

# Evidence of pandemic fatigue associated with stricter tiered COVID-19 restrictions

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**Introduction:** This work, which has already been accepted for publication, aims to provide evidence of pandemic fatigue by studying mobility changes during the second pandemic wave in Italy, from November 2020 to May 2021, in which tiered government interventions were enacted. Pandemic fatigue can be described as the decreased motivation to adhere to social distancing measures and adopt health-protective behaviors [1] and it represents a significant concern for policy makers and health officials. Italy represents a peculiar case since its government imposed social distancing measures which were applied at a regional level and organized into color tiers with increasing levels of restrictiveness (Yellow, Orange, Red) and were renovated according to a periodic risk assessment.

**Main theoretical contributions:** This work provides evidence of pandemic fatigue by means of mixed-effect regression models. Quantifying the temporal decrease in adherence to intervention is of fundamental importance for calibration of interventions and for integration of fatigue metric in mathematical epidemic models. By analyzing mobility data in 20 Italian regions, we explored how changes in adherence to the restrictions varied over time, and whether such temporal variations were different by color tier. Fig 1 displays a mobility metric employed in the study and how it evolves through time jointly with the color restrictions, we can visually observe an increase of the movement and from this we want to assess whether there is a fatigue effect.

**Data and methods:** The mobility data has been retrieved from Movement Range Maps released by the Meta Data for Good program and made publicly available through the Humanitarian Data Exchange platform at [2] and from COVID-19 Community Mobility Reports made publicly available by Google [3]. We consider two metrics, Movement and Residential relative changes, which are evaluated as relative changes with respect to a pre-pandemic baseline. The two metrics capture different aspects of mobility; *Movement Relative Change* is an indicator of active mobility of the users, *Residential Relative Change* is the change of time spent at home and provides an indicator of stillness. The data on history of regional government interventions is provided from ISTAT. We characterized the trends in adherence to social distancing by adopting mixed-effects regression models to analyze the temporal evolution of the change in movement, or the change in time spent at home. In order to assess the presence of both a general time trend that is a global effect of fatigue and a local time trend that is a faster or slower change in adherence in presence of a specific tier we compare the results of different model specifications. The most detailed model includes both a general time trend and a local time trend associated with each color tier, and a random intercept for each region and for each tier. The coefficient of the general time trend measures the overall trend in movement since the beginning of the restrictions. The coefficients associated to the local time variable measure the trend of change in movement since the date of introduction of a new tier.

**Findings:** Overall, we consistently find a global trend of increase in mobility both when including or excluding the local time trends. The two models performed best, when considering their fit to the data both in terms of their adjusted R<sup>2</sup> and Akaike Information Criterion (AIC) values. This shows that change in movements effectively increased over the full period of study, an effect that can be interpreted as a general decrease in adherence to the restrictions. Fig 2 displays the estimated coefficients' values, and their associated error, using the relative change in movement as dependent variable of the full model. Overall, results suggest that adherence to the measures decreased over time, as indicated by a significant and positive trend of the mobility change during the study period (Fig 2, gray). Our model highlighted the presence of a temporal variation in adherence to mobility restrictions, which can be broadly ascribed to the effect of pandemic fatigue. In particular, our statistical analysis showed that changes in adherence were faster during periods characterized by the strictest level of restrictions (the red tier). Furthermore, we found an additional effect that suggests a faster decline in adherence associated with the red tier.

**Impact:** Our results provide a quantitative measure of behavioral responses to tiered intervention and a metric of pandemic fatigue that can be integrated into mathematical models to evaluate future epidemic scenarios. Our results have important implications for modelling efforts aimed at assessing future epidemic scenarios under the adoption of different NPIs and vaccination strategies. A few authors incorporated changes in adherence in their modeling studies so far [4], while models usually assumed a sustained adherence over time due to the lack of available data. According to the results of our analysis, when performing scenario analysis, epidemic modelers should incorporate a faster reduction in adherence in presence of stricter restrictions. In conclusion, we have shown that in a system of tiered restrictions, adherence can be difficult to sustain over time and more so when the most stringent measures are enforced. We focused on the specific case of Italy, due to the availability of relatively long time series, but our approach can be easily extended to other countries, in presence of a similar tiered intervention system. As NPIs remain an important tool against COVID-19 even with widespread vaccination coverage [5], our results will be useful to inform epidemic models in the design of optimal intervention policies for future pandemic waves.

## References

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Figure 1: Daily relative change of mobility as measured by Meta with respect to the baseline in the Italian regions, ordered alphabetically from top to bottom. Color coding (yellow, orange, red) indicates the tier that was in place on a given day. Gray indicates the absence of tiered restrictions (only in Sardinia).

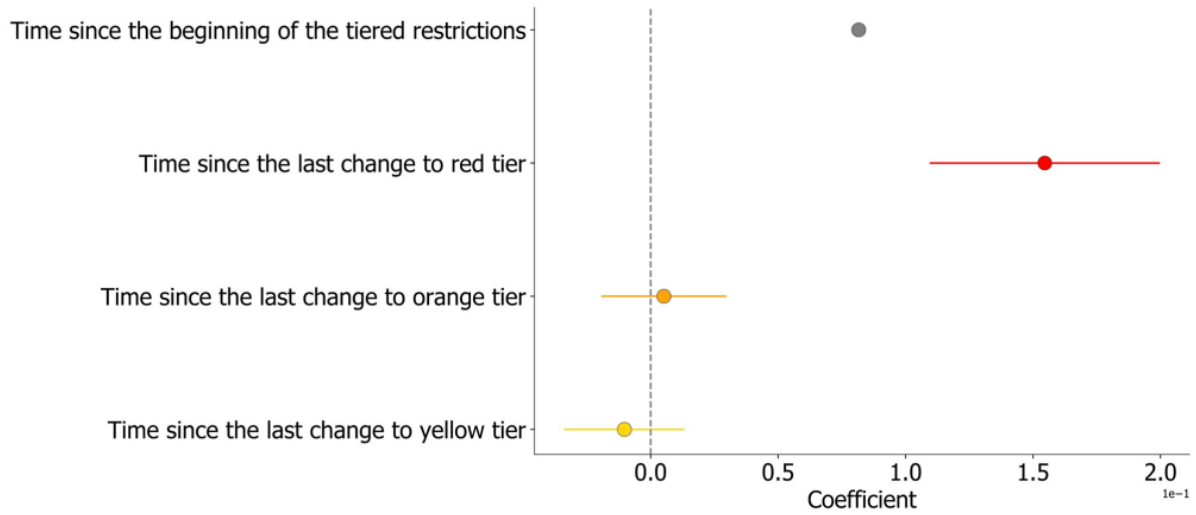


Figure 2: Estimates of the regression coefficients of the mixed-effects model when the daily relative change in mobility is the dependent variable. Error bars correspond to the Standard Error, colors indicate the associated tier