Longitudinal Variability in Mortality Predicts Covid-19 Deaths

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Research Article

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Longitudinal variability in mortality predicts Covid-19 deaths

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Abstract:

Within Europe, death rates due to covid-19 vary greatly, with some countries being hardly hit while others to date are almost unaffected. This has created a very heated debate in particular regarding how effective the different measures applied by the governments are in limiting the spread of the disease and ultimately deaths. It would be of considerable interest to pinpoint the factors that determine a country's susceptibility to a pandemic such as covid-19. Here we present data demonstrating that mortality due to covid-19 in a given country could have been predicted even before the pandemic hit Europe, simply by looking at longitudinal variability of death rates in the years preceding the current outbreak. The variability in death rates during the winter influenza seasons of 2015-2019 correlate strongly to excess mortality caused by covid-19 in 2020 ($R^2=0.48$, $p<0,0001$). In contrast, there was no correlation with age, population density, latitude, GNP, governmental health spending, degree of urbanization, or rates of influenza vaccination.
These data suggest an intrinsic susceptibility in certain countries to excess mortality associated with viral respiratory diseases including covid-19.

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Introduction

Seasonal fluctuations in all-cause mortality are well known with deaths typically peaking in the winter.[1] A main factor driving excess winter mortality is seasonal flu.[1] When examining mortality across Europe it is clear that some countries repeatedly exhibit excess deaths during the winter flu season while others show only minimal variations.[2] In 2020 the peak in excess all-cause mortality was extraordinarily large, came later, and was connected with the covid-19 pandemic.[2] Again, however, the higher death rates were unevenly spread throughout Europe.[2] Here we decided to relate historical death rates 2015-2019 with the mortality rates seen in Europe during 2020 using a publically available database.[2] We find a remarkable correlation between these two parameters.

Methods

The main data presented here have been extracted from the public data base European Mortality Monitoring (Euromomo).[2]

The following sources were used for the other data extracted and used for correlations. Population, age and density[3], degree of urbanization, GNP and governmental health spendings[4], latitude[5], influenza vaccine rates[6], map of Europe used in Fig 1.[7]

Results

Figure 1a shows the degree of excess all-cause mortality in 25 European countries during the 10 first months of 2020. The overall excess in all-cause mortality 2020 in these countries correlated well with reported[3] deaths due to Covid-19 ($R2=0.78$, $p<0.0001$). It is clear that excess mortality varies greatly within Europe in 2020. In fig 1b we show that countries normally experiencing fluctuating mortality exhibited higher excess mortality also in 2020 ($R^2= 0.48$, $p<0.0001$), while those not affected during the preceding years were spared. This pattern is clearly seen when longitudinal mortality rates (Z-scores) for some countries are exhibited (Fig. 1c). Thus, some countries, including Spain, Belgium and Italy that were severely hit by the current pandemic also displayed high excess mortality during the preceding winter influenza seasons. Conversely, Norway, Luxembourg and Estonia show hardly visible fluctuations in mortality rates over the entire study period, including 2020.

Discussion

The data presented here suggest that it was possible to predict high death rates caused by covid-19 even before the pandemic hit Europe simply by looking at fluctuations in mortality in a country during the preceding normal influenza seasons. Why then are some countries apparently unaffected year after year by fatal respiratory viral disease while others suffer considerably? Possible explanations include geographical factors [3], population demographics, and density [4], genetic factors [5], cultural differences along with the organization of health care and elderly nursing homes. However, we found no correlation between population age and excess mortality in 2020 and neither was there any correlation with population density, latitude, GNP, governmental health spending,

degree of urbanization, or rates of influenza vaccination (Table 1 and 2). General organization and quality of health care and in particular elderly nursing homes, where a large portion of the 2020 covid-19 related deaths originated, are more complex factors that cannot be evaluated using these data alone.

It will be interesting also to study if regional cultural differences across Europe might explain the pattern observed here. Again, such analysis will require more sophisticated analytical tools and datasets. In the case of the ongoing covid-19 pandemic, social interactions are influenced by governmental policies ranging from milder regulations to lockdowns. The effectiveness of governmental measures in preventing the spread of infection and ultimately death is currently a matter of great debate. It seems clear to date that many countries that applied very strict measures still have experienced very high infection rates and death tolls during the current pandemic. Although the present data cannot be used to evaluate these strategies, it is noteworthy that whatever factors that drove excess mortality rates in 2020 were present already in 2015-2019, ie during a period when no measures were undertaken in any country. Thus our data suggest that there is an intrinsic susceptibility in certain countries to excess mortality associated with viral respiratory diseases including covid-19. We suggest that knowing about such susceptibility can be of value in preparing health care systems and directing timely help to a certain region when a pandemic hits a continent.

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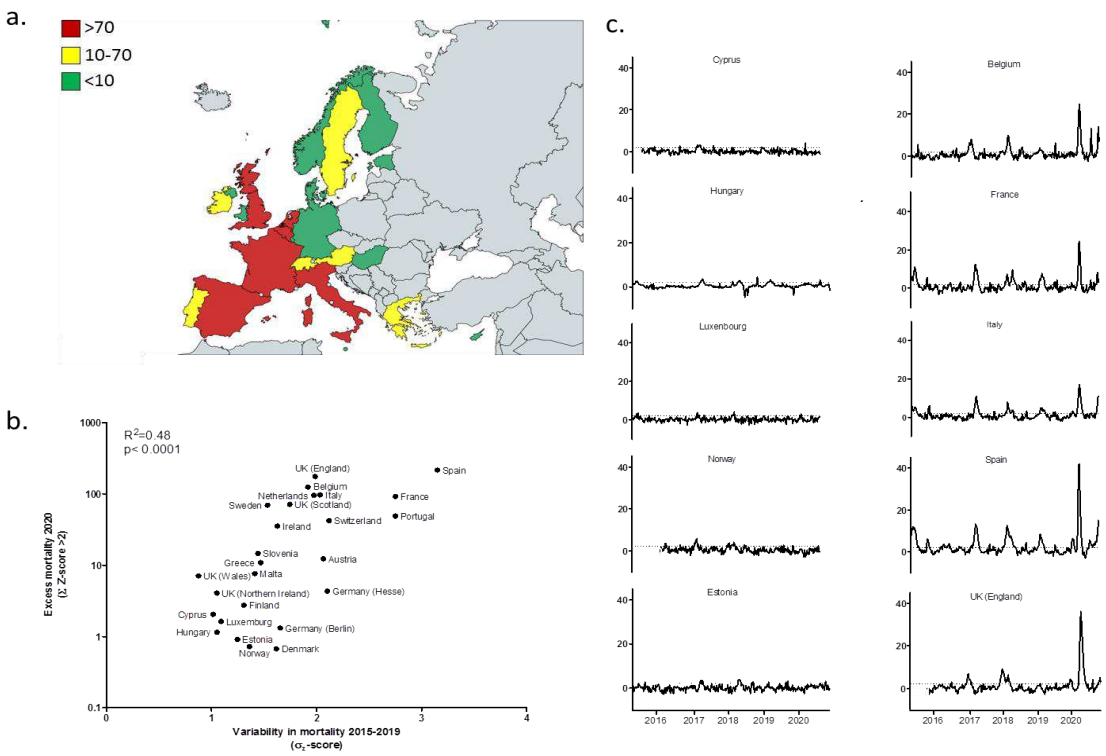

Fig.1. Excess mortality in Europe during the Covid-19 pandemic. (a) Map of Europe showing countries with varying degree of excess all-cause mortality during the Covid-19 outbreak in 2020, (b) variability in all-cause death rates 2015-2019 for 25 European countries plotted against the degree of excess deaths during the covid-19 outbreak and (c) longitudinal mortality patterns (Z-scores) for 10 representative countries demonstrating low (left) or high (right) death rates during 2020. Dotted lines represent a Z-score of 2 which here is defined as the threshold for excess mortality. Countries in gray in the map are not included in the database used. For Germany two regions (Hesse, Berlin) are included in the database and calculations. Colours in the map represent different degrees of excess all-cause mortality (Z-scores, sum of 2020 Z-score >2) with red being highest, yellow intermediate and green low.

Entity	R^2	P-value	N	Ref.
Age (% of poulation +65 yrs)	0.01	0.61	26	1
Population density (inhabitants per Sq km)	0.01	0.72	26	1
Urban poulation (% of total)	0.04	0.35	26	2
Latitude of the Capital	0.02	0.52	26	3
Gross National Product (US$) per capita	0.02	0.51	26	1
Govt. health expenditure (US$ per capita)	0.01	0.69	26	2
Influenza Vaccine (% coverage in 2015)	0.21	0.05	19	3
Variability in Z-score (2015-2019)	0.48	0.00	26	5

Table 1. Predicitive power of some indicators for excess deaths 2020. Excess deaths 2020 defined as sum of weekly Z-scores > 2 during the first 45 weeks[2] of 2020, which was found to correlate well with reported[6] covid-19 deaths (R^2 = 0.78, $p < 0.0001$). Information on influenza vaccine coverage was provided by countries recommending influenza vaccination for older people (in most countries > 65 years old) in 2014/2015. Austria, Belgium, Cyprus and Denmark did not report. Malta recommends vaccination for >55 years old. N – the number of separate regions included in the calculation. Nominal p-values reported in the table, with 'Variability in Z-score' being the only predictors surviving Bonferroni correction ($p_{adj} < 0.001$). The 'Variability in Z-score' was calculated as the standard deviation of the weekly Z-scores for periods available for each country (varying from week 1, 2015 to week 2 2017, see EuroMOMO[2]).

Entity	R^2	P-value	N	Ref.
Age (% of poulation +65 yrs)	0.11	0.09	26	1
Population density (inhabitants per Sq km)	0.00	0.96	26	1
Urban poulation (% of total)	0.01	0.58	26	2
Latitude of the Capital	0.06	0.22	26	3
Gross National Product (US$) per capita	0.02	0.51	26	1
Govt. health expenditure (US$ per capita)	0.00	0.98	26	2
Influenza Vaccine (% coverage in 2015)	0.05	0.37	19	4

Table 2. Correlation between indicators in Table 1 and Variability in Z-score.

Figures

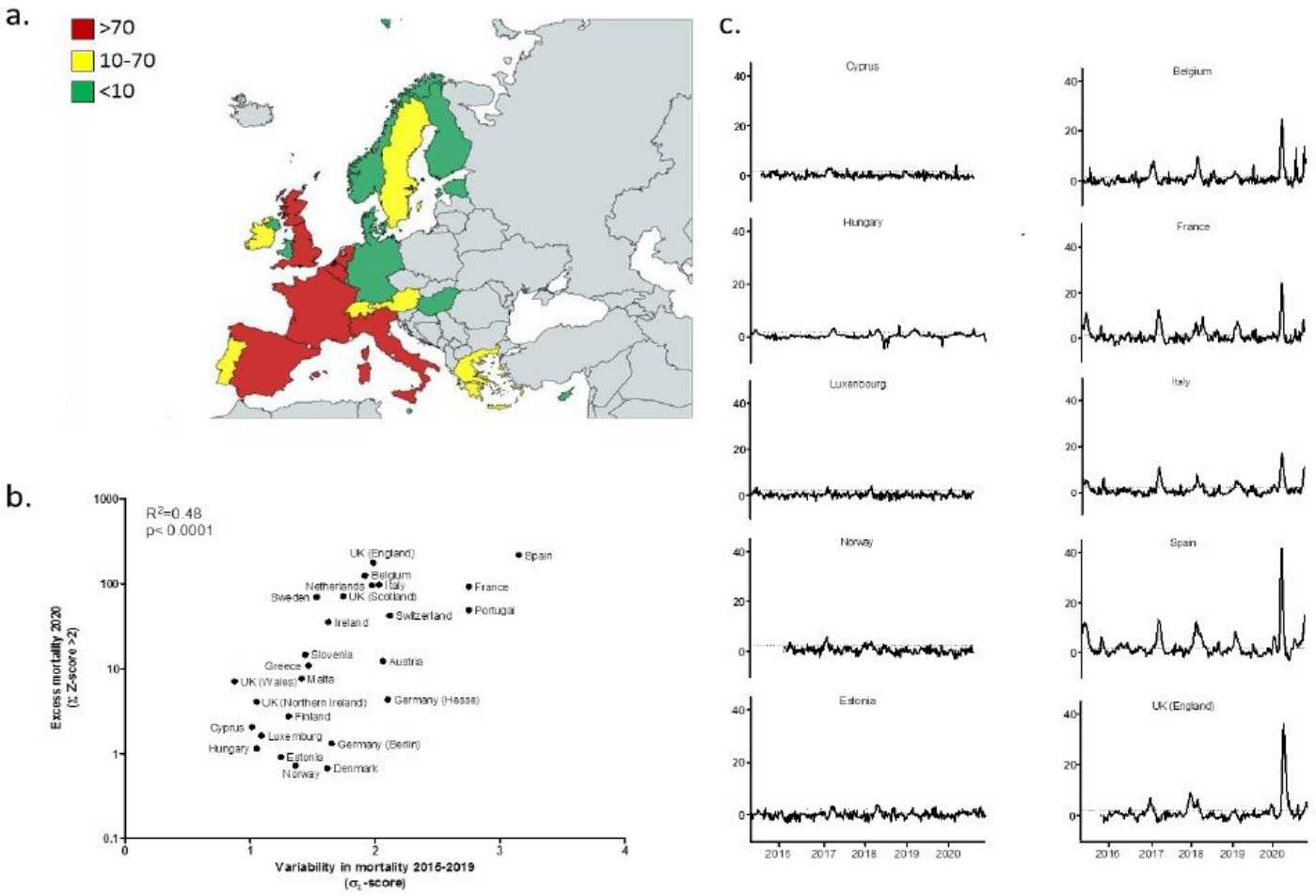

Figure 1

Excess mortality in Europe during the Covid-19 pandemic. (a) Map of Europe showing countries with varying degree of excess all-cause mortality during the Covid-19 outbreak in 2020, (b) variability in all-cause death rates 2015-2019 for 25 European countries plotted against the degree of excess deaths during the covid-19 outbreak and (c) longitudinal mortality patterns (Z-scores) for 10 representative countries demonstrating low (left) or high (right) death rates during 2020. Dotted lines represent a Z-score of 2 which here is defined as the threshold for excess mortality. Countries in gray in the map are not included in the database used. For Germany two regions (Hesse, Berlin) are included in the database and calculations. Colours in the map represent different degrees of excess all-cause mortality (Z-scores, sum of 2020 Z-score >2) with red being highest, yellow intermediate and green low. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.