The Impact of Tiered Control on the SARS-CoV-2 Epidemic in England

Health & Medicine | Lancaster University

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1) Introduction

COVID-19 was declared a global pandemic on 11th March 2020 by The World Health Organisation (WHO) and over the past year there have been more than 100,000,000 cases with over 2 million deaths world-wide (1).

England entered its first national lockdown on the 23rd March 2020 and began easing social distancing restrictions from mid-May 2020 (2). However, a surge in cases in September resulted in the introduction of local tiered restrictions from the 14th October 2020 to try to reduce the spread of COVID-19. This tier system included three levels and were allocated individually to each lower tier local authority (LTLA) (Figure 1), with the majority of the country initially being placed in Tier 1.

It is important to understand the impact this tiered system had on the transmission of COVID-19 to determine whether his was an effective policy. This will be beneficial for future policy decisions either for managing the later stages of this Coronavirus pandemic or for future disease control measures in general.

Our aim was to develop a model to represent the positive case data from Public Health England and determine the impact of the tiered restriction on COVID-19 transmission

Figure 1: Flow chart showing tiered restrictions from tier 1(medium) to tier 3 (very high).

2) Methods

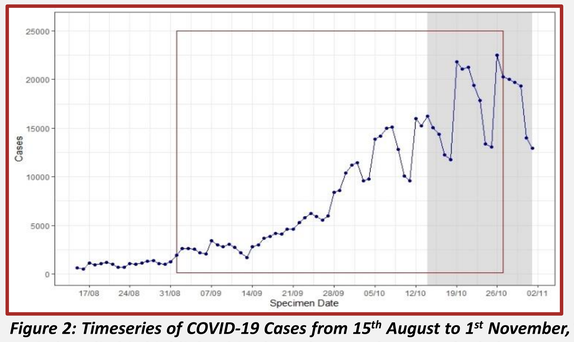

Figure 2: Timeseries of COVID-19 Cases from 15th August to 1st November, period studied is highlighted in the red rectangle. Grey, shaded segment represents the period of tiered restriction.

- This analysis was conducted using daily case data, by specimen date, as reported from Public Health England (3) for the period 1st September – 27th October (inclusive).
- We modelled the daily positive tests in England for each LTLA as a mixed effect, generalised linear model with a poisson distribution including fixed effects for tier level and weekend effect.

$$New\ Cases_i \sim time_i + tier\ level_i + WeekendEffect + (AR\_diff \mid LTLA) + population\ offset(10^5)$$

- Random effects were introduced as a random slope covariate and random intercept which collectively allowed the case acceleration rates to vary, randomly within each LTLA.

3) Results and Discussion

Our mixed effect model produced promising results that areas with higher restrictions (Tiers 2 and 3) experienced significantly lower relative risks than when there was no restriction in place.

In the absence of the tiered restriction for each unit of time (a day) the relative risk of a positive case of COVID-19 was determined to be 2.02 (2.01-2.03) per 100,000 individuals. Tier 1 has no significant effect on this risk whereas tier 2 and 3 did have a significant effect. Tiers 2 and 3 had reduced relative risks of a positive COVID-19 case of 0.81 (0.80-0.82) and 0.68 (0.67-0.68) per 100,000 people respectively.

Table 1: Model Fixed Effects, quoted as relative risk per 100,000 people

Predictors	Relative Risk (per 100,000)	Confidence Intervals (95%)	P-value
Date	2.02	2.01-2.03	<0.001
Tier 1	1.00	0.99-1.01	0.905
Tier 2	0.81	0.80-0.82	<0.001
Tier 3	0.68	0.67-0.68	<0.001

3) Results and Discussion (continued)

These initial findings are promising however there are gaps in the model that limit the confidence in these results.

Firstly, we observed autocorrelation within the model residuals. The order of the lag in the residuals was between 5-7 within each LTLA (figure 3). This suggests that a given days number of positive COVID-19 cases is dependent upon the number of cases 5-7 days previous, with slight variation between regions. Furthermore, this lag is a similar period of time to the incubation period observed with COVID-19, indicating the incubation time for this virus is an important factor for predicting the likely number of positive cases each day (4).

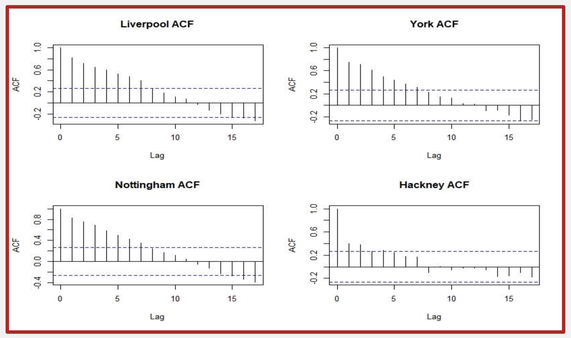

Figure 3: Graphical representation of autocorrelation of model residuals for four LTLAs from our model.

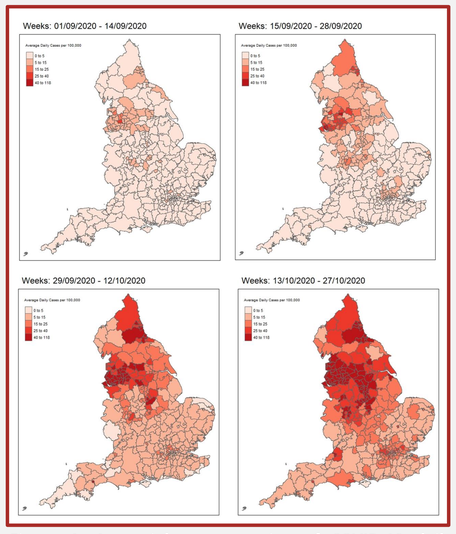

Figure 4: A spatial representation of COVID-19 daily incidence per 100,000 people in each LTLA. Split into fortnightly periods per panel spanning the total 8 week period studied.

Secondly, from observing the changes in average daily incidence throughout our timeframe (Figure 4) there are likely spatial factors that contribute to the spread of COVID-19. High incidence rates appear to begin as small clusters and then gradually spread to surrounding local areas as the weeks pass. Including spatial factors was beyond the scope for this project however this would be a good area of further investigation.

In conclusion our initial results indicate that the English tier system potentially had a significant impact on the SARS-CoV-2 epidemic in England by reducing the relative risk of a positive cases of COVID-19. However more investigation is required to improve confidence in these results. Primarily future investigation should focus on exploring other modelling techniques that can account for the observed autocorrelation and experiment with including spatial factors within this model also.

4) Summary

- Tighter restrictions (Tier 2 and 3) can reduce the relative risk of a positive COVID-19 case, however more investigation is required to develop a more robust model and increase confidence in this assertion.
- Autocorrelation in the model residuals corresponds to the incubation period of COVID-19
- Geo-spatial factors are an important area of future investigation to develop a robust model from this data.

5) References

(1) World Health Organisations, (2021, March 15). *Coronavirus disease (COVID-19) pandemic*. Retrieved from WHO.Int: https://www.who.int/emergencies/diseases/novel-coronavirus-2019
(2) Rt Hon Boris Johnson MP. (2020, May 10). *Prime Minister's statement on coronavirus (COVID-19): 10 May 2020*. Retrieved from Gov.uk: https://www.gov.uk/government/speeches/pm-address-to-the-nation-on-coronavirus-10-may-2020
(3) Public health England: https://coronavirus.data.gov.uk/details/cases
(4) World Health Organisation, (2020, July 9). Transmission of SARS-CoV-2: implications for infection prevention precautions . Retrieved from WHO.int: https://www.who.int/news-room/commentaries/detail/transmission-of-sars-cov-2-implications-for-infection-prevention-precautions#:~:text=The%20incubation%20period%20of%20COVID,to%20a%20confirmed%20case.