed closely by age and sex. The dominance of household composition underlines, in particular, the devastating effect of the epidemic in nursing homes. In contrast, in the second wave, and for all of 2019, the most decisive role is consistently attributed to age.

Finally, excess local mortality was among the five variables with the highest relative importance, except for the 40–64 age group in the first wave. In the context of age-related (thus health-related) frailty, excess mortality in the surrounding area is a determining (or aggravating) factor in mortality during the Covid period.

4.3 | Characteristics Related to Mortality

The all-ages models (Table 1) show that men, older people, disadvantaged social categories, and certain types of households, such as one-person and collective households, have a higher mortality

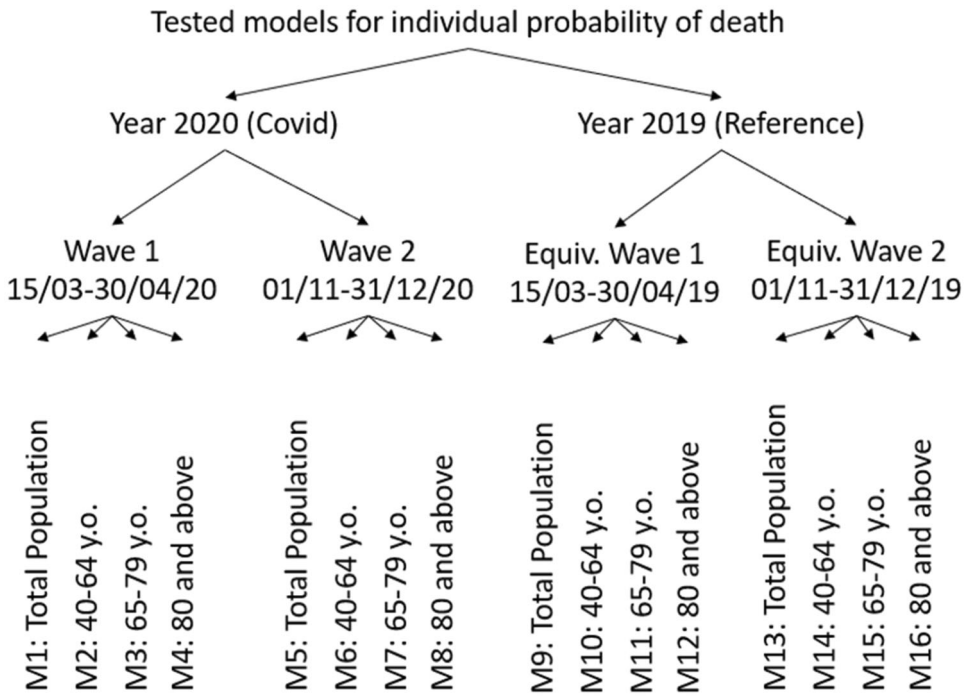

FIGURE 3 | Excess mortality in the first wave (18 March–17 June 2020) and the second wave (28 September 2020–31 January 2021). *Source:* Statbel; authors' calculations; spatial smoothing with Magrit (magrit.cnrs.fr) on the municipal data.

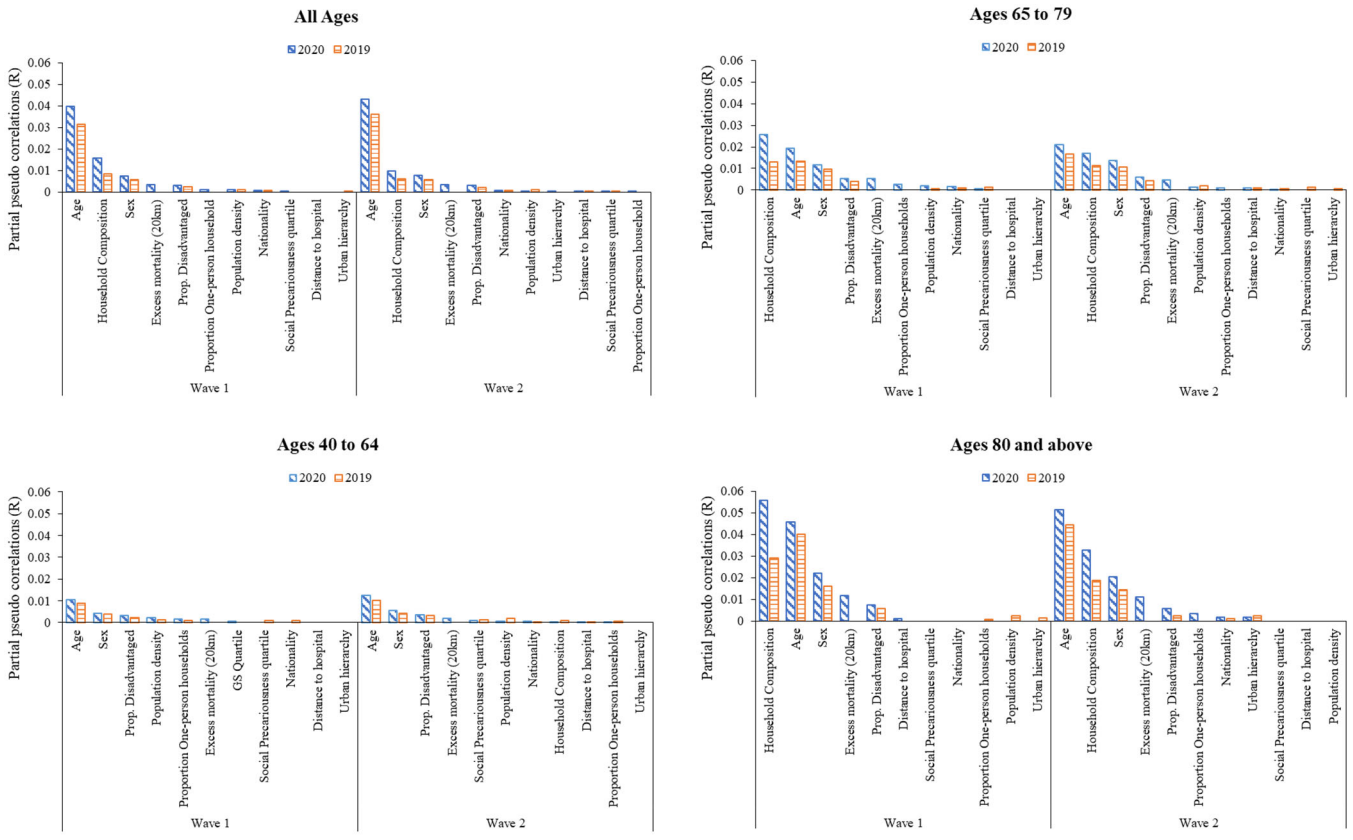

FIGURE 4 | Partial pseudo-correlations from multilevel models estimating the probability of dying during the first or second wave (2020) of the Covid-19 pandemic and the equivalent of these periods for 2019. Graphs produced based on 'all ages' models and by major age groups; prioritisation of variables according to their respective weight in the models for the year 2020. *Source:* Statbel; authors' calculations.

TABLE 1 | Multivariate results estimating the individual probability of dying during one of the two Covid-19 waves (2020), compared with the results obtained during the same periods in 2019, models all ages combined.

	MODEL 1: All – V1 2020			MODEL 9: All – V1 2019			MODEL 5: All – V2 2020			MODEL 13: All – V2 2019		
	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Popu-lation	Number of deaths per 100,000
Sex (ref. Male)		**5,660,064**	**187.4**		**5,628,228**	**122.9**		**5,649,456**	**225.5**		**5,621,309**	**160.5**
Female	0.523	5,832,577	195.9	0.547	5,803,178	121.0	0.553	5,821,152	224.0	0.592	5,796,156	163.4
Age	1.100			1.093			1.104			1.098		
SES quartile (ref. Disadvan-taged)		**2,105,793**	**484.9**		**2,161,269**	**299.1**		**2,095,583**	**555.8**		**2,154,805**	**398.1**
Int. low	0.870	2,391,690	233.2	0.865	2,425,540	148.3	0.888	2,386,113	290.2	0.818	2,421,942	192.9
Int. high	0.777	2,548,680	152.2	0.724	2,574,867	91.9	0.739	2,544,800	175.1	0.739	2,572,501	128.0
Advantaged	0.599	2,462,251	69.2	0.590	2,475,318	45.4	0.563	2,460,547	82.9	0.567	2,474,195	60.9
Unknown	0.989	107,021	342.9	0.962	108,345	192.0	1.072	106,654	339.4	0.931	108,137	210.8
Missing	0.795	1,877,206	15.7	0.835	1,686,067	10.8	0.849	1,876,911	18.7	0.799	1,685,885	12.8
Household composition (ref. Couples with children)		**5503.935**	**26.5**		**5,508,626**	**19.0**		**5,377,863**	**37.8**		**5,387,650**	**27.1**
One-person	1.477	1,744,620	355.9	1.524	1,718,738	242.6	1.176	1,798,045	442.1	1.315	1,764,714	335.0
Couples without children	1.112	2,559,680	243.7	1.198	2,538,616	179.2	0.971	2,592,041	319.7	1.051	2,579,179	237.7
Single-parent households	1.557	1,317,053	74.6	1.764	1,307,845	57.0	1.266	1,321,359	94.2	1.500	1,306,669	77.1
Others	1.679	230,430	198.3	1.820	220,880	147.1	1.160	231,527	215.1	1.460	223,545	188.3
Collectives	6.034	136,923	4,884.5	4.185	136,701	2,272.8	2.725	149,773	3,849.8	2.392	155,708	2287.0
Nationality (ref. Belgians)		**10,065,990**	**203.9**		**10,039,981**	**130.1**		**10,078,773**	**238.8**		**10,066,532**	**172.3**

(Continues)

TABLE 1 | (Continued)

	MODEL 1: All – V1 2020			MODEL 9: All – V1 2019			MODEL 5: All – V2 2020			MODEL 13: All – V2 2019		
	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Popu-lation	Number of deaths per 100,000
French	1.048	170,324	152.1	0.988	167,508	90.7	1.026	169,500	184.7	0.884	166,682	105.6
Italians	0.994	155,696	328.2	0.915	155,866	177.1	0.927	154,152	371.1	0.979	154,220	260.0
Other Europeans	0.887	669,172	76.7	0.871	649,429	50.2	0.794	659,945	81.8	0.809	637,559	63.4
Africans	0.945	191,037	64.9	0.844	188,137	37.2	0.951	180,414	85.9	0.794	175,380	51.9
Asians	1.061	177,072	46.3	0.863	170,389	27.0	1.055	169,159	62.1	0.873	162,161	38.9
Other nationalities	0.688	63,350	26.8	0.833	60,096	21.6	0.952	58,665	44.3	0.734	54,931	27.3
Excess mortality at 20 km	2.531						3.578					
Proportion of one-person household	1.016			0.999			1.001			1.005		
Distance to hospital	1.001			1.000			1.004			1.002		
Population density	1.000			1.000			1.000			1.000		
Proportion of disadvantaged	1.012			1.011			1.009			1.008		
Urban hierarchy (ref. Conur-bation)		**1,539,081**	**189.3**		**1,526,309**	**94.7**		**1,521,928**	**176.9**		**1,511,842**	**129.3**
Suburb	0.954	1,907,456	190.6	1.055	1,899,616	126.8	1.056	1,895,448	238.7	0.987	1,889,904	165.2
ZMA	0.878	1,658,605	211.9	0.989	1,650,103	128.2	1.047	1,653,922	235.3	0.970	1,647,242	174.8
Small town	0.903	2,708,417	204.0	1.029	2,694,209	130.4	1.043	2,710,111	240.0	0.976	2,698,282	172.8
Rural (or other)	0.891	3,679,082	175.1	1.046	3,661,169	121.8	1.050	3,689,199	221.3	0.972	3,670,195	160.0

(Continues)

TABLE 1 | (Continued)

	MODEL 1: All – V1 2020			MODEL 9: All – V1 2019			MODEL 5: All – V2 2020			MODEL 13: All – V2 2019		
	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000
AIC	235269.7			169539.1			277578.9			216392.5		
BIC	235683.1			169938.2			277992.3			216791.5		

Note: Statbel; authors' calculations.

probability than other categories, both during the Covid period and outside the pandemic. In 2020, in both waves, women were half as likely as men to die (in wave 1, Odds-Ratio (OR) = 0.523, and in wave 2, OR = 0.553). This factor is just as strong outside the pandemic (in wave 1, OR 2019 = 0.547, and wave 2, OR = 0.592). At the same time, a 1-year increase in age leads to an additional risk of death of around 10%. Men's and older people's vulnerability was not a distinctive feature of mortality during Covid-19, as it also exists in a non-pandemic context.

In addition, a social gradient is observed: the more socially disadvantaged individuals are, the greater their risk of death. In 2020, the privileged class had an odds ratio at least 40% lower than the most disadvantaged social group (in wave 1, OR = 0.599; in wave 2, OR = 0.563, Table 1). However, the social gradient observed does not differ from that observed in conventional mortality.

Note the case of people for whom the social group cannot be determined (unknown social group): in terms of mortality, they behave similarly to the most disadvantaged social group, in times of pandemic or not. In the context of descriptive analyses, the excess mortality of the 'undetermined' social group during the Covid waves of 2020 was already mentioned (Bourguignon et al. 2021). From a socioeconomic point of view, this group is also a priori in a precarious situation, characterised by an overrepresentation of people of immigrant origin and people living in the Brussels Region (Bourguignon et al. 2021). However, nationality does not lead to substantial differences in mortality.

Finally, the household composition of individuals generates differences in mortality. Individuals living in a couple with or without children are the least exposed to mortality during the two Covid waves. On the other hand, excess mortality in one-person or single-parent households is confirmed in 2020 and 2019. Results in 2019 and 2020 differ for collective households. In the first wave, residents of collective households had a risk of death around six times higher than that observed for couples with (a) child(ren) (OR in 2019—equivalent to wave 1—is around four times higher). In the second Covid wave, excess mortality still characterised these collective households but was roughly comparable in 2020 (OR = 2.7) and 2019 (OR = 2.4).

Some spatial variables (population density, distance from the nearest hospital) resulted in minor differences in mortality in both 2020 and 2019. However, during the two waves of Covid-19, a one-unit increase in the local excess mortality indicator—that is, a massive increase in mortality, which is not observed in reality[5]—is associated with an individual risk of dying 2.5 times and 3.5 times higher in the first and second waves respectively, which is significant. At the same time, a 1% point increase in the proportions of one-person households or disadvantaged people results in a 1% increase (OR = 1.01) in the individual risk of death.

4.4 | Characteristics Related to Mortality by Large Age Groups

The results distinguished by large age groups remain similar (Tables A2–A4). Estimates suggest that the probability of dying

during the Covid-19 period is related to factors similar to those observed in usual mortality (2019). There are, however, several specificities for certain age groups that merit highlighting.

Firstly, the effect of living in a collective household varies between different age groups. The risk of mortality remains higher for individuals living in collective households, but more so for those aged 65–79 (OR = 10.3 (wave 1) or 4.4 (wave 2), Table A3) than for those aged 80 and over (OR = 3.7 (wave 1) or 1.9 (wave 2), Table A4).

Secondly, the effect of excess local mortality increases among the oldest populations, particularly during the second wave.

5 | Discussion

The main objectives of this article were (1) to compare the relative importance of individual and spatial determinants of mortality before and during Covid-19 pandemic, and (2) to compare mortality determinants between pandemic and 'classic' periods. Three research hypotheses were mooted based on an already abundant international literature. Our data come from the National Register, the 2017 tax register, and the 2011 census. The exhaustive nature of these sources allows an analysis of what mortality was like in 2019 and 2020 without the bias associated with inferring and generalising results from population samples. This data helps us contribute to the literature by including many individual and spatial determinants in multilevel models and evaluating the relative contribution of each in an original comparative approach. We could show the similarity of mortality determinants and relative contribution of factors before and during the pandemic period (2019 vs. 2020), but also their nuances between different stages of the pandemic (wave 1 vs. wave 2) and different age groups (40–64 years, 65–79 years and 80 years and over).

5.1 | First Hypothesis: The Major Role of Some Individual Variables

Firstly, we postulated that excess Covid deaths were mainly due to some individual characteristics. We can confirm this hypothesis. The same individual variables mainly influence the probability of dying during the Covid-19 periods in 2020 as during similar periods in 2019, that is, age, sex, and household composition. The nationality and social group have a minimal influence on mortality before and during the pandemic. Between 2019 and 2020, there is no real change in the hierarchy of individual variables according to their respective weight on mortality.

We also hypothesised that pre-existing frailty would be exacerbated during a pandemic, which has to be nuanced. Age and sex relate to multiple, well-studied phenomena, combining biology, metabolic state, health behaviours, and lifestyles. The year 2020 is no exception to the rule of a significant increase in the risk of death after the first year of life, as it is no exception to the excess male mortality rate up to the oldest ages. Even if the socioeconomic position does not impact mortality much compared to other characteristics, we still notice a social gradient. Social inequalities in mortality neither increased nor decreased during the Covid-19 crisis, which means that the social effect of Covid-19-related mortality is not neutral. The pandemic would thus have perpetuated existing disparities to the detriment of disadvantaged populations, as observed elsewhere in the world (Barhoumi et al. 2020; Chen and Krieger 2021; Mayer 2022).

However, there is one point on which the hypothesis is confirmed: the vulnerability of collective households during the Covid period. The excess mortality in collective households also reflects, to some extent, the determining effect of biological factors on mortality via age and/or state of health. It is also accepted that other factors may have contributed to the 'vulnerable state' characteristic of residents of collective households (proximity between residents and with carers, a particularly contagious virus in crowded spaces (Davidson and Szanton 2020; Kemenesi et al. 2020), and the lack of resources, particularly masks and hydroalcoholic gels).

5.2 | Second Hypothesis: An Increased Role of Spatial Determinants in the Pandemic Period?

We assumed an increased weight of spatial variables in 2020 than in 2019, given the highly contagious nature of the virus associated with the Covid-19 pandemic. At this stage, the hypothesis has not been confirmed.

Some spatial variables played a decisive role in mortality in 2020—even if they remain less important than the three key determinants of age, sex or household composition—such as the local excess mortality index and the proportions of disadvantaged people or one-person households in the municipality of residence. These factors present a more significant role in mortality than some individual variables, such as social groups and nationalities. The extent of excess local mortality is in line with what has been observed in France (Levratto et al. 2020) and China (Kang et al. 2021). On the other hand, the results obtained contradict those of other studies that show a greater vulnerability during a pandemic period of individuals living in densely populated regions of France (Pilkington et al. 2021) and in the United States (Abedi et al. 2021). We also notice a non-negligible effect from variables such as the proportions of one-person households and disadvantaged people at the municipal level. The impact of these variables may seem smaller than excess local mortality. Still, the amplitude of the values observed for the variables can significantly affect the individual risk of dying[6]. Results observed with the local excess mortality indicator and the significance of the municipality-level random effect lead us to think that other spatial factors were associated with mortality but were not measured in our study. Nonetheless, the multilevel models with random-effect at the municipality level help us control for the unobserved heterogeneity between the municipalities that our database cannot capture.

However, most spatial variables (population density, distance to the nearest hospital) have a minimal role in mortality, contrary

to some major individual determinants like age and household composition. The absence of a clear density effect is reflected in Figure 3: for both waves, the most urbanised areas are not among the main excess mortality hot spots. We can argue that controlling for individual characteristics such as age, socio-economic situation and household composition, as well as considering mortality at the individual level (and not at the aggregate level), in the context of Belgium, an overall densely inhabited country, does not allow us to come to the same conclusions on the prominent role of population density and urbanicity in Covid-19 mortality.

5.3 | Third Hypothesis: The Specific Characteristics of the Large Age Groups

Finally, the third hypothesis addressed a possible modifying effect in the relationship between individual and spatial characteristics and mortality patterns by large age groups before and during the Covid-19 pandemic. Overall, this hypothesis was not confirmed, with relatively limited differences between the major age groups in terms of the weight of the variables and the disparities between population subgroups. With a few nuances between age groups, age and sex are consistently among the main determinants of mortality patterns, whatever the age group. In other words, the classic biological factors of age and sex act identically across the age groups.

In particular, the hypothesis predicted that the individual social background would have a more visible impact on mortality before the age of 65, given that mortality before this age is considered 'avoidable' or 'premature', with, a priori, the biological effects of age and sex being less significant than at older ages. However, even during a pandemic, there was no reduction or increase in the mortality gap.

At older ages, on the other hand, we hypothesised that a biological effect would supplant the social impact with a return of age, sex, and exposure to contamination through a high population density or household composition. In reality, the only notable difference that emerges is in the variable of household composition. Its weight increases steadily with the age of individuals until it becomes the variable with the highest weight at age 65 and over in the first Covid wave of 2020. Analyses of the parameters for each modality show a remarkable risk of death for residents of collective households, and more so for those aged 65–79 than for those aged 80 and over. This is probably a selection effect. According to Pujol et al. (2021), compared with the population living in private households, the risk of death in a nursing home is much higher among relatively young residents (65–74) than among those aged 75 and over. For people aged 65–79, institutionalisation likely results from health problems that prevent them from remaining at home[7]. Among those aged 80 and over, nursing home residents have survived to a ripe old age and, in addition to medical care, for some of them, residence in an institution is a response not only to health issues but to a need for social interaction and contact (Hanratty et al. 2018), even if this need is not systematically met (Gardiner et al. 2020). It is to be noted that Belgium presents a high rate of institutionalisation: in 2020, 5.7% of the population aged 65 and more received elderly care in a specialised facility (vs. 3% in UE-27) (Gerkens et al. 2024). In countries with lower institutionalisation rates, we could expect different results due to a higher selection (based on health) of those who benefit from long-term healthcare facilities.

In addition, living close to areas of excess mortality would determine the risk of death, particularly at older ages and during the second wave. As this is an indicator of the virulence of the virus in the area, this implies that the individual risk of dying during the Covid period is increased in elderly people living in an area of high mortality, thus pointing to high circulation of the virus. Even if the transmission mechanisms of the virus that generated the pandemic were a little better understood during the second wave, the relaxation of some health measures (or compliance with them) could have led to significant outbreaks of excess mortality, with fatal consequences for the oldest age groups. The spatial context of mortality would, therefore, have repercussions on the individual risk of mortality, and this is all the more justified in the case of the elderly as their resistance and immune capacity diminish.

5.4 | Limitations and Methodological Aspects

Several limitations may affect our analyses over and above the results and the conclusions we can draw from them. Firstly, it should be remembered that the analyses relate to all-cause mortality during the two Covid waves in 2020. At the moment of the analysis, data by cause of death were unavailable in Belgium, making it impossible to identify deaths that resulted directly from the pandemic. We could not clearly distinguish mortality directly related to Covid-19 and mortality due to the overall crisis that led to more limited access to medical healthcare for other diseases and high levels of stress in the population, especially among older adults. Working with ICD codes that would distinguish direct and indirect Covid-19 mortality would also give information on the exact starting point of the pandemic in Belgium (Śleszyński et al. 2024).

We compared the results of models stratified by large age groups. Nevertheless, the comparison of logistic regression estimates must be made with caution due to unobserved heterogeneity: the variation in mortality from one age group to another may depend on unobserved variables, and this unobservable variation may differ (Mood 2010).

It must also be noted that the Covid-19 pandemic started in some European regions in late 2019—partially during our reference period (Śleszyński et al. 2024). However, in Belgium, the comparison between 2019 and 2020 in spring and early autumn limits the risks of comparing the pandemic period with a biased period, as there is no excess mortality to be reported yet at this period of 2019.

The DEMOBEL data set is a high-quality source of information that proved its reliability, even at the local level (Poulain and Herm 2013). However, there are also inherent limitations in the indicators used. For example, we have tried to explain the probability of dying in 2019 or 2020 by characteristics observed

much earlier. This is the case for the social positioning of individuals, which combined information from 2011 to 2017. We admit that individual situations may have changed between 2011 and 2017 and in the most recent period, and that the socio-occupational structure of the population might have changed between the 2011 Census and 2020. However mortality was highest for older ages, for whom education levels, income, and access to housing are relatively stable (Eggerickx et al. 2020). There is no alternative for addressing this concern, as the next update is expected to take place in 2021, that is, at a later date than that relating to the events studied, and with no possible adjustment for people who died between 2011 and 2021.

The distinction between individual and spatial determinants can seem artificial. The probability of living in an underprivileged—very dense, overcrowded, with low access to healthcare and with socioeconomic difficulties—is higher for people who themselves present underprivileged individual situations. Also, considering spatial determinants as a homogenous group can be problematic as they cover a broad series of realities. However, the viral character of the pandemic leads us to make a difference between the individual triggers and what comes from the community: the fragility of the persons around plays a lot in the spread and the severity of the disease. This would not be the case for other pathologies, like chronic diseases. Despite their variety, the spatial determinants all represent how the collective circumstances and shared environment can imply differences in the spread and consequences of the virus. Thus, spatial factors can—to some extent—be considered one category of factors in opposition to individual characteristics.

The possibilities for research into Covid-19 are far from exhausted. Other spatial characteristics could have been investigated. Air pollution was shown in many studies to be a significant determinant in Covid-19 contamination and mortality (Ali and Islam 2020). Knowing that more polluted regions are also more often inhabited by disadvantaged populations (Verbeek 2019), this element can confound the relationship between social inequalities and Covid-19 mortality. Our data set did not allow us to control for this factor directly. Also, the availability of data by cause of death will offer other possibilities for analysis, with questions that could be even more precise since we can work solely with data on the pandemic's victims. Still, studies on all-cause excess mortality will remain solid on the consequences of the pandemic, in terms of death directly related to Covid, as well as other causes of death.

5.5 | General Conclusion

Our results show that pandemic and non-pandemic mortality patterns are similar and that differences between the waves and age groups remain minimal. Vulnerability to the Covid-19 virus mainly affected population groups were already the most vulnerable under normal circumstances especially older people, men and nursing home residents. However, we show that the pandemic amplified inequalities in mortality in certain groups, such as nursing home residents, including the younger residents in their 60s or 70s. Combining spatial and individual factors and their relative importance analysis is rare and contributes to the existing knowledge. The comparison between individual and spatial determinants helped us to see that the former had a more important role in Covid-19 mortality than the latter, especially during the second wave of the pandemic. It confirms that Belgian society and possibly policies directed towards limiting the spread of the virus kept the impact on the surroundings and the community relatively low in the mortality related to a very contagious disease.

Author Contributions

All authors make a substantial contribution to the concept of the article. The authors confirm their contribution to the paper as follows: - Conception of the study: A, B, C, D, E, F; Literature review: A, B, D; Methodology and design of the analysis: C, G - Database management: B, F; - Analysis and interpretation of the analysis: A, B, C, D, F; Draft manuscript preparation: A, B, C, D, E, F. All authors reviewed the results and approved the final version of the manuscript.

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Ethics Statement

We confirm all relevant ethical guidelines have been followed, and any necessary ethics committee approvals have been obtained.

Consent

We confirm that all necessary consent has been obtained, the appropriate institutional forms have been archived, and that any participants' identifiers included were unknown to anyone in the research group, so they cannot be used to identify individuals.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data are not publicly available due to privacy or ethical restrictions. Register microdata is strictly restricted to ensure data privacy and information protection. The authors thank XX for permitting them to work on a pseudonymised version of this data. They also acknowledge the supercomputing facilities of the YY and the ZZ funded by the FF under convention 2.5020.11 and by the RR, for guaranteeing a secured use of the data. The publication of an extract of the data set is not allowed. To request information about the data set and how to access it, please refer to BB. Different strongly anonymised materials related to the analysis (do-files) are available to the corresponding authors upon request.

Endnotes

[1]In Belgium, both Covid-certified and -suspected deaths were considered as Covid deaths, whether they occurred in hospital, at home or in a nursing home.

[2]The study used a multidimensional index including level of education, income, employment category, and housing characteristics. For more details, see the methodology section of this article.

[3]This is the ratio between the age-standardised mortality rate calculated for the two 2020 waves and the standardised mortality rate calculated for the same months over the 2016–2019 observation period.

[4]To better highlight the underlying spatial patterns from the municipality data, we have produced smoothed maps, associating each location with a measure of excess mortality that takes into account the values of neighbouring regions. For this purpose, we have chosen the method of smoothing by potential, that is, Stewart's method (Grasland et al. 2000; Steward and Warntz 1958) With the following parameters: exponential function, span = 10 km, beta = 2. These smoothed values are used only for this map and are not implemented in the models of this paper. Maps without this smoothing process are presented in the Appendix (Figure A1)

[5]At the local level, the excess mortality indices do not exceed 1.7 in wave 1 and 1.4 in wave 2. A local excess mortality of 2 would mean that mortality in 2020 would have doubled compared with 2019.

[6]The difference between the lowest and highest proportion of one-person households at the municipal level is 28 percentage points (minimum value = 7.79%; maximum value = 36.04%). Regarding the proportions of disadvantaged people, the difference between the minimum and maximum proportions is 56 percentage points (minimum value = 6.54%; maximum value = 62.87%), with potentially significant differences in the risk of death between individuals belonging to different municipalities.

[7]In Brussels, the risk of death in a nursing home is strongly associated with age and pathologies, such as chronic illnesses (Houttekier et al. 2009).

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Appendix A

Table A1, Table A2, Table A3, Table A4, Table A5, Figure A1

TABLE A1 | Information about included variables of our models.

Variable	Data source	Measure time	Categories
INDIVIDUAL CHARACTERISTICS			
Age • Derived from the date of birth	Demobel/National Register	Measured yearly, every January 1st	Continuous
Sex	Demobel/National Register	Constant	– Men – Women
SES quartileIndex based on • Instruction level • Occupation status • Housing conditions • Income	Demobel/Census 2011 and tax registers	Once in 2011 for • Instruction level • Occupation status • Housing conditionsYearly, every January 1st, for the tax income.	– Disadvantaged – Intermediate low – Intermediate high – Advantaged – Unknown – Missing
Citizenship	Demobel/National Register	Measured yearly, every January 1st	– Belgian – French – Italian – Other European (includes non-EU) – African – Asian – Other
Household composition	Demobel/National Register	Measured every January 1st. – The value of January 1st 2019 is attributed between 01/01/2019 and 30/06/2019. – The value of January 1st 2020 is attributed between 01/07/2019 and 30/06/2020 – The value of January 1st is attributed between 01/07/2020 and 31/12/2021	– Couples with children – Couples without children – One-person household) – Lone parents and children – Other – Collective households
SPATIAL CHARACTERISTICS			
The following variables are all associated with the municipality of	Demobel/National Register	Measured every January 1st.	

(Continues)

TABLE A1 | (Continued)

Variable	Data source	Measure time	Categories
residence. Each individual is associated with the spatial characteristics of the municipality of residence, that is, the following variables:		– The value of January 1st 2019 is attributed between 01/01/2019 and 30/06/2019. – The value of January 1st 2020 is attributed between 01/07/2019 and 30/06/2020 – The value of January 1st is attributed between 01/07/2020 and 31/12/2021	
Local excess mortality index at 20 km	Demobel	2020	Continuous
Urban hierarchy	Hierarchy from Vanderstraeten and Van Hecke 2019	Measured once in 2019	– Conurbation – Suburbs – ZMA (migration areas) – Small towns – Rural and others
Proportion of one-person household • Derived from the household composition	Demobel/National Register	Measured yearly, every January 1st	Continuous (%)
Distance to the nearest hospital (from the centroid of each municipality)	https://www.health.belgium.be	Measured yearly, every January 1st	Continuous (km)
Population density	Demobel/National Register	Measured yearly, every January 1st	Continuous (inhabitant/km^2)
Proportion of disadvantaged categories • Derived from the SES quartile	Census 2011 and tax registers	Once in 2011 for • Instruction level • Occupation status • Housing conditionsYearly, every January 1st, for the tax income.	Continuous (%)

TABLE A2 | Multivariate results estimating the individual probability of dying during one of the two COVID-19 waves (2020), compared with the results obtained during the same periods in 2019 models for people aged 40–64.

	MODEL 2: 40–64 – V1 2020			MODEL 10: 40–64 – V1 2019			MODEL 6: 40–64 – V2 2020			MODEL 14: 40–64 – V2 2019		
	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000
Sex (ref. Male)		**1,917,228**	**70.7**		**1,912,404**	**59.2**		**1,933,261**	**97.8**		**1,921,458**	**77.6**
Female	0.599	1,901,678	42.7	0.579	1,898,207	35.4	0.552	1,912,239	55.0	0.614	1,903,642	49.4
Age	1.099			1.088			1.106			1.094		
SES quartile (ref. Disadvantaged)		**651,106**	**112.0**		**665,246**	**90.9**		**636,415**	**158.2**		**657,023**	**132.1**
Int. low	0.699	868,833	65.7	0.676	882,002	55.3	0.672	853,489	92.0	0.606	874,280	71.8
Int. high	0.500	1,073,050	42.7	0.461	1,076,859	34.7	0.490	1,072,864	59.7	0.469	1,078,567	50.4
Advantaged	0.403	976,702	29.4	0.405	964,329	26.3	0.346	1,001,314	35.9	0.335	979,526	31.0
Unknown	0.900	43,913	113.9	0.823	42,652	72.7	0.801	46,996	117.0	0.677	44,122	79.3
Missing	0.586	205,302	**35.6**	0.600	179,523	29.0	0.576	234,422	**41.0**	0.446	191,582	28.2
Household composition (ref. Couples with children)		**1,737,614**	**26.8**		**1,733,305**	**22.8**		**1,819,318**	**41.1**		**1,737,230**	**32.3**
One-person	2.580	662,213	112.5	2.566	654,828	91.0	1.774	663,795	139.7	2.199	666,102	122.4
Couples without children	1.286	952,450	61.3	1.377	961,105	54.4	0.953	880,224	91.8	1.091	955,116	71.9
Single-parent households	1.746	379,366	50.6	1.963	376,188	46.8	1.442	394,762	65.9	1.705	380,423	60.5
Others	1.646	69,451	**63.4**	2.078	67,280	65.4	1.242	70,018	**82.8**	1.460	68,023	70.6
Collectives	12.224	17,812	774.8	7.384	17,905	391.0	6.573	17,383	822.6	5.835	18,206	505.3
Nationality (ref. Belgians)		**3,342,696**	**58.1**		**3,347,984**	**49.3**		**3,347,628**	**79.1**		**3,357,785**	**66.1**
French	0.854	57,486	53.9	0.924	56,393	47.9	0.821	60,563	69.3	0.598	57,658	39.9
Italians	0.622	69,987	58.6	0.521	71,442	36.4	0.625	67,241	81.8	0.753	69,788	74.5
Other Europeans	0.814	235,195	42.1	0.664	226,492	30.0	0.707	246,203	50.0	0.706	230,132	38.7
Africans	0.887	55,281	**56.1**	0.760	52,906	39.7	0.838	60,356	**67.9**	0.674	53,588	42.9
Asians	0.899	44,228	45.2	0.427	41,955	19.1	0.817	48,461	53.7	0.972	42,719	51.5
Other nationalities	0.444	14,033	21.4	0.929	13,439	37.2	0.779	15,048	46.5	0.626	13,430	29.8

(Continues)

TABLE A2 | (Continued)

	MODEL 2: 40–64 – V1 2020			MODEL 10: 40–64 – V1 2019			MODEL 6: 40–64 – V2 2020			MODEL 14: 40–64 – V2 2019		
	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000
Excess mortality at 20 km	2.333						2.773					
Proportion of one-person households	1.017			1.006			1.002			1.003		
Distance to hospital	1.003			1.006			1.008			1.008		
Population density	1.000			1.000			1.000			1.000		
Proportion of disadvantaged	1.014			1.011			1.017			1.014		
Urban hierarchy (ref. Conurbation)		**480,329**	**56.6**		**474,733**	**40.9**		**493,219**	**76.6**		**479,801**	**54.2**
Suburb	0.977	598,804	68.3	1.162	598,604	54.1	0.949	603,611	85.0	0.907	599,397	70.1
ZMA	0.865	539,376	62.9	1.197	539,527	52.8	1.067	540,552	83.8	0.961	540,007	71.7
Small town	0.907	915,525	60.8	1.191	914,379	51.4	0.998	918,099	78.0	0.943	917,714	69.5
Rural (or other)	0.829	1,284,872	46.0	1.099	1,283,368	41.4	1.027	1,290,019	68.4	0.879	1,288,181	56.5
AIC	34460.73			29712.98			45284.76			38577.97		
BIC	34842.24			30068.12			45666.26			38946.25		

Note: Statbel; authors' calculations.

TABLE A3 | Multivariate results estimating the individual probability of dying during one of the two Covid-19 waves (2020), compared with the results obtained during the same periods in 2019, models for people aged 65–79.

	MODEL 3: 65–79 – V1 2020			MODEL 11: 65–79 – V1 2019			MODEL 7: 65–79 – V2 2020			MODEL 15: 65–79 – V2 2019		
	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000
Sex (ref. Male)		**729,352**	**465.6**		**713,718**	**319.3**		**804,468**	**790.6**		**745,450**	**410.4**
Female	0.507	818,339	281.9	0.503	804,594	188.8	0.502	884,093	1,027.0	0.523	829,384	252.7
Age	1.099			1.080			1.100			1.088		
SES quartile (ref. Disadvantaged)		**449,161**	**527.0**		**461,983**	**334.6**		**455,559**	**628.9**		**460,592**	**471.8**
Int. low	0.828	457,358	344.2	0.851	450,784	239.1	0.833	492,049	416.0	0.784	465,191	309.8
Int. high	0.698	358,016	288.0	0.716	339,642	203.2	0.698	412,986	318.4	0.661	363,511	252.3
Advantaged	0.536	254,008	212.6	0.607	239,240	166.8	0.502	294,234	225.7	0.532	256,959	199.3
Unknown	0.910	10,379	1156.2	0.773	10,373	510.9	1.095	11,316	1,0693	0.849	10,786	602.6
Missing	0.759	18,769	378.3	0.620	16,290	196.4	0.864	22,417	432.7	0.684	17,795	264.1
Household composition (ref. Couples with children)		**133,805**	**325.1**		**131,119**	**193.7**		**155,393**	**400.3**		**135,792**	**284.3**
One-person	1.249	397,344	394.6	1.526	387,555	280.0	0.985	431,540	452.8	1.214	405,289	366.2
Couples without children	0.848	916,546	265.8	1.054	901,190	201.6	0.783	991,376	344.1	0.912	929,813	272.1
Single-parent households	1.287	50,693	382.7	1.642	49,790	283.2	1.054	57,185	426.7	1.253	51,687	346.3
Others	1.256	25,625	405.9	1.773	24,994	332.1	0.959	28,267	431.6	1.278	26,111	383.0
Collectives	10.312	23,678	4079.7	7.823	23,664	1766.4	4.428	24,800	3,048.4	4.306	26,142	1,820.8
Nationality (ref. Belgians)		**1,442,626**	**366.7**		**1,414,889**	**250.1**		**1,572,033**	**417.4**		**1,467,569**	**325.4**
French	0.797	16,656	372.2	0.968	16,421	274.0	1.081	18,363	582.7	1.141	17,084	415.6
Italians	0.891	31,259	451.1	0.825	30,725	257.1	0.899	34,103	539.5	1.083	31,879	448.6
Other Europeans	0.877	42,491	346.0	0.951	41,666	242.4	0.745	47,922	321.4	0.840	43,499	280.5
Africans	0.884	7566	462.6	0.759	7645	222.4	1.110	8001	674.9	0.727	7646	300.8
Asians	1.045	5584	411.9	1.165	5482	291.9	1.360	6395	625.5	0.867	5616	302.7
Other nationalities	0.664	1509	331.3	0.528	1484	134.8	1.000	1744	458.7	0.585	1541	194.7

(Continues)

TABLE A3 | (Continued)

	MODEL 3: 65–79 – V1 2020			MODEL 11: 65–79 – V1 2019			MODEL 7: 65–79 – V2 2020			MODEL 15: 65–79 – V2 2019		
	OR	**Population**	**Number of deaths per 100,000**	**OR**	**Population**	**Number of deaths per 100,000**	**OR**	**Population**	**Number of deaths per 100,000**	**OR**	**Population**	**Number of deaths per 100,000**
Excess mortality at 20 km	2.647						3.383					
Proportion of one-person households	1.020			0.992			1.007			1.004		
Distance to hospital	1.003			0.996			1.007			1.007		
Population density	1.000			1.000			1.000			1.000		
Proportion of disadvantaged	1.011			1.014			1.013			1.009		
Urban hierarchy (ref. Conurbation)		**150,733**	**500.2**		**149,127**	**274.9**		**163,862**	**431.5**		**153,870**	**338.6**
Suburb	0.876	242,365	385.0	0.992	238,860	278.4	1.176	263,017	489.7	0.994	246,979	373.7
ZMA	0.889	232,685	390.7	0.855	228,340	236.5	1.158	253,452	434.0	0.930	236,705	330.8
Small town	0.898	392,236	375.3	0.942	384,331	249.8	1.147	427,822	427.3	0.918	399,176	328.4
Rural (or other)	0.843	529,672	308.7	0.966	517,654	236.3	1.122	580,408	376.6	0.884	538,104	300.5
AIC	70200.6			51150.4			86629.3			66644.5		
BIC	70555.9			51493.0			86984.5			66987.0		

TABLE A4 | Multivariate results estimating the individual probability of dying during one of the two Covid-19 waves (2020), compared with the results obtained during the same periods in 2019, models for people aged 80 and over.

	MODEL 4: 80+ – V1 2020			MODEL 12: 80+ – V1 2019			MODEL 8: 80+ – V2 2020			MODEL 16: 80+ – V2 2019		
	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000	OR	Population	Number of deaths per 100,000
Sex (ref. Male)		**238,795**	**2386.1**		**235,465**	**1414.2**		**265,965**	**2391.3**		**261,690**	**1633.6**
Female	0.570	408,193	2014.2	0.616	403,443	1177.4	0.637	444,913	2040.8	0.694	438,568	1446.8
Age	1.090			1.108			1.101			1.108		
SES quartile (ref. Disadvantaged)		**299,155**	**2358.3**		**297,740**	**1425.1**		**342,182**	**2243.8**		**321,679**	**1698.6**
Int. low	0.932	176,168	1911.8	0.937	168,748	1168.6	0.984	208,652	1929.5	0.896	186,809	1360.7
Int. high	0.925	115,595	2026.9	0.852	111,768	1128.2	0.869	136,167	1794.1	0.898	122,764	1440.2
Advantaged	0.786	56,412	1519.2	0.710	51,416	846.0	0.779	71,310	1377.1	0.773	59,046	1102.5
Unknown	0.874	5347	3572.1	0.959	5671	2098.4	0.974	5997	3034.9	0.904	6037	2037.4
Missing	0.893	4110	2579.1	0.917	3565	1402.5	1.136	5014	2572.8	1.151	3923	1835.3
Household composition (ref. Couples with children)		**26,996**	**1,622.5**		**26,962**	**1031.1**		**31,968**	**1701.7**		**28,590**	**1360.6**
One-person	0.939	261,338	1471.7	0.892	255,515	952.6	0.858	300,685	1663.2	0.842	274,944	1291.2
Couples without children	0.862	239,618	1333.8	0.937	231,354	944.0	0.859	287,353	1405.2	0.878	251,033	1150.4
Single-parent households	1.128	31,091	1797.9	1.144	30,826	1239.2	0.958	35,727	1914.5	1.039	33,141	1629.4
Others	1.292	14,165	2132.0	1.173	14,149	1321.6	0.930	16,152	1931.6	1.062	15,196	1730.7
Collectives	3.710	83,579	6675.1	2.313	80,102	3264.6	1.876	97,437	4988.9	1.434	97,354	3071.3
Nationality (ref. Belgians)		**621,478**	**2105.9**		**605,038**	**1265.0**		**726,349**	**2010.5**		**662,669**	**1523.8**
French	1.272	5224	3101.1	1.030	4973	1508.1	1.051	6,071	2684.9	0.804	5473	1425.2
Italians	1.192	11,942	2755.0	1.164	11,520	1484.4	1.103	14,392	2306.8	1.039	12,771	1589.5
Other Europeans	0.957	12,896	1961.8	0.932	12,295	1098.0	0.860	16,048	1545.4	0.899	13,727	1311.3
Africans	0.832	3213	1556.2	0.824	3116	866.5	0.724	3978	1282.1	0.731	3429	1049.9
Asians	1.079	1669	1917.3	0.888	1603	935.7	0.957	2055	1654.5	0.786	1800	1111.1
Other nationalities	0.656	365	1643.8	0.614	363	826.4	0.960	429	2097.9	0.718	389	1285.3

(Continues)

TABLE A4 | (Continued)

	MODEL 4: 80+ – V1 2020			MODEL 12: 80+ – V1 2019			MODEL 8: 80+ – V2 2020			MODEL 16: 80+ – V2 2019		
	OR	**Population**	**Number of deaths per 100,000**	**OR**	**Population**	**Number of deaths per 100,000**	**OR**	**Population**	**Number of deaths per 100,000**	**OR**	**Population**	**Number of deaths per 100,000**
Excess mortality at 20 km	2.546						3.860					
Proportion of one-person households	1.008			0.996			0.992			1.002		
Distance to hospital	0.997			1.000			1.001			0.998		
Population density	1.000			1.000			1.000			1.000		
Proportion of disadvantaged	1.011			1.009			1.006			1.004		
Urban hierarchy (ref. Conurbation)		**68,399**	**2704.7**		**67,590**	**1195.4**		**78,888**	**1990.2**		**73,189**	**1557.6**
Suburb	1.001	107,313	2092.9	1.057	105,337	1304.4	1.078	124,926	2130.1	1.027	114,799	1507.0
ZMA	0.885	102,236	2181.2	1.023	99,698	1243.8	1.050	119,193	1921.3	1.034	108,919	1525.9
Small town	0.930	165,523	2084.9	1.072	160,191	1266.6	1.071	194,082	2010.0	1.069	176,133	1500.0
Rural (or other)	0.942	213,316	1942.2	1.103	206,092	1275.6	1.101	252,233	1989.4	1.106	227,218	1516.6
AIC	124432.3			82695.1			138800.3			104439.5		
BIC	124762.8			83013.7			139130.1			104757.8		

TABLE A5 | Multivariate results estimating the individual probability of dying during one of the two Covid-19 waves (2020), compared with the results obtained during the same periods in 2019, models all ages combined and for people aged 40–64, 65–79 and 80 and over.

	MODEL 1: All – V1 2020			MODEL 9: All – V1 2019			MODEL 5: All – V2 2020			MODEL 13: All – V2 2019		
	OR	IC95%		OR	IC95%		OR	IC95%		OR	IC95%	
Sex (ref. Male)												
Female	0,523	0,509	0,539	0,547	0,528	0,567	0,553	0,539	0,568	0,592	0,574	0,610
Age	1,100	1,099	1,102	1,093	1,092	1,095	1,104	1,103	1,105	1,098	1,097	1,099
SES quartile (ref. Disadvantaged)												
Int. low	0,870	0,841	0,900	0,865	0,830	0,902	0,888	0,861	0,916	0,818	0,788	0,848
Int. high	0,777	0,748	0,808	0,724	0,690	0,760	0,739	0,713	0,766	0,739	0,709	0,771
Advantaged	0,599	0,567	0,632	0,590	0,552	0,630	0,563	0,536	0,591	0,567	0,535	0,600
Unknown	0,989	0,887	1,103	0,962	0,835	1,108	1,072	0,962	1,195	0,931	0,814	1,065
Missing	0,795	0,702	0,901	0,835	0,712	0,978	0,849	0,757	0,952	0,799	0,691	0,923
Household composition (ref. Couples with children)												
One-person	1,477	1,389	1,571	1,524	1,416	1,641	1,176	1,115	1,240	1,315	1,236	1,400
Couples without children	1,112	1,047	1,180	1,198	1,116	1,286	0,971	0,922	1,022	1,051	0,989	1,116
Single-parent households	1,557	1,433	1,692	1,764	1,602	1,942	1,266	1,177	1,361	1,500	1,381	1,630
Others	1,679	1,508	1,870	1,820	1,602	2,067	1,160	1,049	1,283	1,460	1,306	1,631
Collectives	6,034	5,647	6,447	4,185	3,856	4,542	2,725	2,567	2,891	2,392	2,228	2,568
Nationality (ref. Belgians)												
French	1,048	0,921	1,193	0,988	0,838	1,165	1,026	0,912	1,154	0,884	0,759	1,030
Italians	0,994	0,906	1,090	0,915	0,809	1,035	0,927	0,849	1,011	0,979	0,883	1,085
Other Europeans	0,887	0,809	0,973	0,871	0,777	0,977	0,794	0,726	0,868	0,809	0,730	0,896
Africans	0,945	0,788	1,133	0,844	0,664	1,073	0,951	0,808	1,119	0,794	0,643	0,980
Asians	1,061	0,849	1,325	0,863	0,643	1,160	1,055	0,866	1,284	0,873	0,678	1,124
Other nationalities	0,688	0,425	1,114	0,833	0,481	1,443	0,952	0,644	1,406	0,734	0,440	1,224
Excess mortality at 20 km	2,531	2,036	3,147				3,578	2,786	4,597			
Proportion of one-person households	1,016	1,005	1,026	0,999	0,993	1,006	1,001	0,992	1,009	1,005	0,998	1,011
Distance to hospital	1,001	0,995	1,006	1,000	0,996	1,004	1,004	1,000	1,009	1,002	0,998	1,006
Population density	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Proportion of disadvantaged	1,012	1,007	1,016	1,011	1,008	1,014	1,009	1,005	1,013	1,008	1,005	1,011
Urban hierarchy (ref. Conurbation)												

(Continues)

TABLE A5 | (Continued)

	MODEL 1: All – V1 2020			MODEL 9: All – V1 2019			MODEL 5: All – V2 2020			MODEL 13: All – V2 2019		
	OR	IC95%		OR	IC95%		OR	IC95%		OR	IC95%	
Suburb	0,954	0,813	1,120	1,055	0,955	1,165	1,056	0,926	1,203	0,987	0,896	1,087
ZMA	0,878	0,744	1,035	0,989	0,893	1,096	1,047	0,913	1,200	0,970	0,879	1,070
Small town	0,903	0,777	1,050	1,029	0,934	1,134	1,043	0,921	1,180	0,976	0,890	1,070
Rural (or other)	0,891	0,770	1,032	1,046	0,948	1,155	1,050	0,930	1,185	0,972	0,886	1,067
	MODEL 2: 40–64 – V1 2020			**MODEL 10: 40–64 – V1 2019**			**MODEL 6: 40–64 – V2 2020**			**MODEL 14: 40–64 – V2 2019**		
	OR	**IC95%**		**OR**	**IC95%**		**OR**	**IC95%**		**OR**	**IC95%**	
Sex (ref. Male)												
Female	0,599	0,549	0,655	0,579	0,526	0,638	0,552	0,512	0,596	0,614	0,565	0,667
Age	1,099	1,090	1,107	1,088	1,080	1,097	1,106	1,099	1,113	1,094	1,086	1,102
SES quartile (ref. Disadvantaged)												
Int. low	0,699	0,625	0,783	0,676	0,598	0,763	0,672	0,610	0,739	0,606	0,545	0,673
Int. high	0,500	0,443	0,565	0,461	0,404	0,527	0,490	0,443	0,543	0,469	0,420	0,524
Advantaged	0,403	0,350	0,465	0,405	0,348	0,472	0,346	0,306	0,392	0,335	0,293	0,384
Unknown	0,900	0,669	1,212	0,823	0,567	1,193	0,801	0,606	1,059	0,677	0,479	0,958
Missing	0,586	0,451	0,762	0,600	0,440	0,816	0,576	0,458	0,723	0,446	0,332	0,599
Household composition (ref. Couples with children)												
One-person	2,580	2,288	2,909	2,566	2,249	2,928	1,774	1,605	1,961	2,199	1,967	2,460
Couples without children	1,286	1,130	1,463	1,377	1,199	1,582	0,953	0,857	1,059	1,091	0,969	1,228
Single-parent households	1,746	1,472	2,070	1,963	1,640	2,350	1,442	1,250	1,664	1,705	1,459	1,991
Others	1,646	1,205	2,246	2,078	1,519	2,844	1,242	0,949	1,625	1,460	1,085	1,964
Collectives	12,224	9,972	14,985	7,384	5,651	9,648	6,573	5,441	7,940	5,835	4,632	7,351
Nationality (ref. Belgians)												
French	0,854	0,594	1,227	0,924	0,627	1,360	0,821	0,602	1,119	0,598	0,394	0,905
Italians	0,622	0,454	0,852	0,521	0,352	0,770	0,625	0,476	0,819	0,753	0,569	0,997
Other Europeans	0,814	0,654	1,014	0,664	0,511	0,861	0,707	0,582	0,859	0,706	0,563	0,884
Africans	0,887	0,614	1,280	0,760	0,488	1,184	0,838	0,609	1,152	0,674	0,443	1,026
Asians	0,899	0,573	1,412	0,427	0,211	0,863	0,817	0,550	1,213	0,972	0,632	1,494
Other nationalities	0,444	0,142	1,388	0,929	0,381	2,260	0,779	0,368	1,650	0,626	0,233	1,683
Excess mortality at 20 km	2,333	1,540	3,534				2,773	1,755	4,380			

(Continues)

TABLE A5 | (Continued)

	MODEL 2: 40–64 – V1 2020			MODEL 10: 40–64 – V1 2019			MODEL 6: 40–64 – V2 2020			MODEL 14: 40–64 – V2 2019		
	OR	IC95%		OR	IC95%		OR	IC95%		OR	IC95%	
Proportion of one-person households	1,017	1,000	1,033	1,006	0,992	1,021	1,002	0,990	1,014	1,003	0,989	1,018
Distance to hospital	1,003	0,992	1,014	1,006	0,996	1,017	1,008	1,000	1,017	1,008	0,999	1,018
Population density	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Proportion of disadvantaged	1,014	1,007	1,022	1,011	1,004	1,018	1,017	1,011	1,023	1,014	1,008	1,021
Urban hierarchy (ref. Conurbation)												
Suburb	0,977	0,750	1,274	1,162	0,916	1,474	0,949	0,770	1,169	0,907	0,722	1,141
ZMA	0,865	0,663	1,128	1,197	0,928	1,544	1,067	0,865	1,317	0,961	0,760	1,215
Small town	0,907	0,704	1,168	1,191	0,927	1,531	0,998	0,813	1,225	0,943	0,751	1,183
Rural (or other)	0,829	0,641	1,073	1,099	0,846	1,427	1,027	0,831	1,269	0,879	0,697	1,109
	MODEL 3: 65-79 – V1 2020			**MODEL 11: 65-79 – V1 2019**			**MODEL 7: 65-79 – V2 2020**			**MODEL 15: 65-79 – V2 2019**		
	OR	IC95%		OR	IC95%		OR	IC95%		OR	IC95%	
Sex (ref. Male)												
Female	0,507	0,480	0,535	0,503	0,470	0,538	0,502	0,478	0,527	0,523	0,494	0,554
Age	1,099	1,092	1,106	1,080	1,071	1,088	1,100	1,094	1,106	1,088	1,080	1,095
SES quartile (ref. Disadvantaged)												
Int. low	0,828	0,775	0,884	0,851	0,786	0,921	0,833	0,786	0,883	0,784	0,733	0,839
Int. high	0,698	0,647	0,752	0,716	0,653	0,785	0,698	0,652	0,746	0,661	0,611	0,715
Advantaged	0,536	0,486	0,590	0,607	0,541	0,679	0,502	0,460	0,547	0,532	0,482	0,588
Unknown	0,910	0,751	1,102	0,773	0,583	1,023	1,095	0,907	1,321	0,849	0,659	1,092
Missing	0,759	0,593	0,970	0,620	0,433	0,889	0,864	0,699	1,067	0,684	0,508	0,921
Household composition (ref. Couples with children)												
One-person	1,249	1,120	1,391	1,526	1,328	1,753	0,985	0,898	1,080	1,214	1,083	1,360
Couples without children	0,848	0,765	0,941	1,054	0,923	1,204	0,783	0,717	0,854	0,912	0,818	1,016
Single-parent households	1,287	1,085	1,527	1,642	1,334	2,021	1,054	0,907	1,224	1,253	1,047	1,498
Others	1,256	1,013	1,557	1,773	1,382	2,274	0,959	0,789	1,166	1,278	1,024	1,594
Collectives	10,312	9,163	11,605	7,823	6,659	9,191	4,428	3,964	4,945	4,306	3,748	4,947
Nationality (ref. Belgians)												
French	0,797	0,617	1,030	0,968	0,718	1,306	1,081	0,888	1,316	1,141	0,898	1,448

(Continues)

TABLE A5 | (Continued)

	MODEL 3: 65-79 – V1 2020			MODEL 11: 65-79 – V1 2019			MODEL 7: 65-79 – V2 2020			MODEL 15: 65-79 – V2 2019		
	OR	IC95%		OR	IC95%		OR	IC95%		OR	IC95%	
Italians	0,891	0,750	1,060	0,825	0,656	1,037	0,899	0,772	1,047	1,083	0,911	1,286
Other Europeans	0,877	0,741	1,039	0,951	0,777	1,164	0,745	0,632	0,878	0,840	0,699	1,010
Africans	0,884	0,629	1,242	0,759	0,468	1,230	1,110	0,842	1,461	0,727	0,479	1,102
Asians	1,045	0,689	1,585	1,165	0,708	1,917	1,360	0,990	1,869	0,867	0,535	1,404
Other nationalities	0,664	0,273	1,614	0,528	0,131	2,128	1,000	0,495	2,017	0,585	0,187	1,825
Excess mortality at 20 km	2,647	1,986	3,529				3,383	2,436	4,699			
Proportion of one-person households	1,020	1,008	1,032	0,992	0,980	1,004	1,007	0,997	1,017	1,004	0,994	1,014
Distance to hospital	1,003	0,996	1,011	0,996	0,988	1,004	1,007	1,000	1,013	1,007	1,000	1,014
Population density	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Proportion of disadvantaged	1,011	1,006	1,017	1,014	1,008	1,019	1,013	1,008	1,017	1,009	1,004	1,014
Urban hierarchy (ref. Conurbation)												
Suburb	0,876	0,721	1,066	0,992	0,822	1,196	1,176	1,001	1,382	0,994	0,843	1,172
ZMA	0,889	0,732	1,079	0,855	0,704	1,038	1,158	0,982	1,366	0,930	0,787	1,101
Small town	0,898	0,749	1,077	0,942	0,784	1,132	1,147	0,981	1,341	0,918	0,782	1,078
Rural (or other)	0,843	0,703	1,012	0,966	0,801	1,164	1,122	0,958	1,314	0,884	0,751	1,041
	MODEL 4: 80+ – V1 2020			**MODEL 12: 80+ – V1 2019**			**MODEL 8: 80+ – V2 2020**			**MODEL 16: 80+ – V2 2019**		
	OR	**IC95%**		**OR**	**IC95%**		**OR**	**IC95%**		**OR**	**IC95%**	
Sex (ref. Male)												
Female	0,570	0,549	0,592	0,616	0,587	0,647	0,637	0,615	0,660	0,69	0,66	0,72
Age	1,090	1,086	1,094	1,108	1,102	1,113	1,101	1,097	1,105	1,11	1,10	1,11
SES quartile (ref. Disadvantaged)												
Int. low	0,932	0,893	0,973	0,937	0,887	0,990	0,984	0,946	1,024	0,90	0,85	0,94
Int. high	0,925	0,881	0,972	0,852	0,799	0,908	0,869	0,829	0,911	0,90	0,85	0,95
Advantaged	0,786	0,729	0,846	0,710	0,642	0,786	0,779	0,727	0,835	0,77	0,71	0,84
Unknown	0,874	0,753	1,016	0,959	0,795	1,155	0,974	0,836	1,134	0,90	0,75	1,09
Missing	0,893	0,726	1,098	0,917	0,683	1,232	1,136	0,941	1,372	1,15	0,90	1,47
Household composition (ref. Couples with children)												
One-person	0,939	0,848	1,040	0,892	0,785	1,014	0,858	0,782	0,940	0,84	0,76	0,94
Couples without children	0,862	0,778	0,954	0,937	0,825	1,064	0,859	0,783	0,942	0,88	0,79	0,98

(Continues)

TABLE A5 | (Continued)

	MODEL 4: 80+ – V1 2020			MODEL 12: 80+ – V1 2019			MODEL 8: 80+ – V2 2020			MODEL 16: 80+ – V2 2019		
	OR	IC95%		OR	IC95%		OR	IC95%		OR	IC95%	
Single-parent households	1,128	0,992	1,282	1,144	0,977	1,339	0,958	0,853	1,075	1,04	0,91	1,19
Others	1,292	1,112	1,501	1,173	0,971	1,416	0,930	0,806	1,072	1,06	0,91	1,25
Collectives	3,710	3,348	4,112	2,313	2,032	2,634	1,876	1,708	2,061	1,43	1,28	1,60
Nationality (ref. Belgians)												
French	1,272	1,074	1,506	1,030	0,810	1,310	1,051	0,888	1,244	0,80	0,64	1,02
Italians	1,192	1,060	1,341	1,164	0,994	1,363	1,103	0,982	1,239	1,04	0,90	1,20
Other Europeans	0,957	0,841	1,089	0,932	0,784	1,109	0,860	0,755	0,979	0,90	0,77	1,05
Africans	0,832	0,625	1,107	0,824	0,560	1,212	0,724	0,545	0,960	0,73	0,52	1,02
Asians	1,079	0,755	1,541	0,888	0,531	1,486	0,957	0,678	1,352	0,79	0,50	1,23
Other nationalities	0,656	0,290	1,484	0,614	0,196	1,923	0,960	0,492	1,872	0,72	0,30	1,74
Excess mortality at 20 km	2,546	1,946	3,330				3,860	2,806	5,310			
Proportion of one-person households	1,008	0,996	1,021	0,996	0,988	1,004	0,992	0,982	1,003	1,00	0,99	1,01
Distance to hospital	0,997	0,990	1,004	1,000	0,994	1,005	1,001	0,995	1,007	1,00	0,99	1,00
Population density	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,00	1,00	1,00
Proportion of disadvantaged	1,011	1,006	1,017	1,009	1,006	1,013	1,006	1,002	1,011	1,00	1,00	1,01
Urban hierarchy (ref. Conurbation)												
Suburb	1,001	0,823	1,217	1,057	0,940	1,188	1,078	0,916	1,269	1,03	0,92	1,15
ZMA	0,885	0,724	1,082	1,023	0,906	1,155	1,050	0,886	1,246	1,03	0,93	1,15
Small town	0,930	0,775	1,117	1,072	0,953	1,206	1,071	0,918	1,249	1,07	0,96	1,19
Rural (or other)	0,942	0,788	1,127	1,103	0,978	1,243	1,101	0,946	1,281	1,11	0,99	1,23

Note: Statbel; authors' calculations.

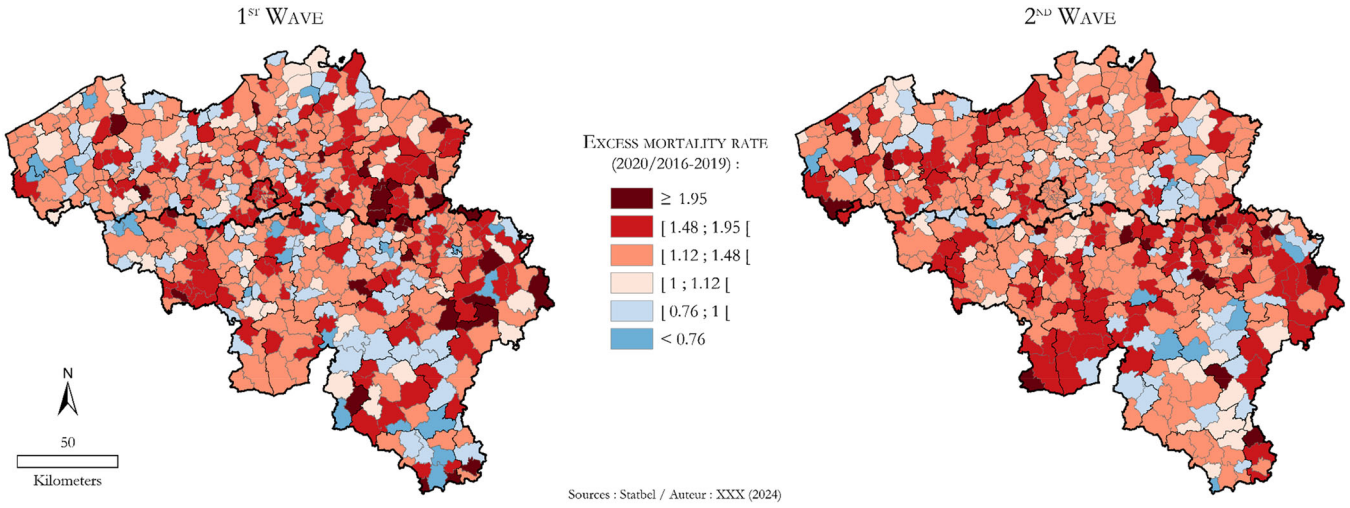

FIGURE A1 | Excess mortality in the first wave (18 March–17 June 2020) and the second wave (28 September 2020–31 January 2021). *Source:* Statbel; authors' calculations on the municipal data.