Logistic behavior of italian Covid-19 epidemic @ 13 March 2020

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Update **13 March 2020**; time evolution looks logistic (or in any event slowly saturating) on all variables, with sizable but decreasing uncertainties on saturation predictions. The focus now shifts onto the appropriateness of the logistic model vs other possibilities.

I report time evolution estimates of the Covid-19 italian epidemic, hypothesizing a logistic behavior. The data are nation-wide up to March 13 (Protezione Civile, `https://bit.ly/2UbpPzt`). The previous reports are at `https://bit.ly/2W6vs4u` as well as in posts at `https://bit.ly/2QaFQEy`.

The onset of saturation behavior sems fairly settled, compared to pure exponential, for all quantities, both visually and statistically. The exponentials are refitted on the whole data set, so they may differ from other (or my previous) estimates. Death count is the most uncertain dataset, possibly for the difficulties of the medical services in Lombardia. The predicted points of inflection and saturation values are still very uncertain, although they have been stabilizing in recent days.

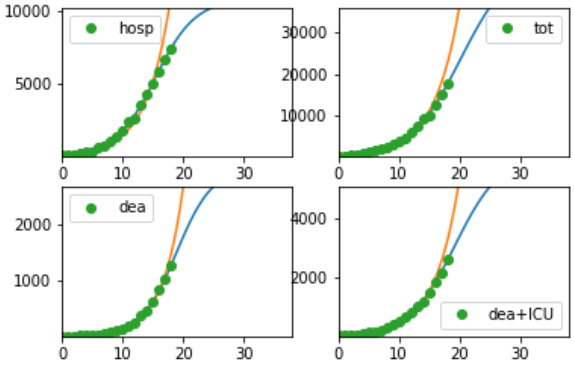

FIG. 1. Exponential and logistic behavior (lin-lin scale) for (top-down, left-right) hospitalized, total infected, deceased, ICU+deceased. Day 0 is February 24.

Fig.1 and 2 visualize the data, and Table I sums up the current estimates. Fit parameters as well as real and simulated data are available at `https://bit.ly/2W6vs4u`. A simplified python code is available for anyone wanting to have a go at a similar estimate, e.g., for other regions, which would be very useful at this point. I did not work on that yet, but Edoardo Gorini (INFN-Uni Salento) did, at `https://bit.ly/2IHbc1p`; he finds that some effects of nation-wide restrictions or early containment may be showing up for other italian regions.

The statistics in Table II point fairly clearly to a superior quality of the logistic fit. According to the logistic prediction based on current data, the saturations for deaths+ICU, deaths, hospitalized, total infected are 6200, 3000, 10800, 48000, compared to 5400, 3000, 10500, 43000 yesterday, so they are stabilizing to some degree. The inflection points for the same quantities are 19, 19, 15, 20 days from 24 February, i.e. 15, 15, 11, 16 March, nearly stable compared to the last reported values.

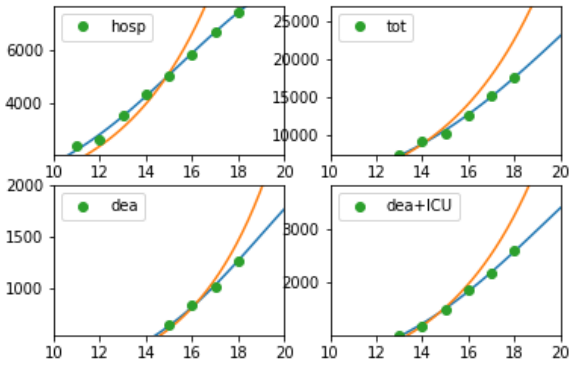

FIG. 2. As in Fig.1, restricted view.

We are now entering the perilous domain of quantitative predictions, and it is essential to ask whether the logistic model is indeed a good predictor. I have no answer to that, hence any estimates I provide must be taken with extreme caution, despite their internal consistency (for example an error-function behavior would double the logistic predictions to 13300, 10000, 17500, 175000 deaths+ICU, deaths, hospitalized, total infected, with inflections moving accordingly forward in time). On the other hand, there are claims that other models may be relevant, such as a version of the Gompertz dynamics, whereby after restrictive measures the rates will decrease exponentially. Preliminary tests suggest that we are not in this phase yet, if one exists, and the best we can hope for now is a"logistization".

Another cautionary flag (which may be for the better in a sense) is the partial inconsistency of the different estimates. Extrapolated final lethality (deaths/positives at the end of the process) would be currently estimated at a very large 6.2%, and the death rate for hospitalized patients at a whopping 28%. On the other hand, it is possible that the ICU crisis in Lombardia has caused both these estimates to be inflated; in the few days of stationary behavior in early March, the predicted ratios

TABLE I. Parameters of logistic and exponential for ICU+deaths, deaths, hospitalized, total infected (data 13 March 2020)

	ICU+deaths	Deaths	Hospitalized	Totali
Logistic				
$n \equiv L$ (saturation)	6205	3018	10780	48020
k (rate, 1/days)	0.26	0.34	0.30	0.24
t_0 (inflection, giorni)	19	19	15	20
$1/k$ (rate, days)	3.84	2.94	3.3	4.17

TABLE II. Statistical comparison (13 March 2020) for logistic (L) and exponential (E).

	S-p	paired-S-p	χ^2	χ^2-p	R^2
Total					
L	0.989	0.579	167.35	0	0.999
E	0.859	0.294	1053.92	0	0.951
Deaths					
L	0.994	0.689	4.812	1.0	0.999
E	0.958	0.558	20.707	0.294	0.985
Hospitalized					
L	0.996	0.802	29.371	0.04	0.999
E	0.827	0.378	1037.48	0	0.902
ICU+deaths					
L	0.992	0.52	10.03	0.93	0.999
E	0.890	0.354	116.046	0	0.961

were constant in time and in line with other previous assessments and estimates.

Finally, the comparison of a few statistical indicators in Table II shows further improvements for the logistic over the exponential for all proxies. Deaths are still compatible with both models