

Epidemiology of COVID-19 and public health restrictions during the first wave of the pandemic in Ireland in 2020

Robert Conway¹, David M. Kelly², Paul Mullane², Clíodhna Ni Bhuachalla³,
Lois O'Connor¹, Claire Buckley⁴, Patricia M. Kearney⁴, Sarah Doyle⁵

¹Health Protection Surveillance Centre, Dublin D01 A4A3, Ireland

²Department of Public Health, Health Service Executive East, D08 W2A8 Dublin, Ireland

³Department of Public Health, Health Service Executive South, T12 XH60 Cork, Ireland

⁴School of Public Health, University College Cork, T12 XF62 Cork, Ireland

⁵Health Service Executive Contact Management Programme, Dr Steevens' Hospital, D08 W2A8 Dublin, Ireland

Address correspondence to David M. Kelly, E-mail: david.kelly10@hse.ie

Robert Conway, David M. Kelly, Paul Mullane, Clíodhna Ni Bhuachalla are Joint First Authors

ABSTRACT

Background We describe the epidemiological trends and report and review the public health restrictions implemented during the first wave of the COVID-19 pandemic in Ireland.

Methods The study reviewed confirmed cases of COVID-19 notified from 1 March to 18 July 2020. Data were obtained from the national COVID-19 Data Hub, the National Health Protection Surveillance Centre, the National Contact Management Programme and the European Centre for Disease Prevention and Control.

Results A total of 25 617 cases were notified during the study period. Weekly cases and deaths peaked in mid-April 2020 at 5701 and 316, respectively. Mean number of close contacts per case was lowest at 0.7 in April, rising to 6.6 by July. Outbreak settings shifted from travel and workplace in March, to healthcare in April. Restrictions implemented on 12 March extended to full lockdown on 27 March. Phased relaxation of restrictions commenced 18 May. Effective suppression of community transmission of COVID-19 was achieved by June 2020.

Conclusion Lockdown is a crude population-level restriction effective in controlling COVID-19. Phased relaxation of restrictions in Ireland, however, led to an immediate increase in mean number of contacts per case, which facilitates viral transmission unless individual-level restrictions are adhered to. This demonstrates a limitation of lockdown as a long-term mechanism of pandemic control.

Keywords contact tracing, COVID-19, epidemiology, lockdown, non-pharmaceutical interventions, surveillance

Introduction

Internationally, there has been considerable variation in the COVID-19 pandemic response by countries worldwide, with correspondingly differing outcomes in COVID-19 epidemiology observed.¹ Much remains to be elucidated regarding the optimal level of public health restrictions and the long-term strategy for COVID-19 control.

The European Centre for Disease Prevention and Control (ECDC) guidelines detail the public health restrictions for COVID-19 pandemic control, referred to as non-pharmaceutical interventions (NPIs), aimed at reducing transmission of SARS-CoV-2.² A recent policy paper contrasted the COVID-19 restrictions implemented and eased by five countries.³ The authors conclude that phased restrictions, informed by local epidemiological indicators and supported by a robust contact tracing and testing

system, are the key components of the COVID-19 pandemic response.

The public health response to the COVID-19 pandemic in Ireland focused primarily on a strategy of containment.⁴ This involves identifying and isolating all COVID-19 cases, regardless of clinical severity, and tracing and quarantining their contacts. The delay phase of containment involves reducing rather than eliminating transmission, so that new cases occur

Robert Conway, Specialist Registrar Public Health Medicine

David M. Kelly, Specialist Registrar Public Health Medicine

Paul Mullane, Specialist Registrar Public Health Medicine

Clíodhna Ni Bhuachalla, Specialist Registrar Public Health Medicine

Lois O'Connor, Consultant Public Health Medicine

Claire Buckley, Consultant Public Health Medicine

Patricia M. Kearney, Professor of Epidemiology

Sarah Doyle, Consultant Public Health Medicine

over a staggered time period, thus preserving the capacity of healthcare services.⁵ During the initial surge in COVID-19 cases, the Irish government, following guidance from the National Public Health Emergency Team (NPHE), imposed various restrictions and issued national guidance aimed at limiting transmission of SARS-CoV-2.⁶

In line with international experience,⁷ we consider the ‘first wave’ in Ireland to have occurred between February and July 2020. The study aim is to describe the trends in COVID-19 morbidity and mortality during the ‘first wave’ of the pandemic in Ireland, to document and review restrictions over time and to contrast the outbreak trajectory of five European Union (EU) states of similar population size.

Methods

Data sources

In Ireland, all cases of COVID-19 are notified to designated public health specialist doctors (Medical Officers of Health) in accordance with the Infectious Diseases Regulations 1981,⁸ who then report surveillance data to the National Health Protection Surveillance Centre (HPSC). Ireland’s COVID-19 Data Hub is updated by the national Computerised Infectious Diseases Reporting (CIDR) surveillance system hosted by HPSC.⁹ This Data Hub is a collaboration between Ordnance Survey Ireland, the All-Island Research Observatory, the HPSC, the Health Service Executive (HSE), the Central Statistics Office and the Department of Health (<https://covid19ireland-geohive.hub.arcgis.com/>).

Data from this source were used to calculate weekly number of COVID-19 cases, number of COVID-19-related deaths, average number of cases in hospital per day and average number of cases in critical care per day from 1 March to 18 July 2020. Data for hospitalized cases are based on aggregate data from 29 acute hospitals publicly available via the COVID-19 Data Hub. Data for critical care cases is based on publicly available aggregate data from the National Office of Clinical Audit ICU Bed Information System. The case counts from the COVID-19 Data Hub relate to confirmed cases of COVID-19 only (detection of SARS-CoV-2 nucleic acid in a clinical specimen).¹⁰ Only confirmed cases and deaths from COVID-19 were included in our study.

The Contact Management Programme (CMP) was established by the HSE, nationally, to identify, contact, issue public health advice to and report on close contacts of confirmed COVID-19 cases.¹¹ This centralized programme became operational nationally from 17 March 2020. Aggregate data for confirmed cases and ‘close contacts’ were extracted from the HSE CMP for the period 17 March to 19 July inclusive. The HPSC definition of a close contact was based on that of

the ECDC.¹² This was defined as either: (i) an individual who spent >15 minutes within 2 m distance of; (ii) an individual who shared an enclosed space for >2 hours with; (iii) a healthcare worker without Personal Protective Equipment who cared for; (iv) a passenger who shared transport while seated within two seats of; (v) or a household contact of a confirmed case of COVID-19.¹³

Irish governmental publications, literature and news media timelines were used to document the timeline of public health restrictions implemented.^{4,6,14,15} The national HPSC interim case definitions, HSE operational reports and news media timelines of reported events were used to report changes in COVID-19 testing strategy and capacity.

Epidemiology review

COVID-19 epidemiological trends observed during implementation and relaxation of restrictions were described for the first 5 months of the pandemic in Ireland from 1 March to 18 July 2020. Epidemiological measures were mean number of close contacts per case, total number of cases, deaths, hospitalizations, critical care admissions, median age of cases and reported most likely source of transmission. Changes in COVID-19 epidemiology in response to public health measures were monitored weekly. Not all variables were available for the entire study period, as it included a period of time before the advent of the CMP and the COVID-19 Data Hub in mid-March. The World Health Organization (WHO) classification of source transmission was employed.¹⁶

Community transmission: evidenced by the inability to relate confirmed cases through chains of transmission for a large number of cases or by increasing positive tests through routine screening;

Local transmission: indicates locations where the source of infection is within the reporting location;

Imported cases: indicates where all cases have been acquired outside the location of reporting.

The HPSC reported on outbreaks across 15 possible settings. The authors classified these into the following nine categories: long-term care, ethnic community, extended family, hospital, private household, hospitality/retail, travel related, workplace and other.

European context

For international surveillance beyond the Irish context, the trajectory of the first wave of the COVID-19 pandemic in Ireland was contrasted with that of four other EU countries with a population of <12 million and similar geopolitical circumstances. Epidemic curves for Austria, Belgium, Ireland, Sweden and Portugal representing COVID-19 cases

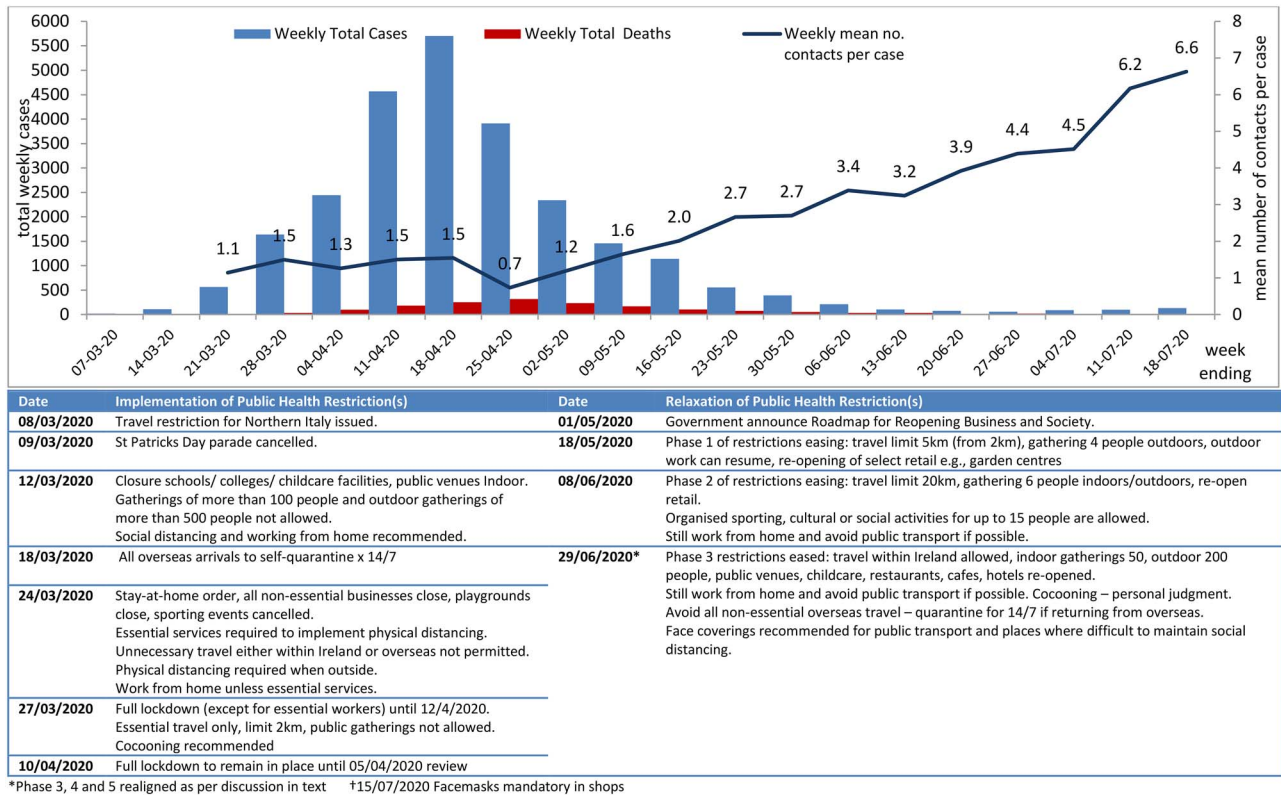


Fig. 1 Epidemic curve of weekly total COVID-19 cases, deaths, mean number of contacts per case and timeline of key public health restrictions implemented and relaxed from March to July 2020 in Ireland.

and COVID-19 deaths were constructed using ECDC data reported via The European Surveillance System (TESSy).¹⁷ The time period for these epidemic curves included data from 1 February to 18 July 2020. Data from all five countries included deaths from laboratory confirmed COVID-19, notified from both hospital and community settings. Belgium included both laboratory confirmed and probable COVID-19 deaths.¹⁸

Results

Morbidity and mortality

The epidemic curve of cases and deaths related to COVID-19 and the timeline of the public health restrictions is illustrated in Figure 1. Weekly cases of COVID-19 peaked at 5701 by week ending 18 April 2020; 6 weeks after the notification of the first COVID-19 case in Ireland (Table 1). Cases then declined to <100 per week by week ending 20 June. Weekly deaths related to COVID-19 peaked at 316 by week ending 25 April.

Transmission source, outbreaks and contacts

Travel was the leading source of transmission for the first 2 weeks of the study period, followed by a shift

to local transmission for the next 13 consecutive weeks (Table 1).

COVID-19 outbreaks in Ireland were predominated by the long-term care facility and private household settings (Table 2). Long-term care setting accounted for over 50% of outbreaks notified during 7 weeks of the study period, from week ending 28 March to 30 May 2020. As of June, private household setting accounted for over 60% of outbreaks notified over seven consecutive weeks. Private household outbreaks occurring March to July were retrospectively notified following data validation on CIDR from mid-June onwards.

The mean number of contacts per case fell to a low of 0.7 by week ending 25 April 2020 and increased steadily to 4.4 by end of June. Following relaxation of restrictions, it rose to 6.6 by mid-July. The median age of cases peaked at 56 years at week ending 28 April and declined to a low of 30 years at week ending 7 July.

Public health restrictions

Following guidance from the NPHET, the Irish government implemented restrictions incorporating increasing levels of NPIs aimed at reducing spread of COVID-19 infection.¹⁵ These NPIs comprised population-level, environmental and individual-level measures. These measures included

Table 1 Weekly number of cases, hospitalizations, critical care admissions and deaths related to COVID-19 in Ireland from 1 March to 18 July 2020

<i>Week ending</i>	<i>Weekly cases</i>	<i>Median age of cases</i>	<i>Average number of hospitalized cases per day</i>	<i>Average number of critical care cases per day</i>	<i>Weekly COVID-19 deaths</i>	<i>Mean number contacts per cases</i>	<i>Leading source of transmission†</i>	<i>Leading outbreak setting</i>
7 March 2020	18	40.5	18	N/A	0	N/A	Travel	Travel
14 March 2020	110	48	30	N/A	2	N/A	Travel	Travel
21 March 2020	565	44	88	N/A	1	1.1	Local	Travel
28 March 2020	1639	48	297	74	33	1.5	Local	Long-term care
4 April 2020	2441	51	633	123	101	1.3	Local	Long-term care
11 April 2020	4568	47	816	148	184	1.5	Local	Long-term care
18 April 2020	5701	48	856	142	252	1.5	Local	Long-term care
25 April 2020	3910	56	773	129	316	0.7	Local	Long-term care
2 May 2020	2342	48	746	108	236	1.2	Local	Private house
9 May 2020	1457	44	633	82	169	1.6	Local	Private house
16 May 2020	1142	40	479	63	102	2.0	Local	Long-term care
23 May 2020	557	42	350	52	77	2.7	Local	Private house
30 May 2020	392	47	251	45	54	2.7	Local	Long-term care
6 June 2020	213	45	162	36	35	3.4	Local	Private house
13 June 2020	105	44	100	31	35	3.2	Local	Private house
20 June 2020	76	41.5	60	21	15	3.9	Local	Private house
27 June 2020	59	39	34	12	21	4.4	Local	Private house
04 July 2020	89	36.5	21	11	13	4.5	Community	Private house
11 July 2020	100	30	15	9	10	6.2	Local	Private house
18 July 2020	133	37	12	9	8	6.6	Local	Private house
Total	25 617	—	—	—	1664	—	—	—

†WHO classification of COVID-19 transmission.

N/A—data not available as period predates advent of the HSE Contact management Programme and Ireland's COVID-19 Data Hub on 17 March 20.

school/childcare closures, closure of non-essential services, advice to work from home and avoid public transport and travel restrictions.¹⁹

Restrictions were imposed sequentially throughout February and March 2020 and eventually amounted to a 'full-lockdown' of the country from 27 March onwards. Following a 'clear impact' on viral suppression at population level, an incremental five phase plan for phased relaxation of restrictions was announced on 1 May,²⁰ beginning with those deemed 'lowest risk' in terms of transmission. Initial relaxation of restrictions commenced 18 May with Phase 1 of the government's Plan for Living with COVID-19.¹⁴ The initial relaxation of restrictions was followed by a continued

decline in weekly cases, hospitalizations and deaths (Fig. 1). There was no overall change in the median age of cases, whereas the mean number of contacts per case increased steadily from week ending 9 May.

Trajectory of the first wave

Figure 2 illustrates the epidemiology of the first wave of the COVID-19 pandemic across five EU states, all with a population of <12 million inhabitants. The COVID-19 outbreak in Ireland followed a similar trajectory to that of Austria and Belgium, with a definitive peak in cases by early April 2020, followed by a steady decline to <200 daily cases by late May. The COVID-19 outbreaks in Austria, Belgium and

Table 2 Tabulation of weekly number of outbreaks by setting and as a percentage of all outbreaks notified from March to July 2020 in Ireland

Outbreak setting	7 March	14 March	21 March	28 March	04 April	11 April	18 April	25 April	2 May	9 May	16 May	23 May	30 May	6 June	13 June	20 June	27 June	4 July	11 July	18 July	Total
Private house ^a	0	1	3	15	13	11	11	18	37	15	3	19	6	16	88	91	364	376	99	188	1374
%	0	20.0	12.5	21.1	9.6	8.9	14.1	16.7	39.8	31.9	5.8	41.3	31.6	59.3	86.3	95.8	97.1	99.7	88.4	93.5	65.7
Long-term care	0	0	4	25	87	87	44	69	36	26	39	8	10	4	7	2	4	0	9	8	469
%	0	0	16.7	35.2	64.4	70.2	56.4	63.9	38.7	55.3	75.0	17.4	52.6	14.8	6.9	2.1	1.1	0	8.0	4.0	22.4
Hospital	0	1	4	14	23	15	12	7	8	1	5	8	1	0	1	0	2	0	0	0	102
%	0	20.0	16.7	19.7	17.0	12.1	15.4	6.5	8.6	2.1	9.6	17.4	5.3	0	1.0	0	0.5	0	0	0	4.9
Workplace	0	1	3	1	0	4	5	7	8	1	4	6	0	4	1	0	0	0	1	1	47
%	0	20.0	12.5	1.4	0	3.2	6.4	6.5	8.6	2.1	7.7	13.0	0	14.8	1.0	0	0	0	0.9	0.5	2.2
Extended family	0	0	4	2	2	2	3	3	0	2	1	4	1	1	3	1	5	1	0	1	36
%	0	0	16.7	2.8	1.5	1.6	3.8	2.8	0.0	4.3	1.9	8.7	5.3	3.7	2.9	1.1	1.3	0.3	0	0.5	1.7
Travel related	1	2	6	6	5	0	0	1	0	0	0	0	0	0	0	1	0	0	2	2	26
%	100	40.0	25.0	8.5	3.7	0	0	0.9	0	0	0	0	0	0	0	1.1	0	0	1.8	1.0	1.2
Ethnic community	0	0	0	4	2	2	2	1	2	1	0	1	0	0	0	0	0	0	0	0	15
%	0	0	0	5.6	1.5	1.6	2.6	0.9	2.2	2.1	0	2.2	0	0	0	0	0	0	0	0	0.7
Hospitality/retail	0	0	0	3	2	0	0	2	2	1	0	0	0	1	0	0	0	0	1	0	12
%	0	0	0	4.2	1.5	0	0	1.9	2.2	2.1	0	0	0	3.7	0	0	0	0	0.9	0	0.6
Other	0	0	0	1	1	3	1	0	0	0	0	0	1	1	2	0	0	0	0	1	11
%	0	0	0	1.4	0.7	2.4	1.3	0	0	0	0	0	5.3	3.7	2.0	0	0	0	0	0.5	0.5
Total	1	5	24	71	135	124	78	108	93	47	52	46	19	27	102	95	375	377	112	201	2092

^aMost private household outbreaks occurring March to July 2020 were retrospectively reported on CDR from week ending 13 June 20 onwards as a result of data validation.

Ireland were effectively suppressed following this ‘first wave’ of infections. The outbreak in Sweden did not show a peak in daily cases until late June, whereas that of Portugal briefly declined below 200 daily cases in mid-May before a sustained rise. The ratio of deaths to cases in Ireland was similar to that of Austria and Portugal. The observed ratio of deaths to cases was higher in Belgium and Sweden (Fig. 2).

Discussion

Main findings of this study

International travel was the primary source for virus transmission in Ireland early in the pandemic, in March 2020, before a shift to sustained local transmission over the next 3-month period. Much of this was driven by outbreaks occurring initially within long-term care facility settings during March, April and May, superseded by outbreaks linked to private households by June.

On the 18 June 2020, the NPHE recommended realigning the latter two phases of the five-phase plan due to declining incidence of COVID-19 and associated public health risk.²¹ This represented a move towards increased ‘personal responsibility’ while continuing cross-sectoral efforts.²¹ This phased relaxation of restrictions does not appear to have had any adverse impact on the rate of decline in cases and deaths as case numbers and mortality rates remained low.

The period of ‘lockdown’ was marked by strong levels of social and civic cohesion in Ireland and a sense of collective responsibility in combatting the pandemic.²² Numbers of close contacts were lowest during ‘lockdown’. The lowest mean of 0.7 contact per case in week beginning 25 April 2020 likely reflected those with zero close contacts from extended lockdown, cases whose contacts had already been contact traced, e.g. in a household, and potentially those contacts who were already cases by April. It is evident that the mean number of contacts per case rose steadily as soon as initial restrictions were relaxed.

Public health physicians led the rapid development and deployment of the national CMP in Ireland early in the first wave. This was essential to maintain quality surveillance data; identify all close contacts; manage complex contacts (e.g. congregate settings) and streamline processes for contact tracing centres. Continued application of and improvements to contact tracing at both local (Departments of Public Health) and national (CMP) level may partly explain maintenance of this trend, i.e. the contact tracing system, established at the outset and subsequently refined, facilitated control of COVID-19 epidemiology throughout the study period.

The increase in the mean number of contacts per case may also reflect individual cases correctly identifying all their contacts when interviewed. Nonetheless, it also suggests that once restrictions on travel distances and activity are sequentially removed, SARS-CoV-2 transmission is facilitated as more opportunities are presented for interaction.²³ Epidemiological trends observed were subject to changes in the HSE’s capacity for testing and contact tracing between February and April 2020. The epidemiological criteria were expanded to include any overseas travel in March, whereas the clinical criteria were expanded to include symptoms of anosmia, ageusia and dysgeusia in April. Routine testing (Day 0 and Day 7) of all close contacts was implemented as of 19 May. Essentially, greater numbers of people became sequentially eligible for testing as the pandemic progressed.

The SARS-CoV-2 testing pathway is complex and comprises multiple steps. In Ireland, however, cross-sectoral efforts, innovation and investment resulted in a more robust national ‘end-to-end’ testing process. The increase in surge capacity ensured that broadening of testing criteria, and the resultant increase in testing referrals could be accommodated. Given current knowledge of SARS-CoV-2 transmission dynamics, especially regarding ‘pre-symptomatic’ and asymptomatic infection, timely testing and contact tracing capacity are critical to any COVID-19 control strategy.

The peak in cases in Sweden in June 2020, and the sustained rise in cases in Portugal from May, indicated a lack of suppression of the first wave of the outbreak in these two countries, compared with Austria, Ireland and Belgium. Sweden adopted a divergent strategy of mitigation early in the COVID-19 pandemic, rather than aiming for one of containment or elimination. The epidemic curves for Austria, Ireland and Belgium demonstrate that effective suppression of community transmission of COVID-19 was achieved within 3 months of restrictions being implemented.

What is already known on this topic

While acknowledging the role of ‘lockdown’ as a crude population level measure to control COVID-19 epidemiology that threatens to overwhelm healthcare systems; the authors of a recent policy article advocate for phased restrictions and individual level measures, in order to prevent the need for recurrent lockdowns.³ They highlight community engagement as an important factor in reducing COVID-19 transmission risk and as a prerequisite for relaxation of restrictions. Communication of clear and consistent public health advice is required, in order to ensure engagement of populations with public health restrictions.³

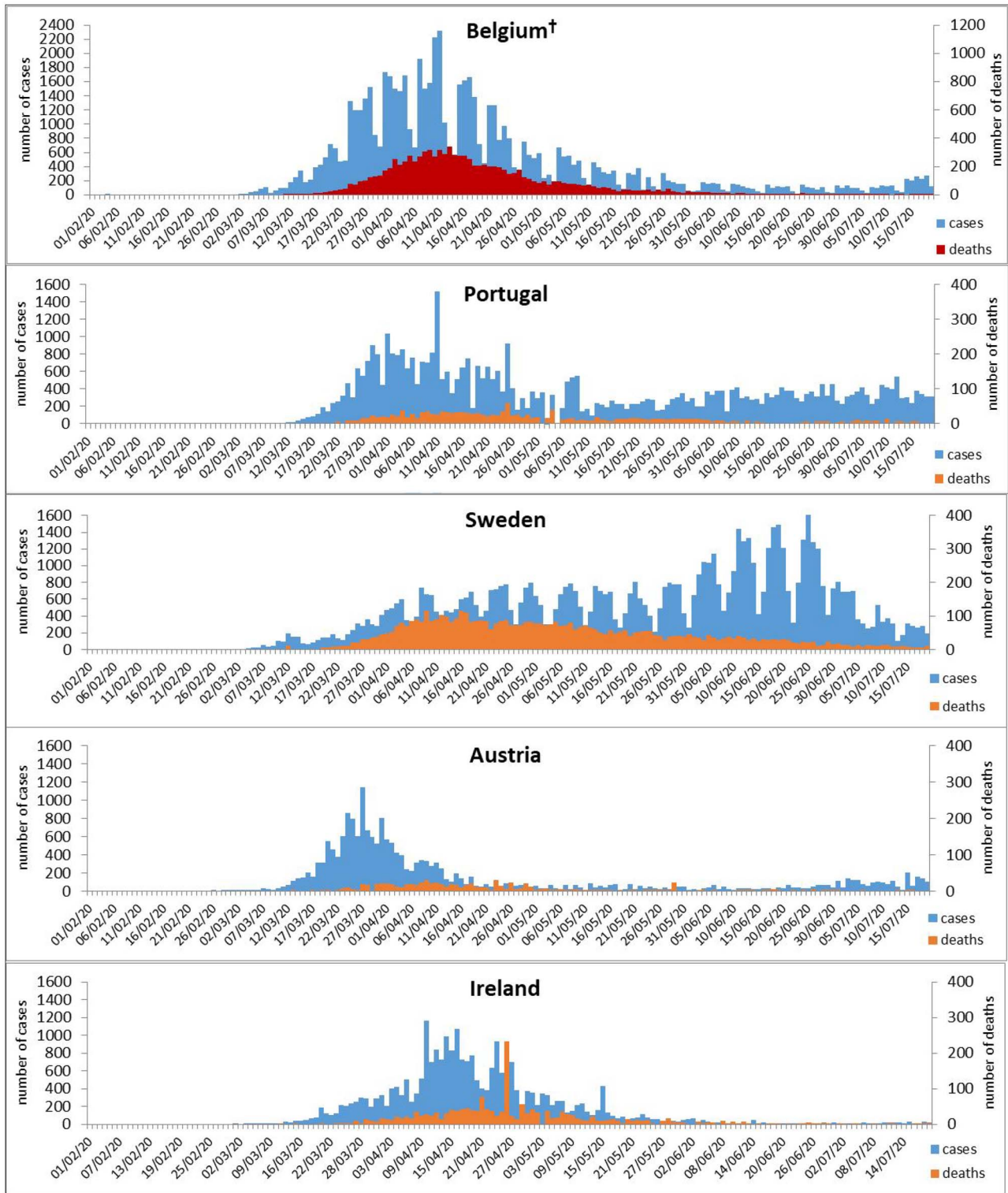


Fig. 2 COVID-19 epidemic curves across five EU member states from February to July 2020 using ECDC TESSy data (all with population <12 million: Belgium 11.5 M, Portugal 10.3 M, Sweden 10.2 M, Austria 8.9 M and Ireland 4.9 M). †Belgium reported both laboratory confirmed and probable COVID-19 deaths.

Subsequent ‘waves’ will occur to varying degrees while the COVID-19 pandemic remains an ongoing global public health threat. Multifaceted public health restrictions that

amount to ‘lockdown’ will remain a crude but important instrument for countries to control COVID-19.²⁴ Further assessments of subsequent pandemic waves using parameters

similar to those presented in this study will provide comparative data that may assist public policy formation. One may reasonably contend that subsequent waves constitute new entities in their own right; thus, the view of ‘what works’ with regard to restrictions is subject to change.

What this study adds

This study provides insights in relation to the value of nationally deployed containment and mitigation measures as a mechanism to combat the COVID-19 pandemic. The measures employed show a temporal association with improved control. Conversely, upon relaxing restrictions, while case numbers did not immediately rise, the mean number of close contacts per case increased steadily. The fact that weekly case totals remained low suggest that continued adherence to individual NPIs (e.g. social distancing, mask use, hand hygiene) may have attenuated viral transmission. Germany, Norway, Scotland and New Zealand have similarly fared well in securing public trust and support for behavioural changes.³ The rise in mean number of close contacts per case over the summer months in Ireland may reflect declining compliance with population level NPIs amongst cases during this period.

Limitations of this study

There are caveats in relation to assigning cases to particular outbreak categories; in our study, household outbreaks predominated due to cases being detected in individuals living together. Most of these were retrospectively notified in June 2020 using validated address data, rather than at the time of diagnosis from March to May. While household transmission is the probable route for many secondary infections, the source for the index/primary case could not always be ascertained. Close contacts are identified based on exposure occurring during the infectious period of the case.²⁵ As a result, household contacts were more readily identified and tested, whereas alternative sources of transmission were likely underreported.

Direct comparison of COVID-19 epidemic curves between EU states is subject to several caveats. These include differences in demographics, testing policy, testing capacity and reporting. Notably, the higher number of deaths in Belgium may be explained by reporting of both laboratory confirmed and possible COVID-19 deaths.^{18,26} The lower number of cases relative to deaths in Sweden likely reflects a lower rate of testing in March and April 2020.^{27,28} The epidemic curves display counts, rather than age-adjusted rates, and so may overestimate deaths in countries with an older demographic. Nonetheless, they provide an overview of the

first wave trajectory of the COVID-19 pandemic amongst these five EU states, without permitting direct comparison of COVID-19 epidemiology.

Conclusion

In the absence of an elimination strategy for COVID-19, such as that pursued by New Zealand and Australia, and until there is widespread vaccine uptake, the health and wellbeing of populations will depend on their adherence to public health restrictions. While the negative impact of NPIs are increasingly recognized,² Ireland remains a susceptible population at high risk of community transmission (and associated adverse outcomes) if restrictions are not adhered to.²⁹ Although effective at suppressing community transmission, ‘lockdown’ is a crude population level NPI for control of COVID-19. It has considerable negative impacts on both populations and individuals,² and risks non-compliance and ‘pandemic fatigue’ if employed beyond the short term.³⁰

The national CMP and a robust COVID-19 surveillance system provide decision makers with local epidemiological data and context to inform the level of NPIs required at any given time in Ireland. Governments should prioritize community engagement to ensure maximal population compliance with individual level restrictions and thus prevent the need for crude population-level restrictions amounting to ‘lockdown’, in order to protect the health and well-being of their populations in a sustainable way.

References

- 1 Kontis V, Bennett JE, Rashid T *et al.* Magnitude, demographics and dynamics of the effect of the first wave of the COVID-19 pandemic on all-cause mortality in 21 industrialized countries. *Nat Med* 2020;**26**(12):1919–28.
- 2 European Centre for Disease Prevention and Control. Guidelines for the implementation of non-pharmaceutical interventions against COVID-19. 24 September 2020. <https://www.ecdc.europa.eu/en/publications-data/covid-19-guidelines-non-pharmaceutical-interventions> (accessed 12 December 2020).
- 3 Han E, Tan MMJ, Turk E *et al.* Lessons learnt from easing COVID-19 restrictions: an analysis of countries and regions in Asia Pacific and Europe. *Lancet* 2020;**396**(10261):1525–34.
- 4 Government of Ireland, Department of Health. *Ireland's response to COVID-19 (Coronavirus)*. 4 June 2020. <https://www.gov.ie/en/publication/a02c5a-what-is-happening/> (accessed 12 December 2020).
- 5 Government of Ireland, *Department of Health. Ireland's Preparedness and Strategy*. 4 June 2020. <https://www.gov.ie/en/publication/a02c5a-what-is-happening/#irelands-preparedness-and-strategy> (accessed 12 December 2020).

- 6 Wikipedia. *Timeline of the COVID-19 Pandemic in the Republic of Ireland*. 2020. https://en.wikipedia.org/wiki/Timeline_of_the_COVID-19_pandemic_in_the_Republic_of_Ireland (accessed 12 December 2020).
- 7 European Centre for Disease Prevention and Control. *Coronavirus Disease 2019 (COVID-19) in the EU/EEA and the UK—Tenth Update*. 20 June 2020. <https://www.ecdc.europa.eu/sites/default/files/documents/RRA-COVID19-update10-2020-06-11.pdf> (accessed 12 December 2020).
- 8 Government of Ireland. *S.I. No. 390/1981 - Infectious Diseases Regulations 1981*. Dublin, 1981.
- 9 Government of Ireland. Department of Health. In: *Ireland's COVID-19 Data Hub*, 2020. (accessed 12 December 2020).
- 10 Health Protection Surveillance Centre. *COVID-19 Interim Case Definition*. 25 June 2020. <https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/casedefinitions/covid-19interimcasedefinitionforireland/> (accessed 12 December 2020).
- 11 Health Service Executive Ireland. COVID-19 Contact Management Programme (CMP) Overview 2020. <https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/guidance/primarycareguidance/nationalresultnotificationandcontactmanagementprogramme/Leaflet%201%20CMP%20Overview.pdf> (accessed 12 December 2020).
- 12 European Centre for Disease Prevention and Control. *Surveillance Definitions for COVID-19. High-Risk Exposure/Close Contact*. 2020. <https://www.ecdc.europa.eu/en/covid-19/surveillance/surveillance-definitions> (accessed 12 December 2020).
- 13 Health Protection Surveillance Centre. *National Interim Guidelines for Public Health Management of Contacts of Cases of COVID-19*. 2020. <https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronaviruses/guidance/contacttracingguidance/National%20Interim%20Guidance%20for%20contact%20tracing.pdf> (accessed 4 February 2021).
- 14 Government of Ireland. *Government Publishes Roadmap to Ease COVID-19 Restrictions and Reopen Ireland's Society and Economy*. 2020. <https://www.gov.ie/en/press-release/e5e599-government-publishes-roadmap-to-ease-covid-19-restrictions-and-reopen/> (accessed 12 December 2020).
- 15 Government of Ireland, Department of Health. *View the Latest Letters From the CMO to the Minister for Health*. 2020. <https://www.gov.ie/en/collection/ba4aa0-letters-from-the-cmo-to-the-minister-for-health/#may> (accessed 12 December 2020).
- 16 Health Protection Surveillance Centre. *Epidemiology of COVID-19 in Ireland. 3. Transmission Classification* 2020. [https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/casesinireland/epidemiologyofcovid-19inireland/COVID-19_Daily_epidemiology_report_\(NPHET\)_27112020%20-Website.pdf](https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/casesinireland/epidemiologyofcovid-19inireland/COVID-19_Daily_epidemiology_report_(NPHET)_27112020%20-Website.pdf) (accessed 27 November 2020).
- 17 European Centre for Disease Prevention and Control. Download the daily number of new reported cases of COVID-19 by country worldwide. 2020. <https://www.ecdc.europa.eu/en/publications-data/download-todays-data-geographic-distribution-covid-19-cases-worldwide> (accessed 12 December 2020).
- 18 European Centre for Disease Prevention and Control. *Weekly Surveillance Report on COVID-19. 5 Surveillance System Description. 5.1. Definition of COVID-19 Deaths by Country*. 2020. <https://www.ecdc.europa.eu/en/covid-19/surveillance/weekly-surveillance-report> (accessed 12 December 2020).
- 19 Government of Ireland, Department of Health. *COVID-19 (Coronavirus)*. 2020. <https://www.gov.ie/en/campaigns/c36c85-covid-19-coronavirus/>.
- 20 Government of Ireland, Department of Health. *Letter from CMO to Minister for Health re COVID-19 (Coronavirus)*. 1 May. 2020. <https://www.gov.ie/en/collection/ba4aa0-letters-from-the-cmo-to-the-minister-for-health/#may> (accessed 12 December 2020).
- 21 Government of Ireland, Department of Health. *Letter from CMO to Minister for Health re COVID-19 (Coronavirus)* 18 June 2020. <https://www.gov.ie/en/collection/ba4aa0-letters-from-the-cmo-to-the-minister-for-health/#june> (accessed 12 December 2020).
- 22 Government of Ireland, Department of Health. *Letter from CMO to Minister for Health re COVID-19 (Coronavirus)* 10 April 2020. <https://www.gov.ie/en/collection/ba4aa0-letters-from-the-cmo-to-the-minister-for-health/#april> (accessed 12 December 2020).
- 23 Wang S, Liu Y, Hu T. Examining the change of human mobility adherent to social restriction policies and its effect on COVID-19 cases in Australia. *Int J Environ Res Public Health* 2020;**17**(21):7930.
- 24 WHO. *COVID-19—Virtual Press Conference*. 30 March 2020. https://www.who.int/docs/default-source/coronaviruse/transcripts/who-audio-emergencies-coronavirus-press-conference-full-30mar2020.pdf?sfvrsn=6b68bc4a_2 (accessed 12 December 2020).
- 25 Health Protection Surveillance Centre. *National Interim Guidelines for Public Health Management of Contacts of Cases of COVID-19; HPSC; V8.6 19.10.20202020*. <https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/guidance/contacttracingguidance/National%20Interim%20Guidance%20for%20contact%20tracing.pdf> (accessed 12 December 2020).
- 26 Bustos Sierra N, Bossuyt N, Braeye T *et al*. All-cause mortality supports the COVID-19 mortality in Belgium and comparison with major fatal events of the last century. *Arch Public Health* 2020;**78**(1):117.
- 27 Habib H. Has Sweden's controversial covid-19 strategy been successful? *BMJ* 2020;**369**:m2376.
- 28 Ludvigsson JF. The first eight months of Sweden's COVID-19 strategy and the key actions and actors that were involved. *Acta Paediatr* 2020;**109**(12):2459–71.
- 29 Health Protection Surveillance Centre. *SCOPI COVID-19 Antibody Research Project*. 20 August 2020. <https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/scopi/> (accessed 12 December 2020).
- 30 WHO Regional Office Europe. *Pandemic Fatigue—Reinvigorating the Public to Prevent COVID-19. Policy Framework for Supporting Pandemic Prevention and Management*. 2020. <https://apps.who.int/iris/bitstream/handle/10665/335820/WHO-EURO-2020-1160-40906-55390-eng.pdf> (accessed 18 December 2020).