The Effects of Multiple Delayed National Regulatory Actions on the Number of COVID-19
Infections in the European Union and the United Kingdom

Karl Von Batten, DHA, FRSPH

6/10/2020

ABSTRACT

There is a noticeable difference in the amount of time it took European Union (EU) member states and the United Kingdom (UK) to enact nationwide stay-at-home orders and mandatory face mask provisions in response to the COVID-19 pandemic. Some EU member states enacted nationwide stay-at-home orders and mandatory face mask provisions shortly after the first confirmed case of COVID-19 infection within their respective jurisdiction. In contrast, other EU member states and the UK took much longer to initiate similar regulatory measures. This study's findings indicate that there is a statistically significant difference in the number of COVID-19 infections between these two groups of countries, with a higher number of COVID-19 infections in the group of countries that took longer to enact nationwide stay-at-home orders and mandatory face mask provisions. This study's findings also show a moderate positive correlation between the number of confirmed COVID-19 infections and the lag time between the first confirmed COVID-19 infections and the issuance of nationwide stay-at-home orders and mandatory face mask provisions, respectively. The results also show a very strong positive correlation between the number of confirmed COVID-19 infections and the number of COVID-19 infection tests. A Stepwise multiple regression analysis was performed, in place of Poisson regression, due to a failure to fit. The regression results indicate that confirmed COVID-19 infections increased by 0.0454 infections each test performed, decreased by -60,017 because of mandatory face mask provisions, and increased by 1,141 each day of lag time between the first confirmed COVID-19 infections and the issuance of mandatory nationwide face mask provisions.

INTRODUCTION

A nationwide stay-at-home order is a national executive order issued by a national government aimed at restricting nonessential population movements to suppress an infectious disease (Hall, Mello, & Studdert, 2020). As of June 7, 2020, in response to the Coronavirus disease 2019 (COVID-19) pandemic, 26 European Union (EU) member states and the United Kingdom have issued nationwide stay-at-home orders. As it pertains to the issuance of mandatory face mask provisions, as of June 7, 2020, 11 EU member states and the UK have not issued mandatory face mask provisions. Despite the close political and organizational structure of the EU and the UK, there is a discrepancy in the timing of the issuance of the noted regulatory guidelines. Some EU member states issued nationwide stay-at-home orders and mandatory face mask provisions shortly after the first confirmed case of COVID-19 within their jurisdiction. At the same time, other countries took over a month to issues similar guidelines. COVID-19 testing levels among EU member states and the UK have also been unequal. This study aims to ascertain the effects of delayed government action as it pertains to the issuance of nationwide stay-at-home orders and mandatory face mask provisions on the number of confirmed COVID-19 infections in the EU and the UK as of June 7, 2020.

METHODS

Data Collection

Data from all 27 member states of the EU and the UK were analyzed as part of this study. Data for this study were gathered from the European Centre for Disease Prevention and Control (2020), Sidley Austin (2020), and the Robert Koch Institute (2020). The gathered data were cross-checked with data gathered from healthcare departments from all 27 EU member states and the UK's Department of Health & Social Care. The data collected represents all confirmed COVID-

19 infections in the EU and the UK from the day of the first confirmed COVID-19 infection to June 7, 2020.

Analysis

The data analyses for this study were conducted using Minitab, a statistics software developed at the Pennsylvania State University. The following statistical tests were performed; Welch's t-test, Pearson correlation coefficient, and multiple linear regression. Poisson regression analysis had been intended for the regression analysis, but the Goodness-of-Fit was found to be significant ($p = 0.000$). As noted by Boshuizen and Feskens (2010), a failure-to-fit indicates that the model does not fit the data. A series of Cohen's d-tests were also performed and were aimed at ascertaining effect sizes.

Notation

As of June 7, 2020, Sweden is the only EU country not to have enacted a nationwide stay-at-home order. As of June 7, 2020, the UK and several EU member states had not enacted mandatory face mask provisions. Assigning a lag time of 0 (zero) to these countries would mean that these countries enacted a nationwide state-at-home order and mandatory face mask provisions on the very day of their first confirmed COVID-19 infection. To ensure proper representation of events, the noted country's lag time was calculated from the day of its first confirmed COVID-19 infection to June 8, 2020, one full day after the analyzed period. In the case of Sweden, this equates to 129 days. In the case of the UK, this equates to 136 days.

Results

The first analysis performed was aimed at ascertaining if a statistically significant difference exists in the time it took EU member states and the UK to issue nationwide stay-at-home orders after the first confirmed case of COVID-19 in their respective jurisdictions. The mean response time by EU member states and the UK to issue a stay-at-home order was calculated to be

32 days. Based on this result, the noted countries were categorized into two groups. The first group comprised of countries ($n=18$) that issued stay-at-home orders at or below the mean (32 days). The second group consists of countries ($n=10$) that issued stay-at-home orders above the mean. (See Table 1 for a complete list of both groups). Due to the unequal sample sizes, a Welch's t-test was performed, and the result was found to be statistically significant at ($M=59.3$, $SD=26.3$) versus ($M=17.33$, $SD=6.34$); $t(9) = 4.96$, $p = 0.00$.

The second analysis performed was aimed at ascertaining if a statistically and practically significant difference exists in the number of COVID-19 infections based on when nationwide stay-at-home orders were issued. The mean response time by EU member states and the UK to issue nationwide stay-at-home orders was calculated to be 32 days. Based on this result, the countries were categorized into two groups. The first group comprised of countries ($n=18$) that issued nationwide stay-at-home orders at or below the mean (32 days). The second group comprised of countries ($n=10$) that issued statewide stay-at-home orders above the mean. (See Table 1 for a complete list of both groups). Due to the unequal sample sizes, a Welch's t-test was performed, and the result was found to be statistically significant at ($M=9326$, $SD=10619$) versus ($M=125734$, $SD=106238$); $t(9) = -3.46$, $p = 0.00$. An effect size analysis was also performed, and the effect size ($d = 1.54$) is above the range of Cohen's (1988) convention for a large effect ($d = 0.80$).

The third analysis performed was aimed at ascertaining if a statistically significant difference exists in the time it took EU member states and the UK to issue mandatory nationwide face mask provisions after the first confirmed case of COVID-19 in their respective jurisdictions. The mean response time by countries to issue mandatory nationwide face mask provisions was calculated to be 82 days. Based on this result, the countries were categorized into two groups. The

first group comprised of countries ($n=11$) that issued mandatory nationwide face mask provisions at or below the mean (82 days). The second group consists of countries ($n=17$) that issued mandatory nationwide face mask provisions above the mean. (See Table 2 for a complete list of both groups). Due to the unequal sample sizes, a Welch's t-test was performed, and the result was found to be statistically significant at ($M=45.2$, $SD=19.8$) versus ($M=105.8$, $SD=16.4$); $t(17) = -8.59$, $p = 0.00$.

The fourth analysis performed was aimed at ascertaining if a statistically or practically significant difference exists in the number of COVID-19 infections based on the time it took EU member states and the UK to issue mandatory nationwide protective face mask provisions. The mean response time by countries to issue mandatory nationwide face mask provisions was calculated to be 82 days. Based on this result, the countries were categorized into two groups. The first group comprised of countries ($n=11$) that issued mandatory nationwide face mask provisions at or below the mean (82 days). The second group consists of countries ($n=17$) that issued mandatory nationwide face mask provisions above the mean. (See Table 2 for a complete list of both groups). Due to the unequal sample sizes, a Welch's t-test was performed, and the result was found to be statistically significant at ($M=10850$, $SD=11744$) versus ($M=76815$, $SD=100053$); $t(16) = 2.69$, $p = 0.02$. An effect size analysis was also performed, and the effect size ($d = 0.92$) is above the range of Cohen's (1988) convention for a large effect ($d = 0.80$).

The fifth analysis (a Pearson correlation coefficient) was performed to ascertain if a correlation exists between the number of confirmed COVID-19 infections and the following variables:

1. The lag time between the first confirmed COVID-19 infections and the enactment of nationwide stay-at-home orders

2. The lag time between the first confirmed COVID-19 infections and the issuance of mandatory nationwide face mask provisions
3. The number of COVID-19 tests performed

Based on Dancey and Reidy's (2007) interpretation of the Pearson's and Spearman's correlation coefficients, the analysis found a not statistically significant moderate positive correlation between the number of confirmed COVID-19 infections and the lag time between the first confirmed COVID-19 infections and the issuance of nationwide stay-at-home orders, $r(26) = 0.04$, $p = 0.06$; a statistically significant moderate positive correlation between the number of confirmed COVID-19 infections and the lag time between the first confirmed COVID-19 infections and the issuance of mandatory face mask provisions, $r(26) = .004$, $p = 0.02$; and a very strong, statistically significant, positive correlation between the number of confirmed COVID-19 infections and the number of COVID-19 testing, $r(23) = 0.91$, $p = 0.00$.

The sixth analysis (a Stepwise multiple linear regression) was performed to ascertain the best fit and to predict the number of confirmed COVID-19 infections based on the following variables:

1. The lag time between the first confirmed COVID-19 infections and the issuance of nationwide stay-at-home orders
2. The lag time between the first confirmed COVID-19 infections and the issuance of mandatory nationwide face mask provisions
3. The number of COVID-19 tests performed
4. EU member states, and UK population size
5. EU member states, and UK population density
6. The issuance of mandatory face mask provisions

7. The issuance of nationwide stay-at-home orders

A statistically significant regression equation was found ($F(3,21) = 69.60$, $p = 0.000$), with an R^2 of 89.56%. The predicted number of confirmed COVID-19 infections is equal to $2,741 + 0.0454$ (testing) $- 60,017$ (mandatory face masks) $+ 1,141$ (The lag time between the first confirmed COVID-19 infections and the issuance of mandatory nationwide face mask provisions). The remaining variables were removed from the equation by the Stepwise regression analysis. (See Table 3).

DISCUSSION

As it relates to the enactment of a nationwide stay-at-home order, the analysis shows that there is a statistically and practically significant difference in the number of confirmed COVID-19 infections between EU member states that responded sooner (between 5 to 28 days after the first confirmed infection) when compared to EU member states and the UK that responded later (between 39 to 129 days after the first confirmed infection). The mean number of COVID-19 infections among countries that enacted stay-at-home orders earlier is 9,326, while the mean number of COVID-19 infections among countries that enacted stay-at-home orders later is 125,734.

As it pertains to the enactment of a mandatory face mask provisions, the analysis shows that there is a statistically and practically significant difference in the number of confirmed COVID-19 infections between countries that responded sooner (between 17 to 79 days after the first confirmed infection) when compared to countries that responded later (between 86 to 136 days after the first confirmed infection). The mean number of COVID-19 infections among countries that enacted mandatory face mask provisions earlier is 10,850, while the mean number of COVID-19 infections among countries that enacted face mask provisions later is 76, 815.

The correlation analyses performed as part of this study were aimed at assessing the EU and the UK's regulatory actions with the numbers of COVID-19 infections as a single group. The correlation analysis shows a moderate positive correlation between the number of confirmed COVID-19 infections and the lag time between the first confirmed COVID-19 infections and the issuance of nationwide stay-at-home orders. Nevertheless, the correlation was not statistically significant. The correlation analysis shows a moderate positive correlation between the number of confirmed COVID-19 infections and the lag time between the first confirmed COVID-19 infections and the issuance of mandatory nationwide face mask provisions. This correlation proved to be statistically significant. The final correlation analysis shows a very strong positive correlation between the number of confirmed COVID-19 infections and the number of COVID-19 tests. This correlation also proved to be statistically significant.

A Stepwise multiple regression analysis was performed, in place of Poisson regression, due to a failure to fit. The regression results indicate that confirmed COVID-19 infections increased by 0.0454 infections each test performed, and decreased by -60,017 because of mandatory face mask provisions. The Stepwise multiple regression analysis also shows that COVID-19 infections increased by 1,141 each day of lag time between the first confirmed COVID-19 infections and the issuance of mandatory nationwide face mask provisions.

LIMITATIONS

A possible limitation of this study is the use of a linear regression model instead of a Poisson regression model. Poisson regression is recommended for response variables that are count data (Payne, 2017). Nonetheless, as experienced during this research, Poisson is not always the best method for modeling count data, and researchers are advised to compare other models to determine the best fit (Payne, 2017).

CONCLUSION:

This study aimed to ascertain the effects of the delay by EU member states and the UK in the enactment of nationwide stay-at-home orders and mandatory face mask provisions on the number of confirmed COVID-19 infections in the EU and the UK. Data from all 27 member states of the EU, and the UK were analyzed as part of this study. The data analyses for this study were conducted using Minitab. The mean response time between the first confirmed case of COVID-19 infection and the enactment of a nationwide stay-at-home order is 32 days, while the mean response time between the first confirmed case of COVID-19 infection and the enactment of provisions mandating the wearing of face masks in public is 82 days. This study's findings indicate a higher number of COVID-19 infections in countries that enacted nationwide stay-at-home orders and mandatory face mask provisions above the noted means. The analysis also shows a moderate positive correlation between the number of confirmed COVID-19 infections and the number of days it took to enact nationwide stay-at-home orders (not statistically significant) and mandatory face mask provisions (statistically significant) after the first confirmed COVID-19 infection. A very strong positive correlation (statistically significant) was found between the number of confirmed COVID-19 infections and COVID-19 tests. A multiple regression analysis was performed, in place of Poisson regression, due to a failure to fit. The regression results indicate that confirmed COVID-19 infection numbers increased by 0.0454 infections each test performed, increased by 1,141 each day of lag time to enact mandatory face mask provisions, and decreased by 60,017 because of mandatory face mask provisions.

References

- Boshuizen, H. C., & Feskens, E. J. (2010). Fitting additive Poisson models. *Epidemiologic perspectives & innovations: EP+I*, 7, 4. <https://doi.org/10.1186/1742-5573-7-4>
- European Centre for Disease Prevention and Control. (2020). Download today's data on the geographic distribution of COVID-19 cases worldwide. Retrieved from www.ecdc.europa.eu
- Hall, M.A, Mello, M.M, Studdert, D.M. (2020). The legal authority for states' stay-at-home orders. *N Engl J Med*. 2020;10.1056/NEJMp2019662. doi:10.1056/NEJMp2019662
- Payne, E.H, Hardin, J.W, Egede, L.E, Ramakrishnan, V, Selassie, A, Gebregziabher, M. (2017). Approaches for dealing with various sources of overdispersion in modeling count data: Scale adjustment versus modeling. *Stat Methods Med Res*. 26(4):1802-1823. doi:10.1177/0962280215588569
- Robert Koch Institute (2020). Coronavirus SARS-CoV-2. Retrieved from www.rki.de
- Sidley Austin (2020). Stay-at-home orders in Europe. Retrieved from www.sidley.com

Table 1

The lag time between the first confirmed COVID-19 infections and the enactment of nationwide stay-at-home orders

EU member states and the UK	Days between first confirmed COVID-19 infection and the enactment of a nationwide stay-at-home	Confirmed Number of COVID-19 Infections as of June 7, 2020
Sweden	129	43887
Slovenia	75	1494
United Kingdom	55	284868
Netherlands	54	47335
France	53	153634
Germany	49	183979
Belgium	48	59072
Finland	48	6964
Spain	43	241310
Italy	39	234801
Ireland	28	25183
Greece	26	2952
Malta	25	622
Hungary	24	3970
Croatia	23	2247
Poland	21	25986
Austria	20	16822
Romania	19	20290
Luxembourg	17	4035
Portugal	16	34351
Czech Republic	15	9567
Cyprus	14	960
Estonia	14	1931
Denmark	13	11924
Lithuania	12	1705
Latvia	10	1086
Slovakia	10	1528
Bulgaria	5	2711

Note. The data included in this table were gathered from the European Centre for Disease Prevention and Control.

Table 2

The lag time between the first confirmed COVID-19 infections and the enactment of nationwide mandatory face mask provisions

EU member states, and the UK	Days between first confirmed COVID-19 infection and the issuance of a nationwide mandatory face mask provisions	Confirmed Number of COVID-19 Infections as of June 7, 2020
United Kingdom	136	284868
Finland	132	6964
Sweden	129	43887
Belgium	125	59072
Spain	110	241310
France	107	153634
Croatia	104	2247
Denmark	102	11924
Estonia	102	1931
Ireland	100	25183
Latvia	98	1086
Hungary	96	3970
Netherlands	95	47335
Italy	94	234801
Bulgaria	92	2711
Cyprus	91	960
Germany	86	183979
Romania	79	20290
Greece	63	2952
Portugal	63	34351
Malta	58	622
Luxembourg	51	4035
Poland	43	25986
Austria	41	16822
Lithuania	38	1705
Slovenia	25	1494
Slovakia	19	1528
Czech Republic	17	9567

Note. The data included in this table were gathered from the European Centre for Disease Prevention and Control and from healthcare departments from all 27 EU member states and the UK's Department of Health & Social Care.

Table 3

Stepwise multiple regression analysis

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	2741	18581	0.15	0.884	
COVID-19 testing	0.04549	0.00485	9.39	0.000	1.42
Mandatory face Mask provisions	-60017	17775	-3.38	0.003	2.44
Mandatory face mask lag time	1141	277	4.11	0.000	2.58

Note. R² adjusted = 89.56%.