



# SFI TRANSMISSION

## COMPLEXITY SCIENCE FOR COVID-19

**STRATEGIC INSIGHT:** Common-sense estimates provide quantitative ways to think about the economic impact of COVID-19 in Italy.

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Is there a principled way of calculating the burden of disease on the economics of a nation? And doing so when the quality of information is heterogeneous and our knowledge of the disease improves from one moment to the next? The great economist John Maynard Keynes in a letter of 1938 wrote, “The object of a model is to segregate the semi-permanent or relatively constant factors from those which are transitory or fluctuating so as to develop a logical way of thinking about the latter, and of understanding the time sequences to which they give rise in particular cases.”

In the spirit of Keynes, it’s an instructive exercise to quantitatively estimate the impact of COVID-19 hospitalizations and deaths by using simple common-sense estimates. Where these estimates make use of more or less constant factors (in this case, national death rates and the costs of medical care) in order to best estimate factors about which we know far less, or, as Keynes put it, transitory factors (in this case, COVID-19 hospitalizations and costs).

Let’s consider the case of Italy. For this country, the current life expectancy is 82.8 years.<sup>1</sup> This number translates to one person dying every 30,222 days, or a death rate of  $1/27,375 \approx 0.0000331$  people per day. Equivalently, the death rate is 0.0121 per year, or 12.1 deaths per year per 1,000 people. This naive estimate is reasonably close to the currently documented value of 10.6 annual deaths per 1,000 people in Italy.<sup>2</sup> Using this documented death rate and  $\approx 60,000,000$  for the population of Italy,<sup>3</sup> roughly 2,200 people die in Italy each day from all causes. In recent years, the leading causes of death were ischemic heart diseases, cerebrovascular diseases, and other heart diseases; these accounted for nearly 30 percent of all deaths.

The number of COVID-19 deaths in the past few weeks in Italy have been:

Daily and total COVID-19 deaths in Italy.<sup>4</sup>

Date	Daily Deaths	Total Deaths	Date	Daily Deaths	Total Deaths
3/16	349	2,158	4/1	727	13,155
3/17	344	2,503	4/2	760	13,915
3/18	475	2,978	4/3	766	14,681
3/19	427	3,404	4/4	681	15,362
3/20	627	4,023	4/5	525	15,887
3/21	793	4,825	4/6	636	16,523
3/22	651	5,476	4/7	604	17,127
3/23	601	6,077	4/8	542	17,669
3/24	743	6,820	4/9	610	18,279
3/25	683	7,503	4/10	570	18,849
3/26	712	8,125	4/11	619	19,469
3/27	919	9,134	4/12	431	19,899
3/28	889	10,023	4/13	566	20,465
3/29	756	10,779	4/14	602	21,067
3/30	812	11,591	4/15	578	21,645
3/31	837	12,428	4/16	525	22,170

The peak value of the daily number of deaths in Italy due to COVID-19 (at the end of March) represents an additional  $\approx 35$  percent on top of the total number of 2,200 daily deaths.

Let's use the above numbers to get a sense of the impact of the epidemic on hospitals and on the economy. For COVID-19, presumably a substantial fraction of patient deaths occur in an acute hospital setting, such as an intensive care unit (ICU). It also seems reasonable to assume that almost all patients who die from COVID-19 spend time in the ICU before expiring. In the USA, roughly 3,000,000 people die each year,<sup>5</sup> with roughly 700,000 in-hospital deaths<sup>6</sup> and approximately 500,000 of these deaths ( $\approx 17$  percent) in an ICU.<sup>7</sup> Corresponding data for Italy does not appear to be available, but it is a reasonable assumption to use the same fractions for Italy; roughly  $\frac{1}{4}$  of all deaths occur in a hospital and roughly  $\frac{1}{6}$  of all deaths occur in the ICU. If we accept these fractions, then roughly 350 Italians die in ICUs daily. Over the nearly one-month period when the epidemic has been at its peak, the number of daily deaths in ICUs due to COVID-19 is *at least 2.5 times larger than the steady-state number of 350*. The stress on hospital staff who are working in an ICU setting during this peak epidemic time is hard to imagine.

The monetary costs of COVID-19 medical care are significant. Using the current number of deaths in Italy ( $\approx 22,000$ ) and assuming another factor of two for patients who were gravely ill but survived,<sup>8</sup> there are roughly 44,000 patients who

have needed or are currently needing ICU care. Multiple sources indicate that the typical length of stay of a COVID-19 patient in an ICU is around 10 days.<sup>9</sup> Multiplying by the daily Italian ICU cost of roughly \$1,600<sup>10</sup> gives an estimate of \$700 million over the past month to tend to critically ill patients. It is difficult to obtain reliable numbers for the total cost of COVID-19-related medical care during the peak of the epidemic, but it is not unreasonable to make the guesstimate that the total cost is three times larger than the critical care cost. This gives an estimated direct medical cost of  $\approx$  \$2 billion which has been incurred over a period of approximately one month.

The GDP of Italy in 2019 was roughly \$2 trillion,<sup>11</sup> which converts to roughly \$166 billion per month. Thus, these direct medical costs represent a bit more than 1 percent of Italy's GDP for the past month. To give some perspective, let's translate these numbers to the scale of the U.S. In 2019, the GDP of the U.S. was roughly \$21 trillion.<sup>12</sup> An expenditure of roughly 1 percent of the U.S. GDP per month corresponds to approximately \$17 billion dollars per month. This is a substantial spending rate; for comparison, the annual budget of the National Science Foundation (NSF) is \$7.8 billion.<sup>13</sup> That is, Italian COVID-19 medical costs, when scaled to the size of the U.S., corresponds to two annual NSF budgets being spent in a single month.

Another perspective comes from comparing COVID-19 medical costs with total medical costs. For Italy, health-care spending is roughly \$3,000 per person annually or \$250 per person monthly.<sup>14</sup> The \$2 billion estimate for acute-care COVID-19 spending corresponds to an expenditure of roughly \$33 per person over the past month. Thus, the direct costs of acute COVID-19 care represent an additional 13 percent charge to the medical costs for every person in Italy; the final cost will clearly be much higher.

By using estimates about which we can be fairly certain to make projections into domains of high uncertainty, this Transmission provides a quantitative way to think about the impact of the COVID-19 epidemic on Italy.

## REFERENCES

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