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An Analysis of Territorial Patterns in COVID-19 Mortality in France, Spain, Italy and the UK

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Abstract

This paper provides an overview of territorial patterns of COVID-19 deaths in four European countries severely affected by the pandemic, Spain, France, Italy, and the United Kingdom. The analysis focuses on cumulated COVID-19 mortality at the sub-regional level, following the territorial subdivision of countries adopted by the European Union. The paper builds upon a dataset with highly granular information on COVID-19 deaths assembled from various sources.

The analysis shows remarkable differences in territorial patterns of COVID-19 mortality, both within and across the four countries reviewed. Results somewhat differ depending on the aspect considered (concentration of deaths or mortality rates) but, in general, Italy, France and Spain display significant territorial disparities, with selected sub-regions being disproportionately affected by the pandemic. Instead, the picture is more uniform in the UK, with comparatively lower differences across the various sub-regions. These findings suggest that analyses of COVID-19 mortality at the national level (and, sometimes, even at the regional level) may conceal major differences and therefore be of limited use, both analytically and from an operational viewpoint.

[1] Silvia Beghelli and Costanza Fileccia assisted in the collation and/or review of data for France and Italy. Data on COVID-19 mortality in Spain was taken from a pre-existing dataset developed by Estudio Montera. The collaboration of Pablo Montera and his colleagues is gratefully acknowledged.

1 INTRODUCTION

Both media sources and scholarly publications analyzing the death toll caused by the COVID-19 pandemic typically focus on mortality in 'high level' geographical areas, i.e. at the country and/or regional (or state) levels. However, there are indications that the pandemic has had a differentiated spatial effect and analyses at an aggregated level may not be able to fully capture its differentiated territorial impact. This paper seeks to address the issue by providing a descriptive analysis of COVID-19 deaths at a finer geographical level.

This paper provides an assessment of territorial patterns of COVID-19 deaths in four European countries severely affected by the pandemic, Spain, France, Italy, and the United Kingdom (UK). The analysis focuses on mortality at the **sub-regional level**, i.e. for the so called NUTS3 areas as defined by the European Union (EU). This is made possible by the collection and systematization of highly granular information on COVID-19 deaths, which was retrieved from various sources.

The paper is structured as follows:

- Section 2 elaborates on the territorial scope of the analysis;
- Section 3 deals with the measurement of COVID-19 mortality and related data sources;
- Section 5 shows the geographical concentration of COVID-related deaths;
- Section 6 does the same with reference to mortality rates;
- Section 7 offers some concluding remarks.

2 Territorial Scope of Analysis

In the 1970s, the EU established a classification of territorial entities commonly known as 'NUTS', which is the acronym of the French expression *Nomenclature des unités territoriales statistiques*. The classification system includes three hierarchical levels, i.e. NUTS1, corresponding to 'macro-regions' (e.g. North Western Italy or Occitanie), NUTS2, corresponding to regions or states (e.g. Piedmont or Bretagne), and NUTS3, corresponding to sub-regional entities. The NUTS classification tends to reflect the administrative subdivisions established within EU Member States, although in some cases a certain NUTS level may be the result of the aggregation/subdivision of administrative units. The NUTS classification is periodically revised. In this paper, reference is made to the classification adopted in 2016.[2]

In the four countries analyzed in this paper, the NUTS3 have different origins and characteristics.

In **Spain**, NUTS3 correspond to the *provincias*, originally established by the administrative reform of 1833 (although some of them can trace their origins to much older territorial entities, such as Navarra). Spain's NUTS3 come in different size and shape but they are generally larger than their counterparts in the other countries: the 52 Spanish *provincias* have an average area of nearly 10,000 square kilometers and a population of about 900,000 (with a median of some 600,000 inhabitants).

The NUTS3 in **France** (*départements*) and **Italy** (*province*) also have a long history (in France, dating back to the end of the XVIII century), although in Italy over the last couple of decades there have been several re-organizations. NUTS3 in the two countries are similar in number (101 *départements* and 107 *province*) and population (570,000 in Italy and 660,000 in France), although French NUTS3 are more than twice the size of Italy's (more than 6,000 vs. less than 3,000 square kilometers).

In the **UK**, NUTS3 are a mix of historical counties (such as Dorset or Devon) and groupings of unitary authorities (in England and Wales) or council/district council areas (in Scotland and Northern Ireland). UK's NUTS3 are much more numerous (179) and significantly smaller (on average, 1,400 square kilometers and 370,000 inhabitants) than in the three other countries.

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[2] A more detailed description of the NUTS system is provided in the EUROSTAT website. See in particular https://ec.europa.eu/eurostat/web/nuts/background

Exhibit 1 – Basic Features of NUTS3

Country	Number of Entities	Average Area	Average Population	Median Population
Spain	52	9,730	902,636	606,834
France	101	6,266	663,494	529,132
Italy	107	2,850	569,430	388,666
UK	179	1,385	372,330	331,297

Source: EUROSTAT

As it will be seen below, the different size of NUTS3 entities in the four countries sometimes does have an impact on the analysis of territorial patterns of COVID-19 mortality.

Overseas Territories. French and Spanish NUTS3 also include some overseas territories, often referred to as 'outermost regions'. These include the five French *départments d'outre-mer* (Guadeloupe, Martinique, Guyane, La Réunion and Mayotte) as well as Spain's Canary Islands, which are subdivided into two *provincias*. Considering that territorial contiguity is a key factor in the spreading of pandemics, these overseas NUTS3 entities have been excluded from the analysis. The same applies to Spain's autonomous cities of Ceuta and Melilla, which, while not formally regarded as 'outermost regions', are located on the northern shores of the Moroccan coast and therefore are not contiguous to the rest of Spanish territory.

3 COVID-19 Mortality

Measurement of COVID-19 Deaths. In the four countries covered by this paper, data on COVID-19 mortality is collected and disseminated primarily by health authorities, at the national and/or regional level. These statistics typically only refer to deaths confirmed by a molecular test (the 'confirmed deaths'). The exclusion of deaths of individuals displaying symptoms but not tested for the virus obviously results in an underestimation of 'real' COVID-19 mortality. Also, in the early stages of the pandemic, data on 'confirmed deaths' concerned mostly or exclusively deaths occurring in hospitals. The coverage of COVID-19 mortality statistics was progressively expanded to include deaths in nursing homes and other institutions, but there are indications that gaps may have remained.[3] Finally, deaths occurring at home, which typically do not involve any form of testing, are still largely unreported.[4]

In some countries, mortality statistics issued by public health authorities are supplemented by data resulting from population registers and death certificates. This is particularly the case of the UK, where the statistical agencies in England & Wales, Scotland and Northern Ireland also issue data on 'certified deaths', i.e. deaths for which there is a mention to COVID-19 in the death certificate. The statistics on based on death certificates also include 'suspect' COVID-19 cases, and therefore are more comprehensive than the data provided by health authorities. However, there are indications that even 'certified deaths' may underestimate COVID-19 mortality.[5]

Overall, there is little doubt that currently available data underestimates the real magnitude of COVID-19 mortality. In addition, as data collection and reporting practices may somewhat differ across countries (e.g. due to differences in the coverage of deaths in nursing homes), figures for the four countries may not be fully comparable. However, this does not have a major impact on the analysis presented in this paper, as the emphasis is more on the comparison of trends rather than of absolute figures.

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[3] For instance, regarding Spain see Mateo, Juan José, Madrid admite que 4.260 personas murieron en residencias con coronavirus o síntomas, de las que solo 781 estaban diagnosticadas, El Pais, 8 April 2020.

[4] For instance, in the case of France, see Le coronavirus aurait fait 9000 morts à domicile, selon ce syndicat de médecins, Le HuffPost, 27 April, 2020. As for Italy, see Merico Chiara, In Italia il conto dei morti per Covid 19 è ampiamente sottostimato. E molti Paesi truccano le cifre, a partire dalla Cina, Business Insider, 3 April 2020.

[5] See Blackall, Molly, UK care home Covid-19 deaths 'may be five times government estimate', The Guardian, 18 April 2020.

Sources of Data. The analysis focuses on cumulated COVID-19 deaths since the onset of the pandemic in March 2020. However, due to data availability issues, there are some differences in the coverage for individual countries.

Data on COVID-19 mortality at the NUTS3 level are not always readily available and the dataset underpinning this paper was built using various sources.[6]

In the case of **Spain**, the information on cumulated COVID-19 'confirmed deaths' at the provincial level was primarily retrieved from the database established by Estudio Montera. In turn, this database relied on data reported by the *Comunidades Autonomas*, i.e. the NUTS2 level entities that have prime responsibility for the running of the health system, or by *Instituto de Salud Carlos III*, Spain's National Health Institute. This paper primarily refers to the situation prevailing at the end of May. However, access to Estudio Montera's dataset also allowed to easily retrieve information on deaths at end March and end April, which in turn allowed for a diachronic assessment.

In the case of **France**, data on COVID-19 mortality in hospitals at the *département* level are published daily by *Santé publique France*, the agency in charge of epidemiological surveillance placed under the *Ministère des Solidarités et de la Santé*. This was complemented with information on deaths occurring in nursing homes and other institutions (*établissements sociaux et médico-sociaux* – ESMS), also published by *Santé publique France* but on a weekly basis and in separate publications. The information presented in this paper refers to the situation at end May.

As for the **UK**, reference is made to data on cumulated 'certified deaths' in the local administrative units and other similar territorial subdivisions, published by the statistical agencies in England & Wales, Scotland, and Northern Ireland. As statistics on 'certified deaths' require more time to be compiled, the data used here refers to the cumulated deaths occurred up to mid-May and registered up to late May.

Finally, in the case of **Italy**, statistics on COVID-19 mortality at the provincial level are not systematically published. Reference was therefore made to a study recently published by the *Istituto Superiore di Sanità* (ISS) and the National Statistical Institute (ISTAT) covering developments up to end of April. While the shorter temporal coverage obviously constitutes a limitation, Italy was the first country seriously affected by the pandemic and two months are a sufficient period for detecting key spatial patterns. In addition, an earlier, similar study covered the situation up to end March, which again allowed for an overtime comparison.

All in all, this paper covers more than 133,000 COVID-19 deaths subdivided among 429 NUTS3 entities in the four countries.

Exhibit 2 – Summary of Data Utilized

Country	Source	Coverage	Number of Deaths	Comments
Spain	Estudio Montera dataset	Confirmed deaths up to 31 May	29,563	Data as of end March and end April also available
France	Santé publique France	Confirmed deaths up to 31 May (hospitals) and 27 May (nursing homes)	29,309	
Italy	ISS – ISTAT studies	Confirmed deaths up to 30 April	27,846	Data as of end March also available
UK	Statistical agencies in England & Wales, Scotland, and Northern Ireland	Certified deaths up to mid/late May	46,533	

[6] For a more detailed description of data sources, please refer to Annex B.

4 Findings – Territorial Concentration of COVID-19 Deaths

The territorial concentration of COVID-19 deaths shows significant variations across countries, with widely diverging patterns.

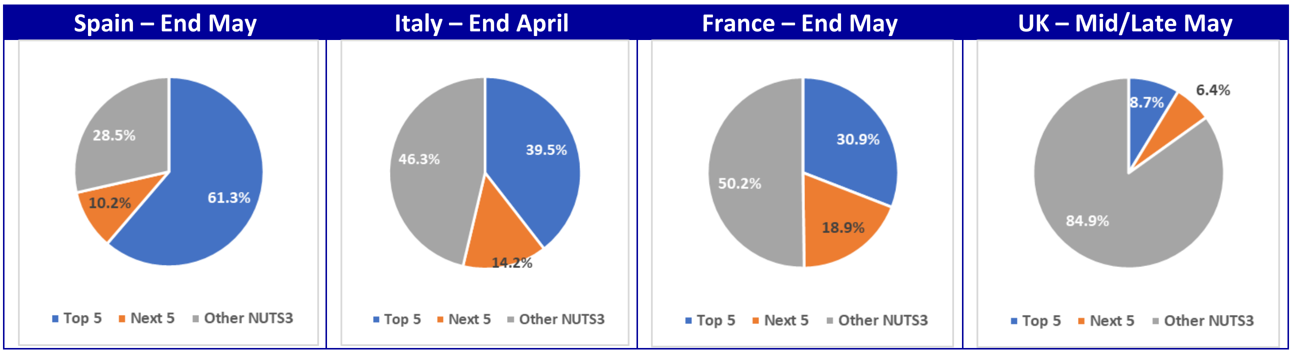
Concentration is fairly high in **Italy**. At the end of April, the five NUTS3 with the highest number of deaths (the 'Top 5'), all located in Lombardia, accounted for nearly 40% of total COVID-19 mortality nation-wide. Another 14% was accounted for by the next five highest ranking NUTS3 (the 'Next 5'), located in Lombardia as well as in Piemonte, Liguria and Emilia-Romagna. All in all, the ten NUTS3 topping the ranking (the 'Top 10'), all located in the northwestern part of the country, accounted for nearly 54% of COVID-related deaths country-wide.

Figures are higher in **Spain**, with the Top5 NUTS3 accounting for over 60% of cumulated deaths country wide, a share increasing to 71% when the Next 5 are added. However, these figures are strongly influenced by the structural features of Spanish *provincias*, that – as mentioned above – are significantly larger than their counterparts in other countries and therefore ceteris paribus are expected to have more deaths. Indeed, Madrid and Barcelona, the two areas with the highest death toll, are quite sizeable territorial entities, cumulatively accounting for more than a quarter of total Spanish population. In comparison, Milano and Bergamo, the two most affected Italian *province* are smaller, with a population of slightly more than 7% nation-wide.

Concentration is lowest in the **UK**. The Top 5 NUTS3 account for less than 9% of the COVID-19 total death toll, and the share increases to only 15% when the Next 5 areas are considered. To some extent, this is also due to the structural features of UK's NUTS3, which are much smaller than in other countries and therefore are expected to have fewer deaths each. However, this is only part of the story. Indeed, even if we consider the top 20 NUTS3, their share in cumulated deaths remains a fairly low 26%, i.e. lower than the share of Madrid alone. In addition, the low geographical concentration of COVID-related deaths is confirmed by geographical dispersion of the Top 10 NUTS3, which include areas spanning across the whole country, from Scotland and Northern England to London and from the Midlands to various parts of Southern and Eastern England.

France is an intermediate case. The Top 5 NUTS3, including Paris and its inner metropolitan area (the so called *petite couronne*) as well as one eastern *département*, account for little more than 30% of total French COVID-19 deaths. The share of the Next 5, also mostly from the Île de France plus the NUTS3 encompassing Lyon and another eastern *département*, is close to 19%, bringing the share of cumulated COVID-19 deaths in the Top 10 close to 50%.

Exhibit 3 – Overview of Territorial Concentration of COVID-19 Deaths



Box 1 - Changes in Territorial Concentration Overtime

In the case of Spain and Italy, the availability of mortality data at various time intervals allows for an assessment of changes in concentration over time. In **Spain**, concentration was highest at the end of March, when the Top 10 *provincias* accounted for 77% of total COVID-19 deaths. The share declined to 71% by end April and stayed at the same level at end May. The list of *provincias* comprising the Top 10 remained broadly the same, with Madrid, Barcelona, Ciudad Real and Bizkaia constantly topping the list, and only few new entries (namely, Girona, ranking 12th at end March but subsequently raising to the 7th/8th position) and exists (namely, Álava, ranking 7th at end March and subsequently dropping out of the Top 10, i.e. 16th at end May).

In **Italy**, the decline in concentration was more marked. At the end of March, the Top 10 NUTS3 accounted for nearly 65% of country-wide deaths, with the top two *province*, Bergamo and Brescia, accounting alone for 29%. By end April, the Top 10 share had declined by more than ten percentage points, to about 54%. The composition of the Top 10 also shows some significant changes, with Milano overtaking Bergamo as the area with the largest number of deaths and the entry of another large urban area, Genova.

5 Findings – Territorial Patterns in Mortality Rates

A complementary and more accurate picture of territorial developments in COVID-related mortality can be obtained by looking at 'mortality rates', i.e. the ratio between the number of deaths and the population in any given geographical area. Expressed in terms of deaths per 100,000 inhabitants, mortality rates are a standardized metric, not influenced by the size of NUTS3.

Once again, there are significant variations across the four countries. In France and, especially, in Italy, mortality rates reached quite high levels in a limited number of NUTS3 and the pandemic scarcely affected many other areas. In contrast, COVID-19-related deaths are more evenly spread nationwide in Spain and especially in the UK.

In **France**, the first outbreak was in the Eastern part of the country and the pandemic quickly reached the capital and the rest of the Île de France region. There were other localized outbreaks (e.g. in Corse-du-Sud in the early days), but they were of much smaller size, and the south and south western regions were largely spared. As a result, the five most affected *départements* (the 'Top 5'), with mortality rates ranging from 110 up to nearly 190 deaths per 100,000, are all located in the North Eastern part of the country. In these areas mortality rates are twenty to forty times bigger than those recorded in the five least affected areas (the 'Bottom 5'), all located in South Western France, which reported fewer than 5 deaths per 100,000. The skewed territorial distribution of mortality rates is confirmed by summary statistics, with the average being nearly twice the median value (38 vs. 22 deaths per 100,000). The corresponding coefficient of variation (CV)[7] is fairly high, at 98%

The situation is even more polarized in **Italy**, where mortality rates have reached very high levels in the initial Codogno cluster (in Lombardy's Lodi province) and surrounding areas.[8] Indeed, at the end of April four of the Top 5 *province* (located in Lombardy and Emilia-Romagna) recorded mortality rates in in the order of 270 – 310 per 100,000, by far the highest values recorded at the NUTS3 level across the four countries. These values are more than one hundred times bigger than those found in the Bottom 5 areas (mostly in Sicily), which reported just one or two deaths per 100,000. The extremely skewed distribution of mortality rates in Italy is again captured by the difference between the average and median values, with the former being more than double than the latter (46 vs. 20 deaths per 100,000), while the CV is quite high, at 137%.

Box 2 - Differences in Mortality Rates Within Italian Regions

In Italy, stark differences in mortality rates are sometimes found also within regions, i.e. at the NUTS2 level. This is particularly the case of the **Emilia-Romagna** region, where the 308 deaths per 100,000 recorded in the northwestern

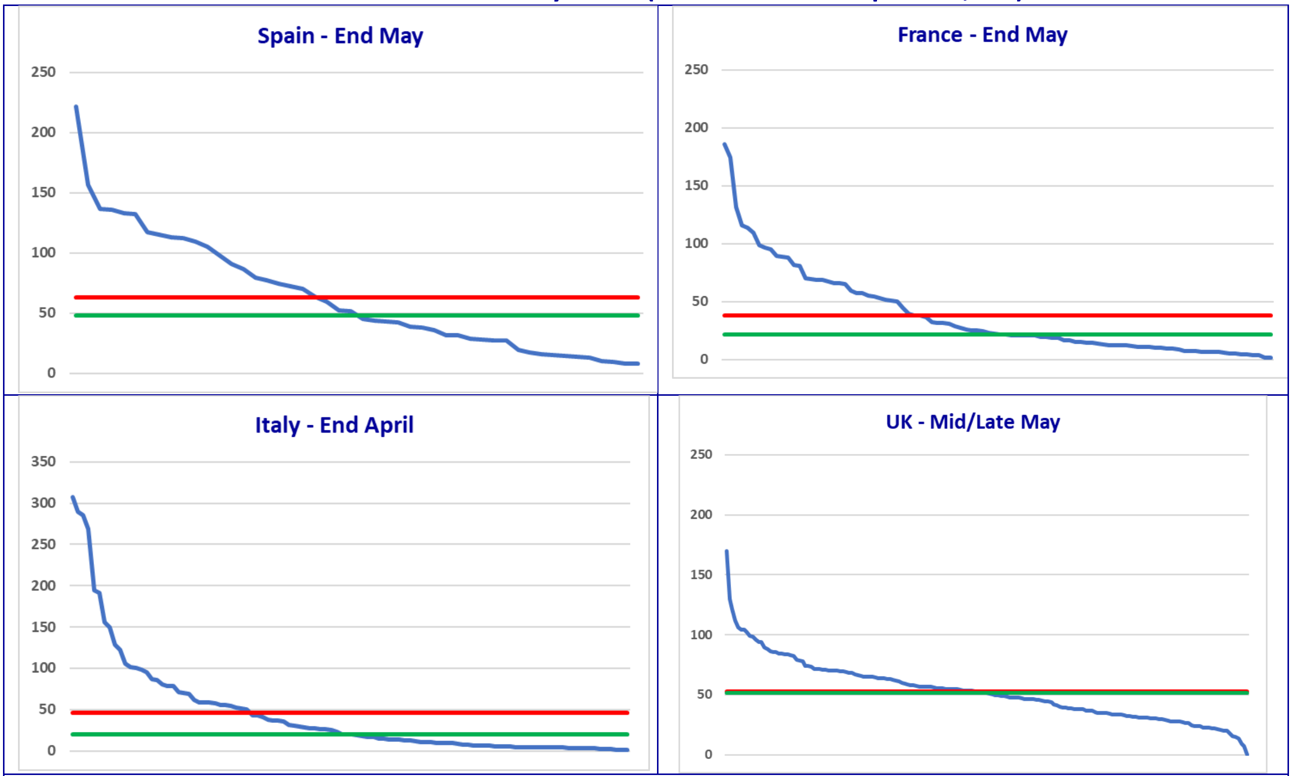
[7] The CV is a measure of dispersion, defined as the ration between the standard deviation and the average.
[8] In Italy, there was another initial cluster in the Veneto region, but it was quickly eradicated thanks to a massive testing and tracing program. See Crisanti, Andrea and Dorigatti, Ilaria (senior and corresponding authors), Suppression of COVID-19 outbreak in the municipality of Vo', Italy, medRxiv, 18 April 2020.

province of Piacenza (which lies just across the Po river at short distance for the initial Codogno cluster) was ten to twenty times the rate recorded in the majority of eastern provinces (17 deaths per 100,000 in Ravenna and 36/37 deaths per 100,000 in Ferrara and Forlì-Cesena). An even starker contrast is found in the **Marche** region, were the 128 deaths per 100,000 recorded in Pesaro Urbino are a multiple of the 5 deaths per 100,000 in the Ascoli Piceno province, which yet lies just 200 kilometers to the south. Even in **Lombardy**, where the vast majority of province were heavily affected, there are some notable differences. In particular, the 43 deaths per 100,000 recorded in Varese cases are one sixth/one seventh of the 270/285 deaths per 100,000 found in Lodi and Bergamo, which are just 100 kilometers away.

In **Spain**, the pandemic also had a differentiated territorial impact, but the distribution of mortality rates is comparatively less unbalanced. In the Top 5 *provincias* (all in central Spain), mortality rates were typically in the order of 130 – 160 deaths per 100,000, with only Ciudad Real reaching the level of 221 deaths per 100,000. These figures are about ten times the values displayed by the Bottom 5 NUTS3 (mostly in Southern Spain), which recorded between 8 and 13 deaths per 100,000. Spain's more uniform territorial distribution of mortality rates is confirmed by summary statistics, with the average value of 63 deaths per 100,000 being higher but not too dissimilar from the median value of 48, while the CV is 76%.

An even more uniform pattern is found in the **UK**, where there are only moderate differences across territorial subdivisions. The mortality rates for the Top 5 NUTS3 (located in England's North East and North West as well as in Scotland) are in the order of 110 to 170 deaths per 100,000, i.e. only six to ten times the values displayed by the Bottom 5 NUTS3, of which three are in Scotland, one in England, and one in Northern Ireland. Indeed, in the UK the average mortality rate across all NUTS3 almost coincide with the median value, the two being respectively 53 and 52 deaths per 100,000. Consequently, the CV is a modest 48%.

Exhibit 4 – Territorial Distribution of Mortality Rates (COVID-19 Deaths per 100,000)



Average values in **red**. Median values in **green**
Please note: the scale of the vertical axis for Italy is 0 – 350, whereas it is 0 – 250 for the other countries

6 Concluding Remarks

The results presented above clearly show remarkable differences in territorial patterns of COVID-19 mortality, both within and across the four countries reviewed. Results somewhat differ depending on the aspect considered (concentration of deaths or mortality rates) but, in general, Italy, France and Spain display significant territorial disparities. Instead, the picture is comparatively more uniform in the UK. These findings confirm the initial intuition of the paper, i.e. that analyses of COVID-19 mortality at the national level (and, sometimes, even at the regional level) may conceal major differences and therefore be of limited use, both analytically and from an operational viewpoint.

The reasons for these territorial differences remain to be investigated. Prima facie, the most heavily affected NUTS3 areas appear to be those where the initial outbreaks took place (e.g. Lodi, Haut-Rhin), suggesting s declining rate of propagation, also because of the lockdown measures adopted. However, the impact of other, more structural aspects (such as population density or the share of older population) must also be considered. The availability of the highly granular information on COVID-19 deaths assembled for this paper will greatly facilitate a more comprehensive analysis, making it possible to match mortality data with a range of socio-economic indicators available at the NUTS3 level.

ANNEX A – DETAILED RESULTS

Exhibit A.1 – Territorial Concentration of COVID-19 Deaths

Spain – End May			France – End May			Italy – End April			UK – Mid/Late May		
Top 10 NUTS3	Share of Deaths	Share of Population	Top 10 NUTS3	Share of Deaths	Share of Population	Top 10 NUTS3	Share of Deaths	Share of Population	Top 10 NUTS3	Share of Deaths	Share of Population
Madrid (Madrid)	30.7%	14.9%	Paris (Île de France)	8.1%	3.3%	Milano (Lombardia)	12.4%	5.4%	Birmingham (West Midlands)	2.3%	1.7%
Barcelona (Catalunya)	21.2%	12.5%	Hauts-de-Seine (Île de France)	6.4%	2.5%	Bergamo (Lombardia)	10.8%	1.8%	Hertfordshire (East of England)	2.0%	1.8%
Ciudad Real (Castilla-la Mancha)	3.7%	1.1%	Val-de-Marne (Île de France)	6.3%	2.2%	Brescia (Lombardia)	8.9%	2.1%	Berkshire (South East)	1.5%	1.4%
Bizkaia (País Vasco)	3.0%	2.6%	Seine-Saint-Denis (Île de France)	5.4%	2.6%	Pavia (Lombardia)	3.8%	0.9%	Harrow & Hillingdon (London)	1.4%	0.8%
Toledo (Castilla-la Mancha)	2.6%	1.6%	Haut-Rhin (Grand Est)	4.8%	1.2%	Cremona (Lombardia)	3.7%	0.6%	Staffordshire (West Midlands)	1.4%	1.3%
Valencia (Comunidad Valenciana)	2.4%	5.7%	Val-d'Oise (Île de France)	4.1%	1.9%	Torino (Piemonte)	3.5%	3.7%	Tyneside (North East)	1.4%	1.3%
Zaragoza (Aragón)	2.3%	2.2%	Seine-et-Marne (Île de France)	3.9%	2.2%	Piacenza (Emilia-Romagna)	3.2%	0.5%	Glasgow City (Scotland)	1.3%	0.9%
Girona (Catalunya)	1.9%	1.7%	Rhône (Auvergne-Rhône-Alpes)	3.8%	2.9%	Monza (Lombardia)	2.7%	1.4%	Barnsley, Doncaster and Rotherham (Yorkshire & Humber)	1.3%	1.2%
Albacete (Castilla-la Mancha)	1.8%	0.9%	Essonne (Île de France)	3.6%	2.0%	Parma (Emilia-Romagna)	2.5%	0.7%	Leeds (Yorkshire & Humber)	1.3%	1.2%
Navarra (Navarra)	1.7%	1.5%	Moselle (Grand Est)	3.5%	1.6%	Genova Liguria)	2.4%	1.4%	Greater Manchester NE (North West)	1.2%	1.0%
Concentration Ratios			Concentration Ratios			Concentration Ratios			Concentration Ratios		
Top 5	61.3%	32.6%	Top 5	31.0%	11.7%	Top 5	39.5%	10.8%	Top 5	8.7%	7.0%
Next 5	10.2%	11.9%	Next 5	18.9%	10.6%	Next 5	14.2%	7.8%	Next 5	6.4%	5.6%
Top 10	71.5%	44.5%	Top 10	49.8%	22.3%	Top 10	53.7%	18.6%	Top 10	15.1%	12.7%

Exhibit A.2 – Territorial Distribution of Mortality Rates (COVID-19 Deaths per 100,000)

France - End May		Italy - End April		Spain - End May		UK - Mid/Late May	
Top 5 NUTS3	**Rates**	**Top 5 NUTS3**	**Rates**	**Top 5 NUTS3**	**Rates**	**Top 5 NUTS3**	**Rates**
Haut-Rhin (Grand Est)	185.8	Piacenza (Emilia-Romagna)	307.9	Ciudad Real (Castilla-la Mancha)	221.4	Darlington (North East)	169.9
Territoire de Belfort (Bourgogne-Franche-Comté)	174.4	Cremona (Lombardia)	289.2	Cuenca (Castilla-la Mancha)	156.8	Blackpool (North West)	130.1
Val-de-Marne (Île de France)	131.5	Lodi (Lombardia)	285.8	Madrid	136.6	Blackburn with Darwen (North West)	121.7
Hauts-de-Seine (Île de France)	116.0	Bergamo (Lombardia)	268.6	Albacete (Castilla-la Mancha)	135.5	Inverclyde, East Renfrewshire and Renfrewshire (Scotland)	111.9
Vosges (Grand Est)	114.0	Brescia (Lombardia)	194.8	Soria (Castilla y León)	133.0	East Dunbartonshire, West Dunbartonshire and Helensburgh & Lomond (Scotland)	106.0
Bottom 5 NUTS3	**Rates**	**Bottom 5 NUTS3**	**Rates**	**Bottom 5 NUTS3**	**Rates**	**Bottom 5 NUTS3**	**Rates**
Dordogne (Nouvelle-Aquitaine)	4.1	Oristano (Sardegna)	2.5	Cádiz (Andalucía)	12.6	Hertfordshire (East of England)	15.2
Landes (Nouvelle-Aquitaine)	3.9	L'Aquila (Abruzzi)	2.3	Murcia (Murcia)	9.8	Fermanagh and Omagh (Northern Ireland)	13.7
Lot-et-Garonne (Nouvelle-Aquitaine)	3.6	Ragusa (Sicilia)	1.6	Huelva (Andalucía)	9.2	Orkney Islands (Scotland)	9.1
Ariège (Occitanie)	1.3	Palermo (Sicilia)	1.2	Lugo (Galicia)	8.2	Inverness & Nairn and Moray, Badenoch & Strathspey (Scotland)	6.9
Lozère (Occitanie)	1.3	Trapani (Sicilia)	0.9	Almería (Andalucía)	7.6	Western Isles (Scotland)	0.0
Summary Statistics	**Rates**	**Summary Statistics**	**Rates**	**Summary Statistics**	**Rates**	**Summary Statistics**	**Rates**
Average	38.2	Average	46.1	Average	63.2	Average	52.9
Median	21.8	Median	20.0	Median	48.2	Median	51.8
Coefficient of Variation	98%	Coefficient of Variation	137%	Coefficient of Variation	76%	Coefficient of Variation	48%

ANNEX B – DATA SOURCES

B.1 Spain

Data on COVID-19 cumulated deaths used in this paper are mostly taken from the dataset built by Estudio Montera (hereinafter, the 'Estudio Montera Dataset'), complemented with own estimates for the three provincias in the Pais Vasco.

The Estudio Montera Dataset is accessible at https://github.com/montera34/escovid19data. The database includes information on deaths as well as a host of other relevant variables (number of cases, tests performed, etc.). For each variable, the dataset also shows the original sources of data, typically health authorities in the various *Comunidades Autonomas* and the *Instituto de Salud Carlos III*. The data collection and compilation work performed by Estudio Montera is extremely valuable as information on COVID-19 deaths at the provincial level is sometimes not easily accessible. Therefore, Estudio Montera's contribution is once again gratefully acknowledged.

The analysis presented here relies on cumulated deaths data at end March, end April and end May.[9] Regarding the latter, in some cases available data do not refers to the situation as of 31 May but to earlier dates. In the case of five *provincias*, figures are only marginally older, as they refer to 23 May (A Coruña, Asturias), 28 May (Lugo and Pontevedra, also in the Asturias) and 29 May (Badajoz and Cáceres, in Extremadura). Considering that these provinces have relatively low levels of COVID-19 mortality and the bulk of deaths occurred in April, the underestimation of mortality entailed by the use of older data is minimal, probably in the order of few units.

The situation is different for the three *provincias* in the País Vasco (Álava, Bizkaia and Gipuzkoa), as the most recent figures included in the Estudio Montera Dataset are significantly older, referring to 13 May. Therefore, the end of May figures used for this paper were estimated by applying the proportion of deaths in each province on 13 May resulting from the Estudio Montera Dataset to the total number of COVID-19 deaths reported by regional authorities in their daily epidemiological report.[10]

Overall, the total number of COVID-19 deaths considered for the analysis at the end of May was 29,563, whereas the deaths at end March and end April were, respectively, 9,176 and 25,776.

B.2 France

The data on COVID-19 deaths used for this paper comes from two sources, namely: (i) the statistics on COVID-19 deaths occurring in hospitals; and (ii) the statistics on deaths occurring in the ESMS, which nursing homes (*établissements d'hébergement pour personnes âgées dépendantes* - EHPAD) and other institutions.

Data on deaths in hospitals are collected by *Santé publique France* and made available through an online database updated daily (https://www.coronavirus-statistiques.com/stats-globale/coronavirus-nombre-de-morts-par-departement/). The database was last accessed on 7 June 2020 and at the date of 31 May it showed a total of 18,413 deaths (excluding 51 deaths in the overseas *départements* not covered by this paper).

Data on COVID-19 deaths in ESMS are also collected by *Santé publique France* and published in a series of regional epidemiological reports. These reports are published on a weekly basis and they are available

[9] The Estudio Montera Dataset was last accessed on 7 June 2020.
[10] See Gobierno Vasco, Situación Epidemiológica del Coronavirus (COVID-19) en Euskadi, 01/06/2020 - 00:00 horas.

through a dedicated section of *Santé publique France*'s website.[11] The website was last accessed on 29 May and the regional reports available at that date covered the situation up to the week ending on 27 May.

The format of regional reports shows some variations and details on the deaths in each *département* are not always readily available. Accordingly, in some cases the relevant information had to be estimated. In particular:

- In the case of three regions, Corsica, Hauts-de-France and Nouvelle-Aquitaine, epidemiological reports consulted only provided the total number of deaths in ESMS. The figures at the *département* level were estimated by applying the proportion of deaths in hospitals derived from the online database mentioned above;
- The report on the Île de France region does provides figures at the *département* level but they also include the deaths of people living in ESMS that occurred in hospitals, therefore partly overlapping with data provided in the online database. Since deaths in hospitals were reported to account for 22% of total ESMS deaths region-wide, figures for individual *départements* were computed by discounting this proportion.

Based on the above, COVID-19 deaths in ESMS were estimated at 10,896 as of 27 May. When added to the deaths in hospitals, this brings the total number of deaths considered in the analysis at 29,309.

B.3 Italy

In Italy, data on COVID-19 deaths at the provincial level are not systematically published. Information is provided by some regions (e.g. Toscana) and some figures are from time to time published in the media, but there is no way to obtain a comprehensive picture of mortality at the NUTS3 level.[12]

Therefore, this paper primarily relies on the information provided in a study published in early June by ISS and ISTAT and covering developments up to the end of April.[13] The purpose of the study is to assess the impact of the COVID-19 pandemic on overall mortality, by comparing COVID-19 deaths at the provincial level with total mortality over the same period as well as with the mortality recorded in previous years. The study provides the provincial breakdown of 27,846 COVID-19 deaths occurred as of 30 April. This figure is smaller than the total number of COVID-19 deaths recorded over the same period in Italy (28,561). However, the difference is quite small (715 deaths, i.e. about 2.5%) and it is not deemed to affect the validity of the analysis.[14]

Obviously, the main limitation of our dataset is that the ISS-ISTAT study covers developments only up to end April, thereby affecting the comparison with the other countries. At the same time, it is important to recall that Italy was the first European country seriously affected by the pandemic and it is reasonable to expect

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[11] https://www.santepubliquefrance.fr/recherche/#search=COVID%2019%20point%20epidemiologique&publications=donn%C3%A9es&regions=Antilles|Auvergne-Rh%C3%B4ne-Alpes|Bourgogne%20/%20Franche-Comt%C3%A9|Bretagne|Centre-Val%20de%20Loire|Grand%20Est|Guyane|Hauts-de-France|Ile-de-France|Normandie|Nouvelle-Aquitaine|Occitanie|Oc%C3%A9an%20Indien|Pays%20de%20la%20Loire|Provence-Alpes-C%C3%B4te%20d'Azur%20et%20Corse&sort=date.

[12] This problem was faced by the authors of an earlier study on COVID-19 mortality at the provincial level, who were able to locate information only for about three quarters of Italian *province* (78 out of a total of 107). See Ferrari Luisa and others, COVID-19 in Italy: An app for a province-based analysis, arXiv, 27 April 2020, accessible at https://arxiv.org/abs/2004.12779. An updated version of the dataset underpinning the study is available at http://demm.ceeds.unimi.it/covid/.

[13] ISS – ISTAT, Impatto dell'epidemia COVID-19 sulla mortalità totale della popolazione residente primo quadrimestre 2020, 4 giugno 2020. Available at https://www.epicentro.iss.it/coronavirus/pdf/Rapp_Istat_Iss_3Giugno.pdf.

[14] The difference is due to two factors, First, for some deaths it was not possible to ascertain the place of residence and therefore they could not be allocated at the provincial level. Second, the study does not consider the COVID-19 deaths for which no corresponding figures for total mortality are available. However, this is the case for only a minority of municipalities accounting for less than 7% of total population.

that after two months the key patterns in mortality had already consolidated. Therefore, while the addition of data up to end May (expected to become available in early July) would certainly be a positive development, it is unlikely that it could materially alter the picture depicted in this paper.

On the positive side, this paper could also rely on a previous, similar study also from ISS and ISTAT, which covered developments in mortality up 31 March.[15] The existence of two studies with comparable information at two points in time allowed to assess the evolution of territorial patterns in COVID-19 mortality.

A final note concerns Sardinian provinces. In 2016, a reform reduced the number of *province* from eight to five and also involved the transfer of some territory among previous and new administrative units. The reform is not yet reflected in EU statistics on NUTS3, which are still based on the previous territorial architecture. As population data for the computation of mortality rates per 100,000 was taken from EU statistics, there could be small discrepancies due to (minor) changes in provincial boundaries. For the same reason, the Sud Sardegna province is lumped together with the *Città Metropolitana di Cagliari*. In practice, this means that this paper considered 106 NUTS3 entities instead of 107. As Sardinia was one of the least affected areas by COVID-19, none of these adjustments had any appreciable effect on the analysis.

B.4 United Kingdom

As anticipated in the text, in the case of the UK this paper relied on data on 'certified deaths' collected and published by statistical agencies. In particular:

- In the case of England and Wales reference was made to data published by the Office for National Statistics (ONS) and concerning the deaths occurred up to 15 May but recorded up to 23 May, subdivided by local authority;[16]
- For Scotland, reference was made to the dataset published by the National Records of Scotland (NRC) and concerning deaths registered up to 24 May, subdivided by council area of usual residence;[17]
- Regarding Northern Ireland, data comes from the Northern Ireland Statistics and Research Agency (NISRA) and concern the deaths registered in the week up to 15 May, subdivided by local government district.[18]

The preference for 'certified deaths' statistics is obviously due to their wider coverage compared with data on 'confirmed deaths' issued by health authorities. Since 'certified deaths' statistics require more time for their compilation, information is available with some delay (in the order of one to two weeks from occurrence) and therefore UK data is slightly less up to date than information available for France and Spain.

In using the UK data, the main challenge was of an operational nature and concerned the need to consolidate highly granular mortality data (provided at the local authority, council area or local government district) to 'match' the NUTS3 level. This was particularly the case for England, as data for 317 local authorities had to be combined in order to derive the figures for England's 139 NUTS3 entities. Overall, the analysis presented in this paper considers a total on 46,533 deaths.

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[15] ISS – ISTAT, Impatto dell'epidemia COVID-19 sulla mortalità totale della popolazione residente primo trimestre 2020, 4 maggio 2020. Available at https://www.istat.it/it/files//2020/05/Rapporto_Istat_ISS.pdf

[16] The ONS data set is accessible at https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsregisteredweeklyinenglandandwalesprovisional/weekending15may2020.

[17] Th dataset is available through at https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/weekly-and-monthly-data-on-births-and-deaths/deaths-involving-coronavirus-covid-19-in-scotland

[18] The Weekly Deaths dataset is available at https://www.nisra.gov.uk/publications/weekly-deaths. As the dataset is continuously updated, the version used for this paper is no longer available.

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