Italian Covid-19 epidemic @ 15 March 2020: logistic and Gompertz

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Update **15 March 2020**; time evolution looks logistic (or in any event slowly saturating) on all variables, with decreasing uncertainties on saturation predictions. The focus now shifts onto other fit models and their properties. Here I look at logistic and Gompertz model and its current parameters.

I report time evolution estimates of the Covid-19 italian epidemic using nation-wide data up to March 15 (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`. Simulated data are available at `https://bit.ly/2W6vs4u` and a simplified python code is available.

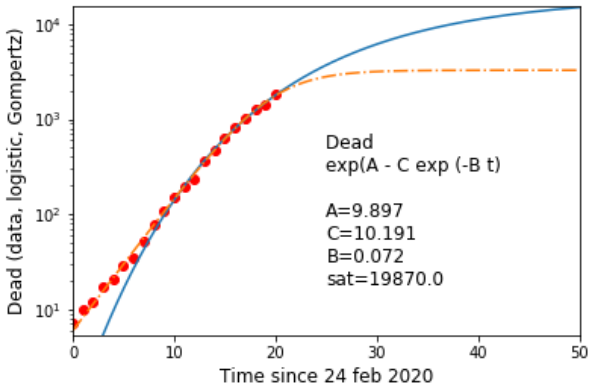

FIG. 1. Gompertz and logistic fit to the death count up to March 15, 2020. The fit parameters are reported.

The early-stage onset of saturated behavior is quite settled for all quantities, the exponential being now statistically to be rejected. I thus choose to compare the fits to the data with the logistic and the Gompertz function $f(t, A, B, C) = \exp(A - C\exp(-Bt))$. An example is in Fig.1 for the death count.Table I reports the predicted asymptotic values and inflection points (these are calculated both as zeros of second derivatives and maxima of first derivatives - "the peaks"). Fig. 1 compares logistic and Gompertz fits for the various quantities.

It is apparent that we are at another "bifurcation", and we will learn in the next days whether the data will settle down on the logistic or still climb onto the Gompertz. Of course, an intermediate possibility is that the exponentially changing Gompertz rate (i.e. the exponential in the exponent) may get suppressed somewhat, thus scaling down the long-term behavior to plausible values. The current rates are similar to those found yesterday (for death count, they are in the Figure). It is debated whether one should exclude some early points from the time series or not; for now I keep them all. Another thing I will try tomorrow is compare the data of a model by A. Mattoni with the Gompertz prediction to try to improve the accuracy of the prediction.

The results for Gompertz are similar to those yesterday, and similarly internally inconsistent. The fit statistics in Table II are mixed, favoring slightly the logistic for death count, but Gompertz for other indicators. The logistic predictions are similar to those in recent days, though highly fluctuating. Also as yesterday, the extrapolated final lethality (deaths/positives at the end of the process) is currently still large at 4%, and the death rate for hospitalized patients also large, at 24%.

TABLE I. Predictions with logistic and Gompertz for ICU+deaths, deaths, hospitalized, total infected (data 15 March 2020)

	ICU+deaths	Deaths	Hospitalized	Totali
		Saturation		
L	6859	3283	13678	73250
G	54269	19870	33553	3805000
		Inflection (days)		
L	20	20	17	23
G	39	32	23	71

TABLE II. Statistical comparison (15 March 2020) for logistic (L) and Gompertz (G).

	S-p	paired-S-p	χ^2	χ^2-p	R^2
		Deaths			
L	0.997	0.893	6.221	0.999	0.999
G	0.883	0.389	107.14	0.0	0.95
		ICU+deaths			
L	0.991	0.439	15.387	0.754	1.0
G	0.995	0.658	10.824	0.951	1.0
		Hospitalized			
L	0.984	0.493	106.602	0.0	0.998
G	0.993	0.711	80.966	0.0	0.999