

© 2020 EDIZIONI MINERVA MEDICA
 Online version at <http://www.minervamedica.it>
 Panminerva Medica 2021 March;63(1):86-7
 DOI: 10.23736/S0031-0808.20.04212-3

Forecasting the burden of COVID-19 hospitalized patients during the SARS-CoV-2 second wave in Lombardy, Italy

Although the epidemiological dynamics of SARS-CoV-2 infection are highly dependent on political, environmental, and social determinants, reliable forecasting of the incidence of SARS-CoV-2 infections and of symptomatic COVID-19 patients can help plan strategic choices for the healthcare system (e.g. remodeling of and/or building of hospitals).¹ In Lombardy, the estimation of hospital beds at different levels of care for COVID-19 patients is key since it is the Italian region with the highest COVID-19 cases and deaths.

Several studies showed the mortality and infection diffusion trend in different settings.¹⁻³ During the first wave of SARS-CoV-2 pandemic, we reported trend curves of virus-related deaths in Italy, European and non-European countries. A 3rd-grade polynomial curve with a growth up to the daily peak, and then, a five-parameter logistic (5PL) asymmetrical sigmoidal curve following a parametric growth described the temporal evolution of the deaths.⁴

Aim of the present study was to model official data on hospitalizations collected in Lombardy (real-time data on COVID-19 infection in Italy from Protezione Civile)⁵ to estimate the number of COVID-19 hospitalized cases until the end of 2020, taking into account the impact of strict measures to tackle the SARS-CoV-2 diffusion.

The predicted number of hospitalized cases in Lombardy was determined using the following formula: hospitalized (t0) = hospitalized (t-1) - deaths (t-1) - ICU transferred (t-1) - recovered (t-1) + new hospitalized (t0). The estimation relies on the time period between October 4, the first day after which the number of hospitalized patients began to grow daily (305 hospitalizations) and October 13, 2020 (546 hospitalizations). Importantly, we considered data of the confinement rules implementation since the estimation of COVID-19 patients is strictly related to the containment measure. The new model describes the expected number of COVID-19 related hospitalized patients, and we drew two curves (Figure 1), based on the strengthening measures implemented on October 24 and November 5, 2020 (Gazzetta Ufficiale della Repubblica Italiana)⁶ respectively, with the purpose of identifying the impact of the containment measures implementation on the number of hospitalized patients in Lombardy. Each curve is characterized by three distinctive phases:

- growth: the trend maintains the same growth rate up to the effect of strict measures adoption, occurring 9 days after its start. This time frame is coherent with an average of seven days of incubation, plus two days for symptoms occurrence before hospitalization. This phase is in keep with 4-PL symmetric sigmoidal curve showing estimated values weighed on $1/y^2$;⁴

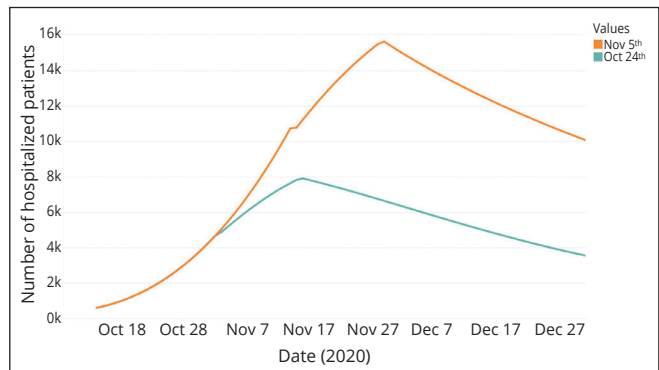


Figure 1.—Model describing expected hospitalized COVID-19 patients in Lombardy (Italy) until the end of 2020, considering the containment measures of October 24 and November 5, 2020.

- peak: the turning point is calculated 23 days after the containment measures implementation, as we previously described for COVID-19 death trends.² The curve follows a 4-PL parametric symmetric sigmoidal, assuming a peak of 60% can be reached nine days after the adoption of the control rules;
- decrease: 4-PL parametric symmetric sigmoidal interpolated using the following data: 1) -30% of cases during the following 23 days after the peak; 2) -50% of cases in double the time needed to reach the peak; 3) -100% of cases which occurs in a number of days equal to four times to reach the turning point.

The curve grows up to 23 days after the adoption of the strict measures, becoming flat for a few days and then decreasing, even if more slowly than during the growth phase. Although calculated using local data, we surmise that these trends can be inferred to other settings, keeping into consideration the different public health restrictions.

Figure 2 shows the potential peak of hospitalized COVID-19 pa-

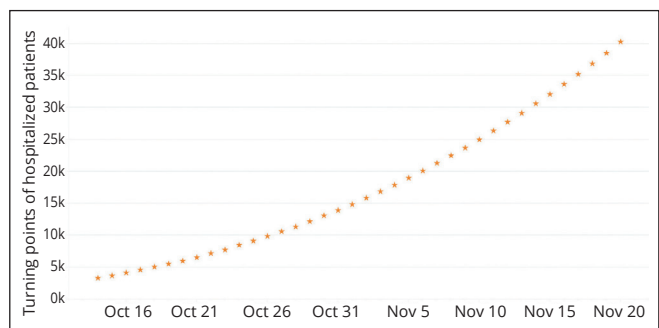


Figure 2.—Trend showing the different peaks of hospitalized COVID-19 patients in Lombardy (Italy) after 23 days from the strict measures' implementation (dates indicated in x-axis).

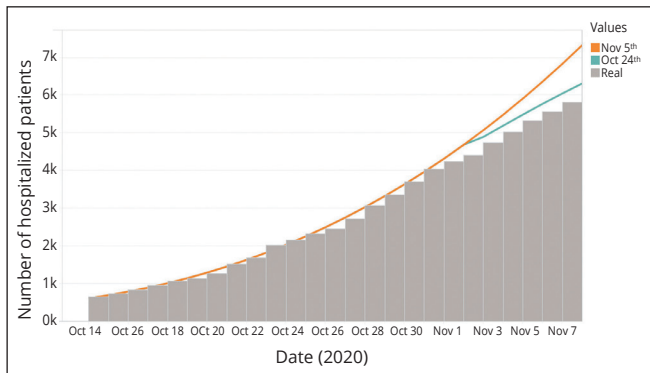


Figure 3.—The accuracy curve of our model was achieved by plotting real data until November 7, 2020 (grey bars) with expected hospitalized COVID-19 cases in Lombardy (Italy), considering the impact of the strict measures of October 24 and November 5, 2020.

tients in Lombardy, calculated after 23 days from the day of implementation of the containment measures. In x-axis are indicated the turning points, and by this curve it is possible to estimate the effect of the delay of strict containment measures on the number of hospitalized patients. If there had not been any containment measures taken until November 15, the number of hospitalizations would have reached 32,900, 23 days after their implementation. If we consider the beginning of the restrictions starting from October 24, we estimate about 8000 by November 26. Finally, if we consider the beginning of the containment from November 5, the estimate is 15,000 by November 28.

To estimate the reliability of our model, we calculated the accuracy curve by plotting real data of Lombardy (grey bars) with the expected cases (Figure 3). The accuracy curve was achieved by plotting real data until November 7 (grey bars) with expected hospitalized COVID-19 cases, considering the impact of the strengthening measures of October 24 and November 5, 2020. R^2 values are 0.997 and 0.998 considering November 5 and October 24, respectively; while calculated delta for the same dates are 17.8% and 1.5%, respectively. Taken together these findings suggest the reliability of the model. It can be also inferred that the trend has started flattening after October 24, suggesting that also less restrictive measure can have an impact on SARS-CoV-2 spreading.

Although considering the limitations of forecasting data, we surmise that it is crucial to identify the trend and the dynamics of disease for the second COVID-19. Recently, Cacciapaglia *et al.*⁷ used the renormalization group (eRG) approach to efficiently simulate the trend of pandemic transmission and spreading across different European countries. Although with a different modeling method, they also used in the simulation data, the information from the first wave.

We are aware that our findings are strongly influenced by several factors, such as the number of non-hospitalized symptomatic patients, the proportion of past and current asymptomatic or mildly symptomatic cases in the population, the potential lack of homogeneous treatment protocols, and the inaccuracy of reporting of hospitalized cases. In addition, our model did not consider stratification for the main confounding variables (*e.g.* age, sex, and pre-existing comorbidities), which can affect outcomes of the SARS-CoV-2 infection.

Even if intrinsic limitations of forecasting data are considered, the rapid growth of new COVID-19 hospitalizations requires rapid public health action.

Alberto G. GERLI¹, Monica MIOZZO^{2,3*},
Stefano CENTANNI^{4,5}, Laura FONTANA³,
Davide CHIUMELLO^{4,6}, Giovanni SOTGIU⁷,
Carlo LA VECCHIA⁸

¹Management Engineering Tourbillon Tech srl, Padua, Italy; ²Department of Pathophysiology and Transplantation, University of Milan, Milan, Italy; ³Foundation IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy; ⁴Department of Health Sciences, University of Milan, Milan, Italy; ⁵Respiratory Unit, ASST Santi Paolo e Carlo, Milan, Italy; ⁶Department of Anesthesia and Intensive Care, ASST Santi Paolo e Carlo, Milan, Italy; ⁷Unit of Clinical Epidemiology and Medical Statistics, Department of Medical, Surgical and Experimental Sciences, University of Sassari, Sassari, Italy; ⁸Department of Clinical Sciences and Community Health, University of Milan, Milan, Italy

*Corresponding author: Monica Miozzo, Department of Pathophysiology and Transplantation, Foundation IRCCS Ca' Granda Ospedale Maggiore Policlinico, University of Milan, Milan, Italy. Via F. Sforza 28, 20122, Milan, Italy. E-mail: monica.miozzo@unimi.it

References

- Goldstein JR, Lee RD. Demographic perspectives on the mortality of COVID-19 and other epidemics. *Proc Natl Acad Sci USA* 2020;117:22035–41.
- Gerli AG, Centanni S, Miozzo MR, Virchow JC, Sotgiu G, Canonica GW, *et al.* COVID-19 mortality rates in the European Union, Switzerland, and the UK: effect of timeliness, lockdown rigidity, and population density. *Minerva Med* 2020;111:308–314.
- Sotgiu G, Gerli AG, Centanni S, Miozzo M, Canonica GW, Soriano JB, Virchow JC. Advanced forecasting of SARS-CoV-2-related deaths in Italy, Germany, Spain, and New York State. *Allergy* 2020;75:1813–5.
- Gerli AG, Centanni S, Miozzo M, Sotgiu G. Predictive models for COVID-19-related deaths and infections. *Int J Tuberc Lung Dis* 2020;24:647–50.
- COVID-19 dashboard. Protezione Civile; 2020 [Internet]. Available from: <http://opendatadpc.maps.arcgis.com/apps/opsdashboard/index.html#/b0c68bce2cce478eaac82fe38d4138b1> [cited 2020, Nov 24].
- Decreto del Presidente del Consiglio dei Ministri 3 novembre 2020. *Gazzetta Ufficiale della Repubblica Italiana*; 2020 [Internet]. Available from: <https://www.gazzettaufficiale.it/eli/id/2020/11/04/20A06109/sg> [cited 2020, Nov 24].
- Cacciapaglia G, Cot C, Sannino F. Second wave COVID-19 pandemics in Europe: a temporal playbook. *Sci Rep* 2020;10:15514.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions.—Alberto G. Gerli has given substantial contributions to model design, computational framework and data mining, Monica Miozzo and Laura Fontana to manuscript writing, Stefano Centanni and Davide Chiumello to manuscript supervision, Giovanni Sotgiu and Carlo La Vecchia to data analysis and interpretation. All authors read and approved the final version of the manuscript.

History.—Article first published online: November 13, 2020. - Manuscript accepted: November 13, 2020. - Manuscript received: November 10, 2020.

(Cite this article as: Gerli AG, Miozzo M, Centanni S, Fontana L, Chiumello D, Sotgiu G, *et al.* Forecasting the burden of COVID-19 hospitalized patients during the SARS-CoV-2 second wave in Lombardy, Italy. *Panminerva Med* 2021;63:86-7. DOI: 10.23736/S0031-0808.20.04212-3)