

## A simple statistical model to infer the number of effective deaths and infected, with an application to the town of Bergamo

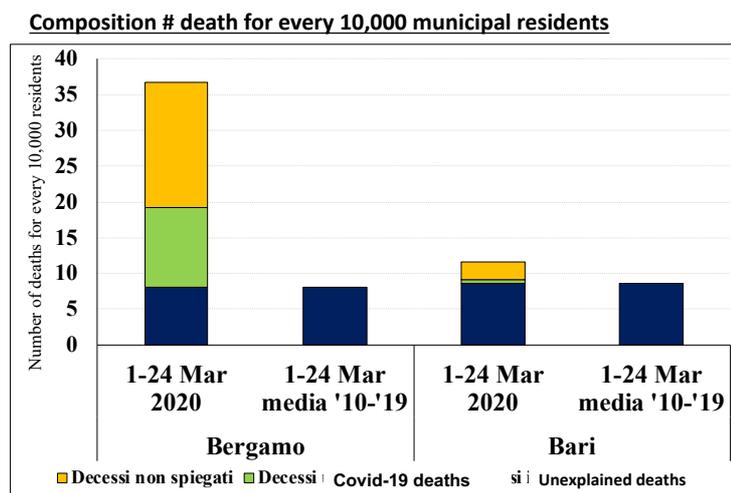
The number of official deaths for Covid-19 in Italy on March 30 was 11591. By official number we mean deaths of individuals that resulted positive at the Covid-19 test. There are different reasons, reported in the media across different countries affected by the spread of Covid-19, that makes us believe that the official number of deaths due to Covid-19 maybe highly underestimated

A simple strategy to estimate the size of this under-reporting is to look at the differences in total number of deaths by municipality in March 2020 relative to March 2019, and possibly relative to March of previous years as well. The ratio between (i) the difference in total deaths in the same month over two consecutive years and (ii) the officially recorded number of deaths by Covid-19 is therefore an estimate of the size of this under-reporting. This is called “difference-in-difference” estimation.

An assumption in this procedure is that all deaths in March 2020 that are in addition to the typical number of deaths in the same municipality in previous years are considered deaths for Covid-19. As a matter of fact, some of those “atypical” deaths may be individuals who did not contract Covid-19 but did not receive adequate medical assistance because of the congested health system. Those are “collateral damages” due to Covid-19.

We now illustrate the possible bias of recorded death using official data obtained from the city councils of Bergamo. The analysis is summarised in the following table and figure.

1-24 March	Bergamo	Bari
population	121633	320862
Number of deaths with Covid-19: March 2020	136	21
Total number of deaths: March 2020	446	374
Total number of deaths: average March 2010-2019	98	274



In the period between 1-24 March 2020, the number of recorded deaths for Covid-19 in the city council of Bergamo was 136. In the same period, the total number of deaths was 446. However, the average number of deaths in the same period for the years 2010-2020 was 98 (Unfortunately, we did not receive the year-by-year information and therefore we cannot

report confidence interval). This means that in the period between the first of March 2020 and the 24<sup>th</sup> of March 2020 Bergamo registered a number of 348 deaths more than the typical number of deaths registered in previous years. Of those 348 “atypical” deaths, only 136 have been registered as caused by Covid-19. This leaves 212 deaths unexplained, which is roughly a factor of two higher than the number of deaths registered for Covid-19.

The numbers from the town of Bari depict a similar picture. Bari registered 100 more deaths in the period 1-24 of March relative to the typical year. Of those 100 deaths only a fifth have been registered as Covid-19. We are investigating the data we have received from Bari better.

This method can be easily adapted for all towns in other regions in Italy and in other countries. The Excel file attached to this short article allows each city council to input the relevant data and to change the parameters in a way that is more appropriate given the local information. The Excel file will then estimate the “corrected” number of deaths for Covid-19. The file also provides an inference of the total number of individuals that have been infected. This is done by multiplying the corrected number of deaths with the fatality rate. For example, assuming a fatality rate of 1% (with a range between 0.5% and 1.5%), the estimated number of infected in Bergamo on 24/03 is around 30000 residents (19000—52000). As of today, 31/03, more than 30% of residents is likely to be infected!

Concluding, number of deaths is an important data to understand the spread of Covid-19. For example, a new Imperial Report published on March 30 (see reference), uses the number of recorded deaths over time for Covid-19 as an important input to infer the effect of intervention of social distancing in lowering the replication number of Covid-19, and, consequently, to estimate the prevalence of contagion. The results of those analysis are sensitive to the accuracy of the number of deaths considered for the analysis and it is therefore important to have feasible ways to correct for obvious biases in the official data.

Andrea Galeotti [agaleotti@london.edu](mailto:agaleotti@london.edu)

Paolo Surico [psurico@london.edu](mailto:psurico@london.edu)

London Business School

#### Reference

Seth Flaxman, Swapnil Mishra, Axel Gandy et al. [Estimating the number of infections and the impact of nonpharmaceutical interventions on COVID-19 in 11 European countries](#).

Imperial College London (2020) doi: 30 March

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**Composition # death for every 10,000 municipal residents**

