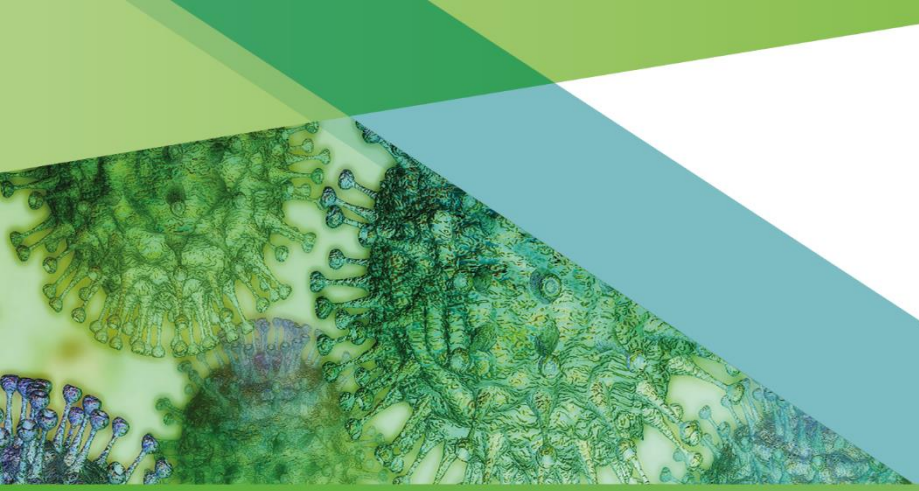

TECHNICAL REPORT

Analysis of COVID-19 contact tracing data from Ireland, Italy and Spain – 2020 data

15 March 2022

Introduction

This document describes the project *Analysis of COVID-19 contact tracing data*, conducted between September 2020 and April 2021 as part of the European Programme for Intervention Epidemiology Training (EPIET), coordinated by ECDC.

Aim and objectives

The aim of this project was to explore the main challenges in analysing contact tracing data and to identify areas for improvement that could enhance the use of contact tracing data for surveillance and public health management, as well as facilitate the sharing of information and experiences among European Union/European Economic Area (EU/EEA) Member States. The specific objectives were to:

- Perform an analysis of contact tracing data in three countries (Italy, Ireland and Spain) and describe the methods used to analyse these data, the main challenges that arose during this analysis, and how these challenges were overcome.
- Assess the feasibility of using a list of contact tracing indicators for countries to report from their contact tracing systems.

As a result, suggestions for best practice, together with a set of essential variables and a set of suggested variables to calculate contact tracing indicators, are proposed. These indicators are useful for understanding transmission dynamics in the population, understanding locations or settings of high transmission and measuring the impact of mitigation measures.

Background

Contact tracing is an important public health measure for the control of COVID-19, aiming to promptly identify and manage contacts of COVID-19 cases in order to reduce further onward transmission. There are many features of contact tracing that have developed rapidly during the COVID-19 pandemic, such as the use of mobile apps and new analysis software. Analyses of data from contact tracing can provide key information that can help to inform more effective response measures.

Through analysis of contact tracing data, public health authorities have the opportunity to:

- monitor efficiency and effectiveness of contact tracing by looking at indicators, such as how quickly contacts are reached and the extent of onward transmission from known cases and infected contacts;
- learn about the local epidemic by identifying settings and situations where transmission is likely to occur; and
- refine the definition of close contact at the EU level by, for example, gaining a better understanding of the transmission dynamics, such as attack rates and time of exposure relative to symptom onset.

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Methods

This project was structured into three phases. In the first phase, we liaised with the relevant authorities in Ireland, Italy and Spain to explore access to local, regional or national contact tracing data for the period May to December 2020. Data ownership remained with national authorities and no data were transferred to ECDC. Data were stored and managed according to the GDPR and the data protection regulations of each country. As this activity was undertaken for surveillance and public health management purposes, ethical approval was not required. For each country, we obtained an overview of the local contact tracing and data collection system used; the availability of data at local, regional and national levels; and the type and structure of data collected.

In the second phase, taking into account the available data and the list of indicators developed by the ECDC contact tracing team in May 2020 (see Table 1A in the Annex), we selected the indicators that could be calculated. The indicators developed by the ECDC contact tracing team aim to help understand transmission patterns and dynamics, as well as to monitor the performance of the contact tracing programme. Some of the indicators we selected were previously published in the *ECDC monitoring and evaluation framework for COVID-19 response activities in the EU/EEA and the UK* as of June 2020 [1], which was developed to provide strategic information to assist decision makers at subnational, national and EU levels to support preparedness and response planning.

In the third phase, data analysis was done with the use of R and STATA software. The first step of the analysis was data management and cleaning to remove inconsistencies, followed by the calculation of contact tracing indicators (e.g. number of contacts per case, attack rates among contacts, location of contacts and cases, and proportion of cases that had contact tracing implemented within 24 hours of case identification).

Results

When collecting the data from Ireland, Italy and Spain, we found that contact tracing systems are usually decentralised and organised at the regional and local levels. In some instances, this subnational feature represents a challenge for the collection of comprehensive and harmonised data at the national level.

Ireland

Contact tracing

In Ireland, contact tracing for cases of COVID-19 was initially managed by eight Departments of Public Health. However, early in the pandemic, the rapid increase in the number of cases impacted the departments' capacity to contact trace all cases in a timely manner. Consequently, a centralised Contact Management Programme (CMP) was established nationally from 17 March 2020. The purpose of the CMP is to support the work of the departments with regard to routine contact tracing, thereby enabling them to concentrate on complex contact tracing and on surveillance. Only COVID-19 cases with a positive SARS-CoV-2 test are contact traced by the CMP. Contacts are traced from 48 hours before symptom onset in the case or 24 hours prior to a positive test result in asymptomatic cases, until the case is either isolated or classified as no longer infectious (usually 10 days from symptom onset and 5 days fever free for cases in the community; however, it may be longer for residents of long-term care facilities (LTCFs) and cases who are hospitalised).

Contacts of a COVID-19 case are classified as casual or close contacts according to defined criteria, which varies from country to country. Close contacts are considered to be at higher risk of infection. Public health doctors or contact tracers determine the type of contact during contact tracing and public health risk assessments.

The method for contacting close contacts is by telephone call. Close contacts are contacted and actively followed up (i.e. they are given health advice and receive a daily call to discuss any symptoms) for 14 days after last exposure to a case. They are offered free of charge testing on Day 0 (the day they are identified as a close contact) and Day 7 after their last contact with the case.

Data collection system

Designated COVID-19 contact tracing centres (CTCs) were set up across Ireland starting from mid-March 2020 at universities, government offices and statutory agencies. As of September 2020, nine CTCs were in operation with two virtual contact tracing groups working remotely and over 1 500 people trained to work in contact tracing centres. People working in the health service, wider public service, educational sectors and others were redeployed to work in CTCs as contact tracers. Contact tracing data is usually entered by the contact tracers into a web-based platform called the COVID Care Tracker (CCT) while the contact tracer is speaking to the COVID-19 case or contact. Contact tracers receive training on the use of the CCT and on conducting contact tracing calls. They collect data on cases and close contacts, including demographic information, the type of contact, date of last exposure to the case, as well as the setting of the exposure (e.g. household, healthcare setting, etc.). They also collect clinical data (comorbidities) and whether contacts developed symptoms or not. Data from the CCT

are analysed by the CMP to produce regular reports for decision makers and the data are published in a weekly press briefing. Surveillance data on cases are also collected, extracted and transferred to the national infectious disease reporting system (CIDR) for surveillance purposes.

COVID-19 laboratory results are uploaded to the CCT from all public COVID-19 testing laboratories in Ireland. Laboratory data include the name, date of birth, address, telephone number and COVID-19 test result of the case. Efforts are made to ensure that all COVID-19 cases reported to the Departments of Public Health are entered into the CTT. Data validation processes are not routinely done on the data entered into the CCT, so duplicate cases and data quality issues may arise in the system.

Italy

Contact tracing

Italy has a decentralised healthcare system with 19 regions and two autonomous provinces (AP) that organise and manage all aspects of healthcare, including contact tracing in the context of COVID-19. At the local level, regions and APs are organised in one or more local healthcare units that coordinate with regional governments for the activities of healthcare delivery, prevention and health protection. Local healthcare units are, in practice, autonomous and can decide how to operatively manage contact tracing in coordination with the requirements set by the regional governments.

Staff working in contact tracing are asked to reconstruct, hour by hour, the activities of the case, starting from 48 hours before and up to two weeks after symptom onset, collection of the positive sample or isolation. They also identify any exposed people (collecting, when possible, their personal data, address and telephone number), evaluate their level of exposure and list them in a database. Another objective of the interview is to identify the source of the case's infection, collecting details on possible exposures in the 14 days prior to symptom onset (or the date of sample collection, if the person is asymptomatic). During the interview, staff is asked to provide cases with guidance on isolation and practices that can prevent further transmission, and to reassure them of the confidentiality of the information collected. The interview can take place through a telephone call or a video call, where possible. If the case is hospitalised and/or unable to cooperate, hospital staff or the treating physician can collect the information directly from a close family member or carer.

The number of staff working on contact tracing, as well as on other COVID-19-related activities, is monitored by the Ministry of Health on a weekly basis according to the national monitoring strategy. This strategy sets the number of needed personnel working on COVID-19 to one per 10 000 persons and the regions/APs that do not comply are notified [2].

Data collection system

All local health units have been encouraged to collect a minimum data set on contacts and related cases. The database collating this data should contain information on demographics, contacts, dates and times (including the date of last exposure to the case, as well as the frequency and duration of such exposure), as well as the context of the exposure (e.g. household, work, hospital). They are also asked to collect clinical data (comorbidities) and whether contacts developed symptoms or not.

Data collection varies from region to region and between local health units. Many local health units collect data in spreadsheets (e.g. Microsoft Excel) and in some other areas the systems are not digitalised. Other regions have developed specific digital platforms to collect contact tracing data. The Ministry of Health and the National Institute for Health offered Go.Data to the regions to manage contact tracing and, while some local health units have been using it, the use has been inconsistent.

Spain

Contact tracing

Spain has 19 administrative autonomous regions (17 autonomous communities and two autonomous cities) that are in charge of the healthcare system and surveillance of diseases in the corresponding area.

In January 2020, the Health Alerts, Preparedness and Response Commission prepared a strategy protocol for the early detection, surveillance and control of COVID-19 [3]. This strategy is updated regularly according to the evolution of the pandemic, priorities and response capacity [4]. Since May 2020, the strategy has included recommendations on contact tracing and contact management.

According to the recommendations described in the strategy, contact tracing is initiated for suspected cases, who are asked to identify the contacts they live with and to recommend that these contacts quarantine (i.e. avoid physical interactions). The identification and control of other close contacts – in addition to household contacts – may be delayed until the case is classified as a confirmed case with active infection, provided that such

confirmation can be guaranteed within 24-48 hours. If the test result (for active infection) of the suspected case is negative, the quarantine of the contacts is suspended. Close contacts who were confirmed with SARS-CoV-2 infection in the three months prior to the tracing are exempt from contact management and quarantine.

Every region is responsible for conducting contact tracing and managing close contacts, but there is flexibility on how these control measures can be implemented. The autonomous regions organise contact tracing and contact management activities based on their capacities. In some regions, contact tracing activities are supported by members of the military. Close contacts are contacted and informed according to the protocol established in each autonomous region. Only aggregated data are reported to the Ministry of Health.

Data collection system

The extent and capacity of data collection systems varies across the regions. The Coordination Centre for Health Alerts and Emergencies of the Ministry of Health recommended the use of Go.Data as a tool for contact tracing and for managing contact information. A few regions have adopted Go.Data, while others have developed their own digital platforms. Some regions have outsourced contact tracing to call centres and others have used less flexible systems to collect contact tracing information.

The data flow depends on the data collection system. In some regions, the local health units are responsible for data collection and for sharing information at the regional level. In others, contact tracers enter the data in real-time at the regional level. Once a week, the regional services report the number of close contacts who became cases to the Coordination Centre for Health Alerts and Emergencies of the Ministry of Health.

Data sets

Characteristics of the COVID-19 data sets from Ireland, Italy and Spain that were available for analysis at the time of this project are described in Table 1.

Table 1. Characteristics of the COVID-19 data sets available for analysis, Ireland, Italy and Spain, 2020

Characteristics	Ireland	Italy	Spain
Geographic coverage	National	Regional and local: One region (Molise) and three local health units (Reggio Emilia (Emilia Romagna), Cosenza (Calabria) and Lanciano-Vasto-Chieti (Abruzzo)) that, together, constitute a population of 1 899 468 (Istituto Nazionale di Statistica, 2020) [5].	Regional: One autonomous region, La Rioja, a single-province autonomous community in the north of Spain, with a population of 315 931 inhabitants (National Institute of Statistics, 2020) [6].
Time period	18 May 2020 to 1 October 2020	1 Mar 2020 to 31 December 2020	12 July 2020 to 31 October 2020
Main variables	• Case information (including demographic, clinical and epidemiological characteristics) • Close contact information (including demographic and epidemiological details)	• Case information (including demographic, clinical and epidemiological characteristics) • Close contact information (including demographic, exposure context and other epidemiological details)	• Case information • Close contact information • Follow-up information

More details on which variables were collected by each country are summarised in Table 2A, in the Annex.

Key issues with the data

In Italy and Spain, contact tracing data are collected at the regional and local levels and are not shared regularly with the national authorities. This subnational feature represented a challenge for the collection of the data needed to carry out this project and a substantial delay was experienced before the data was accessible. In Ireland, the contact management program was created in March 2020 and contact tracing data are collected at the national level. However, in September 2020 (when this project commenced), a formal structure for accessing contact tracing data for analysis purposes was not yet in place. This represented a challenge for the project that was similar to the one experienced in the other two countries.

Contact tracing systems in the three countries were also overwhelmed at various stages during the pandemic, which affected the data collected (e.g. complete information about contacts was not collected).

Ireland

The data in Ireland is collected nationally. Contact tracers collect a wide range of data that enables the monitoring of the effectiveness of contact tracing and changes in the patterns of disease transmission. However, the data set has some limitations, as follows:

- The follow-up history of close contacts and their testing pathway has been linked to cases from mid-May 2020 onwards. Prior to this, cases and contacts were not linked in the data set and, therefore, the chain of transmission could not be analysed. Consequently, contacts identified prior to 18 May 2020 were excluded from the analysis.
- 'Complex contacts' are close contacts of a case who reside in or have attended a congregate setting or a setting with vulnerable individuals during their infectious period. Contacts described as complex are usually traced by staff of Departments of Public Health, resulting in less comprehensive data on these cases in the CCT, as the departments do not always upload data to the CCT. In addition, hospital inpatient contacts are identified and monitored by infection prevention and control (IPC) staff within the hospital and the departments. Again, uploading of this data to the CCT is incomplete.
- There are several identifier fields created automatically in the CCT for different purposes during the contact tracing process. Having one unique identifier field that a person carries forward through all different stages in the contact tracing pathway would have been more beneficial from a data analysis perspective.
- The data set was available in a long data format. To be able to calculate some of the indicators, we created a wide data set (cases and their contacts each represent a row in the data set) and a long data set (data on the case are repeated for each of their contacts) version and switched between formats when analysing the data. When choosing a statistical software, the data structure should be considered, as not all software can easily transform wide and long data structures.
- Some inconsistencies were observed in the reporting of dates, which led to the exclusion of some observations.

Italy

Data were collected in different formats. For the Region of Molise and the local health unit of Reggio Emilia, data for cases and contacts were sent directly from the institutions in spreadsheet format. Data from the local health units of Cosenza and Chieti were obtained through Go.Data. It was necessary to download four files to calculate the indicators of this project: case information, close contact information, relationship between contact and case, and relationship between cases.

As data came from different digital platforms/systems, time was needed for data management to harmonise the data before starting the analysis. While data on cases was of good quality, data on contacts often included only demographic data and no further information. Several issues led to the exclusion of some observations, including:

- inconsistencies in the data, especially in dates;
- the direction of the relationships was sometimes incoherent (e.g. in two connected cases the date of onset in the first case was later than the date of onset in the second case that was thought to be infected by the first one); and
- often cases and contacts were linked to an event and not to an index case (e.g. outbreak in an LTCF).

Spain

Five of the 19 autonomous regions were approached to obtain data for this work. Due to the overwhelming situation in Spain, only the region of La Rioja participated. Contact tracing data was exported from the application and was shared in a spreadsheet format. The unique identifier was not always recorded; therefore, the link between cases and contacts was found through the name of the case.

Several variables were not collected or there were inconsistencies in the data, and this restricted the data analysis and number of indicators calculated, including:

- the follow-up information for contacts was not usually collected, although these variables were present in the questionnaire;
- the interview date was not collected, making it impossible to calculate how much time had passed between when the case was identified and when the contact was called;
- the result and the date of test were both available, but were stored in a single variable;
- the date of symptom onset for the case was not collected during the contact tracing and only the date of the last test was recorded;
- often cases and contacts were linked to a location and not to an index case (e.g. an outbreak in an LTCF);
- sex was not collected as a variable, which may not be an issue for contact tracing analysis, but restricted the presentation of the main results.

Inconsistencies in the data were also found in relation to the location. Although the place of residence and basic health area were collected, the format in which they were exported made data cleaning challenging and time consuming.

Data collected

Ireland

The Irish data set includes all COVID-19 cases (n = 14 360) and their close contacts (n = 61 135) reported on the COVID Care Tracker (CCT) platform from 18 May to 1 October 2020. This analysis is limited to close contacts only. For this analysis, an epidemiological date variable was created. The epidemiological date is the date COVID-19 cases and their contacts were contacted and informed of their status as a COVID-19 case or close contact. When this date was not available, the date they were last in contact with the COVID-19 case was used as the epidemiological date.

COVID-19 cases who could not be reached for contact tracing were excluded from the analysis (n = 238). After all restrictions were applied 13 448 COVID-19 cases and their 59 852 close contacts remained in the data set.

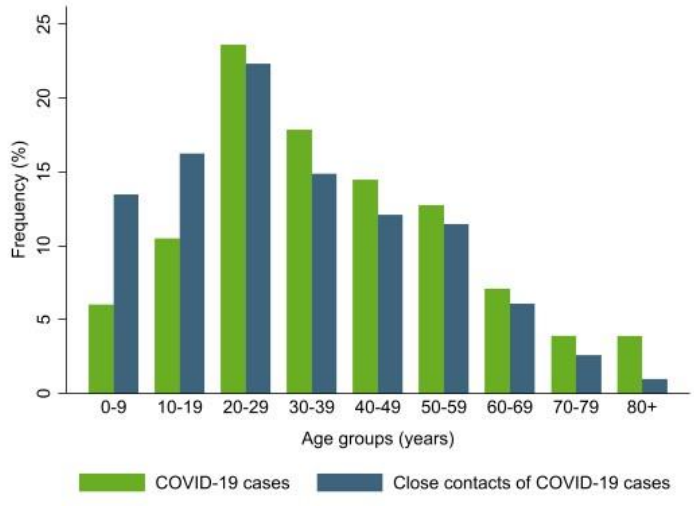
Sex and age distribution of close contacts

The sex distribution of COVID-19 cases and their close contacts was similar, with a slightly higher proportion of female cases and close contacts (Table 2). COVID-19 cases were older than close contacts, with 16.3% of cases (compared with 26.9% of contacts) younger than 19 years old and 15.1% of cases (compared with 6.7% of close contacts) older than 60 years old (Figure 1).

Table 2. Sex distribution of COVID-19 cases and close contacts, Ireland, 18 May–1 October 2020

Sex	Number of cases	Frequency	Number of contacts	Frequency
Female	6 820	50.6	28 279	47.3
Male	6 573	48.7	27 271	45.6
Missing	98	0.7	4 302	7.2
Total	**14 024**	**100.0**	**59 852**	**100.0**

Figure 1. Age distribution of COVID-19 cases and close contacts, Ireland, 18 May–1 October 2020



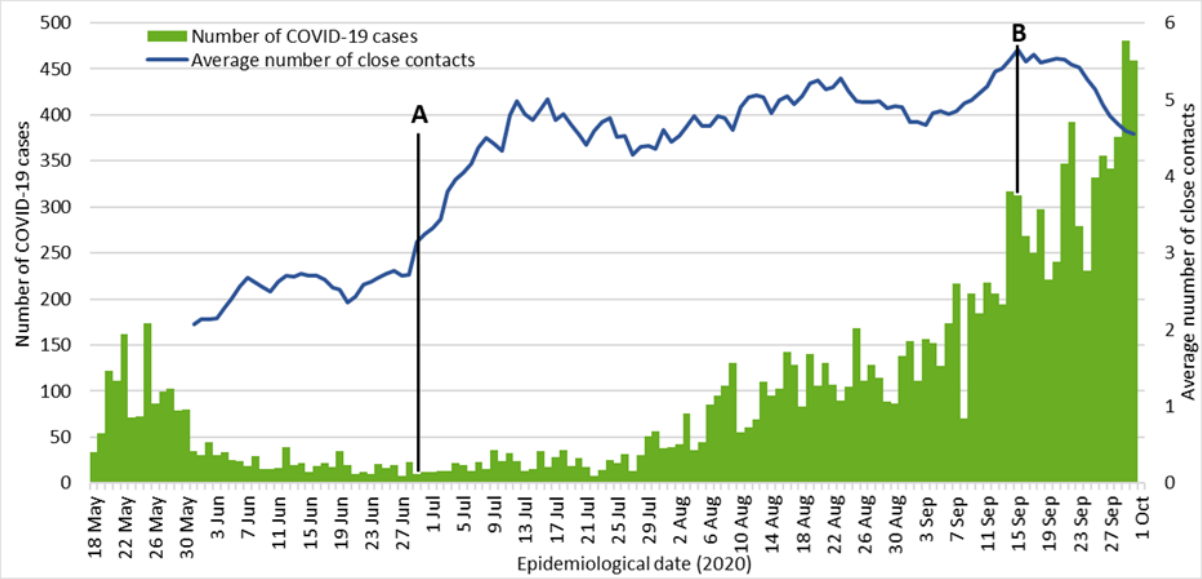
Description of number of close contacts per COVID-19 case

The median number of close contacts per case was 3 (interquartile range (IQR): 0-6) and the mean number of close contacts per case was 4.5 (Figure 2).

A considerable proportion (27.7%; n = 3 773) of COVID-19 cases had no close contact reported in the contact tracing data set. A case can be described as not having any close contacts for a number of reasons (e.g. if there are no actual close contacts or if the close contacts have already been recorded in relation to another case).

The mean number of close contacts per COVID-19 case showed a clear age-related pattern. COVID-19 cases belonging to younger age groups had a higher mean number of close contacts than people in older age groups. COVID-19 cases in the age group 20-29 years had the highest mean and median number of close contacts, while people over the age of 80 years had the lowest (Table 3). The mean number of close contacts was similar among males and females.

Figure 2. COVID-19 cases and 14-day moving average number of close contacts per case, Ireland, 18 May–1 October 2020



Point A: Re-opening of businesses after the national lockdown that commenced in March 2020.
Point B: National level restrictions introduced, as well as additional restrictions in Dublin.

Table 3. Mean, median and interquartile range (IQR) of close contacts per COVID-19 case, by age group, Ireland, 18 May–1 October 2020

Age group (years)	Mean number of contacts per case	Median number of contacts per case	IQR
0-9	5.0	0	0-5
10-19	5.5	3	0-7
20-29	5.8	4	1-8
30-39	4.5	3	1-6
40-49	4.1	3	1-6
50-59	4.1	3	1-6
60-69	3.4	2	0-5
70-79	2.6	1	0-3
80-89	1.3	0	0-1
Total	**4.5**	**3**	**0-6**

Cases were categorised by the most likely source of infection. These categories are: close contact of a known COVID-19 case, healthcare setting (acquired as a patient), healthcare setting (acquired as a staff member), travel-related cases (includes cases who acquire COVID-19 infection outside of Ireland (imported cases) and cases who acquire COVID-19 infection directly from imported cases), or community transmission where the source of infection was investigated and reported as not known. For some cases, transmission source data was not reported.

The average number of close contacts per case varied depending on the most likely source of infection of the initial case. This might reflect the age and circumstances of the person infected. Community transmission (source of infection not known) cases had the highest average number of close contacts (Table 4).

Table 4. Mean, median and interquartile range (IQR) of close contacts per COVID-19 case, by transmission source, Ireland, 18 May–1 October 2020

Transmission source	Number of contacts	Mean number of contacts per case	Median number of contacts per case	IQR
Close contact of a case	7 123	3.7	2	0-5
Healthcare setting (acquired as a patient)	448	2.2	1	0-4
Travel related	481	5.9	4	1-8
Healthcare setting (acquired as staff)	404	3.9	3	2-5
Community transmission	3 783	7.1	5	2-9
Transmission source not reported	1 039	1.8	0	0-2

Testing of close contacts and attack rate

During the period assessed in this report, close contacts were tested at Day 0 (i.e. the day they were identified) and, when this was negative, again on the seventh day from the last contact with the confirmed case [7]. Day 0 testing of all close contacts commenced on 19 May 2020. Day 7 testing commenced on 28 May 2020.

In total, 59.3% of the contacts included in the data set participated in Day 0 testing (n = 35 469) and had a valid test result. The Day 0 attack rate in close contacts tested was 10.7%. On Day 7, 15.6% of contacts participated in the testing (n = 9 359) and the attack rate was 3.8%. The overall attack rate among close contacts tested on Day 0 and Day 7 was 11.1%.

Close contacts were considered COVID-19 cases if they had at least one positive test result on Day 0 or on Day 7. For the contacts with at least one valid test result on Day 0 or Day 7 testing (n = 36 534), the attack rate was highest for cases in the age group 40-49 years (16.5%; Table 5) and for contacts in the age group 10-19 years (13.3%; Table 6).

The attack rate was similar among male and female close contacts of COVID-19 cases, 11.2% and 11.0%, respectively. The attack rate was much higher among those with ongoing exposure to the case than among those who had no ongoing exposure (24% compared to 9.8%). This result mostly explains the high attack rate among household contacts (18.6%), as 97.5% of contacts with an ongoing exposure were also household contacts (Table 7). The attack rate was higher among close contacts of symptomatic COVID-19 cases compared to asymptomatic cases (Table 8).

Table 5. Attack rate among close contacts, by age group of the COVID-19 case, Ireland, 18 May–1 October 2020

Cases	Close contacts		
Age group (years)	Total number of close contacts	COVID-19 detected	Attack rate (%)
0-9	1 601	117	7.3
10-19	4 116	323	7.9
20-29	11 180	1 065	9.5
30-39	6 118	786	12.9
40-49	4 733	783	16.5
50-59	4 008	599	14.9
60-69	1 853	218	11.8
70-79	810	116	14.3
80-89	343	35	11.0
Unknown	2 207	82	3.7

Table 6. Attack rate among close contacts to COVID-19 cases, by age group of the close contacts, Ireland, 18 May–1 October 2020

Age group (years)	Total number of close contacts	COVID-19 detected	Attack rate (%)
0-9	3 782	452	12.0
10-19	5 468	728	13.3
20-29	8 094	901	11.1
30-39	5 461	563	10.3
40-49	4 615	444	9.6
50-59	4 439	455	10.3
60-69	2 401	262	10.9
70-79	989	112	11.3
80-89	315	28	8.9
Unknown	960	94	9.9

Table 7. Attack rate in close contacts, by context of exposure to the COVID-19 case, Ireland, 18 May–1 October 2020

Context of exposure	Total number of close contacts	COVID-19 detected	Attack rate (%)
Household	12 397	2 370	18.6
Social	9 288	765	8.2
Workplace	3 437	182	5.3
Other	1 352	72	5.3
Unknown setting	10 136	736	7.3

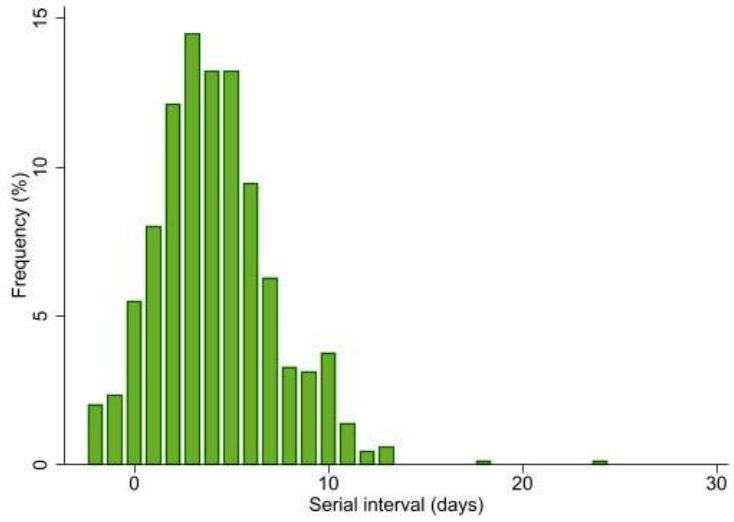
Table 8. Attack rate by symptom status of the COVID-19 case, Ireland, 18 May–1 October 2020

Symptom status of COVID-19 case	Total number of close contacts	COVID-19 detected	Attack rate (%)
Symptomatic	27 573	3 364	12.2
Asymptomatic	5 260	428	8.1

Serial interval

The serial interval can be defined as the time from symptom onset in the primary case to symptom onset in the secondary case, and is a key parameter for assessing the dynamics of an infectious disease. In this analysis, we have assumed that close contacts who are subsequently diagnosed with COVID-19 infection (secondary cases) acquired the infection from the primary case who identified them as a close contact. Results are restricted to exposures that occurred from 48 hours before to 24 days after symptom onset in the primary case (Figure 3). After restricting for this time period, 634 primary case and secondary case (infected close contact) pairs remained in the data set. The mean serial interval was 4.2 days and the median was 4 days (IQR: 2-6 days).

Figure 3. Duration in days from symptom onset of the primary COVID-19 case to symptom onset of the secondary case, Ireland, 18 May–1 October 2020



Time intervals

The mean time from symptom onset in COVID-19 cases to testing was 2.8 days (median: 2 days; IQR: 1-4 days). This varied over the study period. When stratified by transmission source, the mean number of days from symptom onset to testing was longer for cases with an unknown transmission source (mean: 3 days; median:3 days; IQR: 2.5-3.4 days) compared with cases with a known transmission source (mean: 2.5 days; median: 2.5 days, IQR: 2-2.8 days). The mean time interval between COVID-19 PCR testing and COVID-19 cases being informed of the results ranged from 1.5 days to almost 3 days (Figure 4).

During the study period, 98.2% (n = 13 448) of the cases recorded on COVID Care Tracker (CCT) platform had been successfully contacted for contact tracing purposes. In total, 238 COVID-19 cases were not contactable for contact tracing. Among close contacts, 97.6% (n = 51 380) were informed that they were a close contact of a COVID-19 case (Figure 5).

The mean number of days from the primary case testing positive to their close contact being informed of their close contact status was higher for cases with an unknown transmission source (mean: 1.8 days; median:1.7 days; IQR: 1.2-2.4 days), compared with those with a known transmission chain (mean: 0.5 days; median: 0.7 days; IQR: 0-1 days).

In Figure 6, data was restricted to close contacts who did not have an ongoing exposure to the case (n = 33 150) and the time range was restricted from -4 days to 16 days between symptom onset in the case and last exposure with the close contact. The attack rate was highest when the exposure was four to five days after symptom onset in the case (19.6%; Table 9).

Figure 4. Time interval between PCR testing and COVID-19 cases being informed of positive results, Ireland, 18 May–1 October 2020

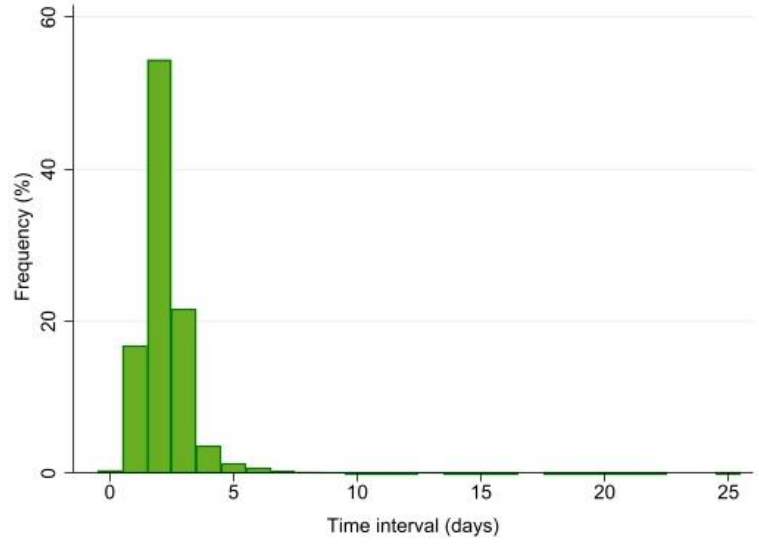


Figure 5. Proportion of close contacts informed less than 48 hours from COVID-19 case testing positive, Ireland, 18 May–1 October 2020

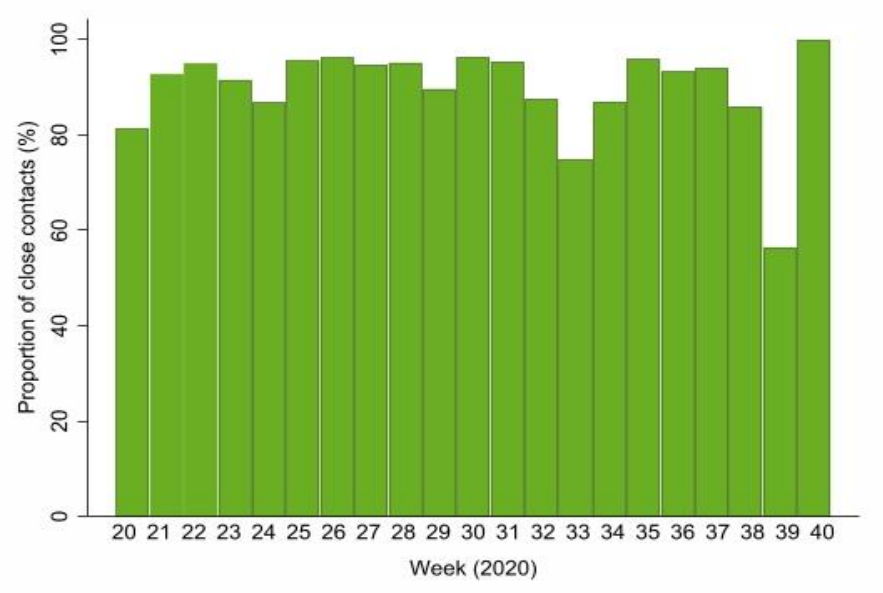


Figure 6. Time interval between symptom onset of the COVID-19 case and last exposure of the close contact, by test outcome of the close contact, Ireland, 18 May–1 October 2020

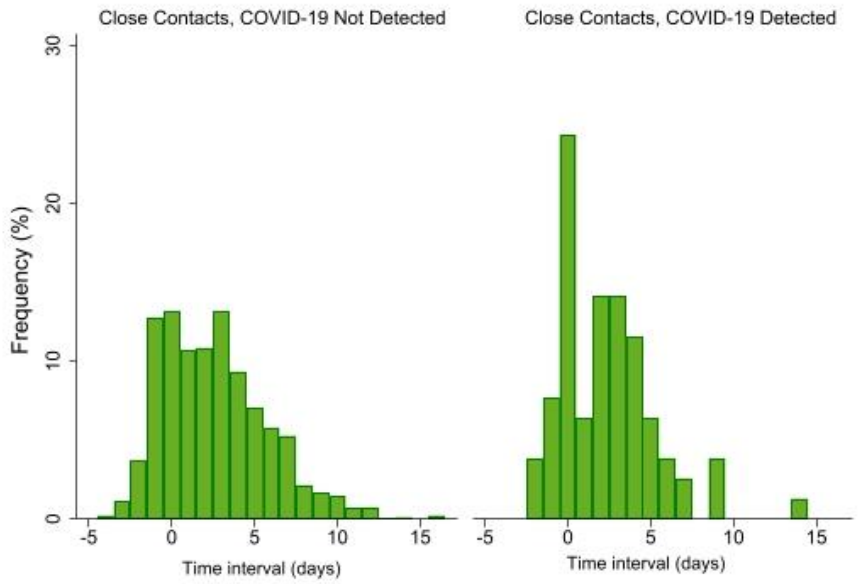


Table 9. Attack rate by date of exposure relative to symptom onset in the COVID-19 case, Ireland, 18 May–1 October 2020

Date of exposure relative to symptom onset	COVID-19 detected	Negative test result	Attack rate (%)
3-4 days before	14	298	4.5
2 days before	108	1 125	8.8
1 day before	103	1 757	5.5
On the same day	148	1 557	8.7
1 day later	80	750	9.6
2 days later	81	647	11.1
3 days later	84	578	12.7
4-5 days later	182	749	19.6
6-7 days later	96	411	18.9
More than 7 days later	44	263	14.3
Total	**864**	**7 972**	**9.8**

Italy

Four different databases, corresponding to the four geographical areas, were merged to analyse the Italian data. In total, information was provided for 20 899 cases and 25 727 close contacts.

Table 10 presents the main characteristics of cases and contacts included in the analysis. In terms of sex, there were slightly more female cases and contacts than males, whereas contacts were younger than cases.

The age groups 40-49 years and 50-59 years had higher numbers of cases, while the age groups 0-9 years and 10-19 years had higher numbers of contacts (Figure 7). The mean number of contacts per case was 1.28. The mean number of contacts was higher in younger age groups (0-9 and 10-19 years old). Table 11 shows the total number of contacts per case, as well as the mean, the median and the IQR, by age group. The mean number of contacts for a female case was the same as the mean number of contacts for a male case.

Table 10. Description of the COVID-19 cases and contacts, Italy, 1 March–31 December 2020

Characteristics	Cases	Contacts
Sex		
Female	10 549 (50.5%)	10 754 (41.8%)
Male	9 946 (47.6%)	10 507 (40.8%)
Missing	404 (1.9%)	4 466 (17.4%)
Age (years)		
Median (IQR)	49.0 (31-65)	33.0 (14-54)
Health unit of diagnosis (geographical area)		
A	17 706 (84.7%)	20 601 (80.1%)
B	1 994 (9.5%)	3 802(14.8%)*
C	1 147 (5.5%)	1 234 (4.8%)
D	52 (0.2%)	90 (0.3%)
Time period**		
March to May	6 190	7 398
June to December	14 587	14 466
Missing	122	2 588

IQR: interquartile range.
** Of which, 1 200 could be linked to cases in the database.*
*** Time period was determined by date of sampling for cases and start date of follow-up for contacts.*

Figure 7. Age distribution of COVID-19 cases and contacts, Italy, 1 March–31 December 2020

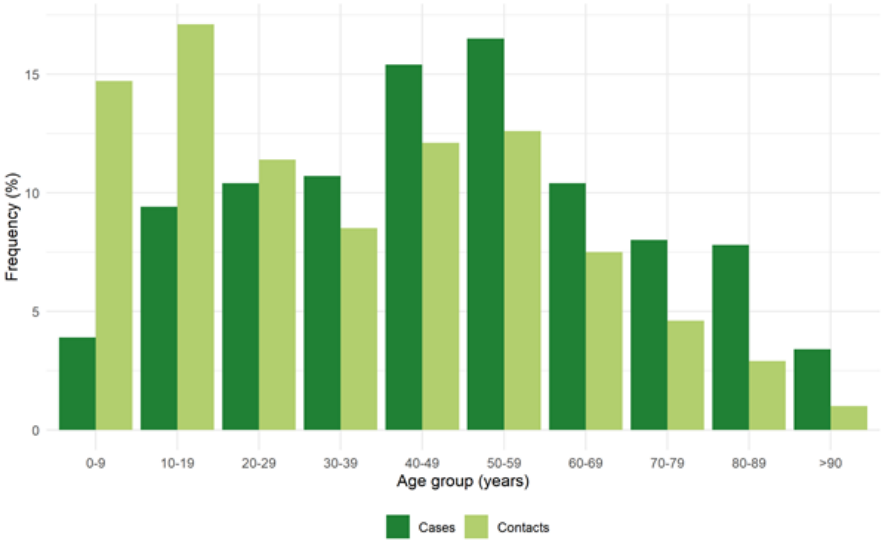


Table 11. Mean, median and interquartile range of close contacts per COVID-19 case, by age group, Italy, 1 March–31 December 2020

Age group (years)	Number of contacts	Mean number of contacts per case	Median number of contacts per case (IQR)
0-9	2 085	2.6	0 (0-91)
10-19	3 425	1.7	0 (0-46)
20-29	2 344	1.1	0 (0-44)
30-39	2 662	1.2	0 (0-40)
40-49	4 401	1.4	0 (0-54)
50-59	3 150	0.9	0 (0-53)
60-69	1 586	0.7	0 (0-47)
70-79	1 080	0.6	0 (0-38)
80-89	806	0.5	0 (0-46)
≥90	266	0.4	0 (0-31)

Proportion of contacts followed up

The proportion of contacts with recorded dates for when they were reached and when their follow-up ended varied by age group, with higher proportions in the younger age groups (Table 12 and Table 13).

Table 12. Proportion of contacts with recorded date for when they were reached, by sex and age, Italy, 1 March–31 December 2020

Age group (years)	Female contacts		Male contacts	
	Recorded date of interview	%	Recorded date of interview	%
0-9	1 728	98.5	1 818	99.1
10-19	1 890	96.5	2 036	96.0
20-29	1 116	93.0	1 358	94.3
30-39	873	91.7	862	91.5
40-49	1 363	94.1	1 149	93.1
50-59	1 336	91.7	1 253	93.9
60-69	788	91.8	720	90.8
70-79	492	87.7	395	84.4
80-89	257	69.3	184	71.0
≥90	72	40.4	35	64.8

Table 13. Proportion of contacts with recorded date for when their follow-up ended, by sex and age, Italy, 1 March–31 December 2020

Age group (years)	Female contacts		Male contacts	
	Recorded date of interview	%	Recorded date of interview	%
0-9	1 730	98.6	1 814	98.9
10-19	1 891	96.6	2 037	96.1
20-29	1 116	93.0	1 361	94.5
30-39	869	91.3	860	91.3
40-49	1 357	93.7	1 150	93.2
50-59	1 330	91.3	1 251	93.8
60-69	779	90.8	716	90.3
70-79	487	86.8	391	83.5
80-89	257	69.3	182	70.3
≥90	72	40.4	35	64.8

Proportion of contacts that had contact tracing implemented within 24 hours of identification

The overall proportion of contacts that had contact tracing implemented within 24 hours of identification (by date of epidemiological interview) was 92.1%. There were some variations by age group, with higher proportions in older age groups (Table 14).

The overall proportion of contacts that had contact tracing implemented within 24 hours of identification (by start date of follow-up) was 76.1%. There were some variations by age group, with higher proportions in older age groups (Table 15).

Table 14. Proportion of contacts that had contact tracing implemented within 24 hours of identification, by date of epidemiological interview (if reported), Italy, 1 March–31 December 2020

Age group (years)	Female contacts		Male contacts	
	Interview within 24 hours from notification	%	Interview within 24 hours from notification	%
0-9	741	88.0	784	89.1
10-19	1 048	90.5	1 125	90.9
20-29	803	91.9	1 003	91.2
30-39	589	91.9	617	92.2
40-49	946	92.6	831	93.3
50-59	937	92.0	930	94.7
60-69	560	94.4	509	92.5
70-79	342	96.9	273	95.5
80-89	192	95.5	141	96.6
≥90	52	100.0	26	96.3

Table 15. Proportion of contacts that had contact tracing implemented within 24 hours of identification, by start date of follow-up (if reported), Italy, 1 March–31 December 2020

Age group (years)	Female contacts		Male contacts	
	Start date of follow-up within 24 hours from notification	%	Start date of follow-up within 24 hours from notification	%
0-9	509	66.4	537	63.6
10-19	783	67.9	893	72.0
20-29	692	79.1	831	75.8
30-39	492	75.5	522	78.1
40-49	769	76.7	701	78.7
50-59	807	80.2	793	81.2
60-69	500	85.3	449	80.8
70-79	290	82.4	241	84.3
80-89	170	86.3	127	87.0
≥90	45	80.4	23	92.0

Attack rate among contacts and attack rate among contacts of contacts

The total attack rate among primary contacts (i.e. contacts of a COVID-19 case) was 26.25%. The attack rate was also calculated according to two different time periods: from March to June 2020 it was 28.6% and from July to December 2020 it was 20.3%.

The attack rate steadily increased by age, with the highest attack rate in the 90 years and older age group (67.4%) (Table 16). The attack rate was highest three to nine days before the date of symptom onset (Table 17). Out of 25 727 close contacts, the context of exposure was collected for 1 724 contacts. Compared to other settings, the attack rate was very high in LTCFs (Table 18).

The total attack rate among contacts of contacts was calculated according to two different time periods: from March to May 2020 it was 29.2% and from June to December it was 23.3%. The attack rate among contacts of contacts increased with age (Table 19) and was highest three to nine days before the date of symptom onset (Table 20).

Table 16. Attack rate by age group of contacts, Italy, 1 March–31 December 2020

Age group (years)	Became a COVID-19 case	Did not become a COVID-19 case	Attack rate (%)
0-9	389	3 384	10.3
10-19	966	3 439	21.9
20-29	761	2 168	26.0
30-39	642	1 541	29.4
40-49	910	2 192	29.3
50-59	1 015	2 228	31.3
60-69	689	1 249	30.2
70-79	475	719	39.8
80-89	375	363	50.8
≥90	180	87	67.4

Table 17. Attack rate by when exposure occurred relative to symptom onset, Italy, 1 March–31 December 2020

Date of last contact	Became a COVID-19 case	Did not become a COVID-19 case	Attack rate (%)
10-14 days before symptom onset	250	1 041	19.4
6-9 days before symptom onset	532	1 326	28.6
3-5 days before symptom onset	782	1 913	29.0
Within 2 days before symptom onset	978	3 064	24.2
Within one week after symptom onset	589	3 284	15.2
Over one week after symptom onset	46	231	16.6

Table 18. Attack rate by context of exposure, Italy, 1 March–31 December 2020

Context	Became a COVID-19 case	Did not become a COVID-19 case	Attack rate (%)
Household	380	940	28.8
Long-term care facility	88	41	68.2
Workplace	37	42	46.8
Other cluster events	94	102	48.0

Table 19. Attack rate among contacts of contacts, by age group, Italy, 1 March–31 December 2020

Age group (years)	Became a COVID-19 case	Did not become a COVID-19 case	Attack rate (%)
0-9	55	490	10.1
10-19	125	497	20.1
20-29	113	245	31.6
30-39	110	154	41.7
40-49	143	244	37.0
50-59	172	230	42.8
60-69	88	137	39.1
70-79	88	70	55.7
80-89	49	36	57.6
≥90	14	7	66.7

Table 20. Attack rate among contacts of contacts, by when exposure occurred relative to symptom onset, Italy, 1 March–31 December 2020

Date of last contact	Became a COVID-19 case	Did not become a COVID-19 case	Attack rate (%)
10-14 days before symptom onset	47	110	29.9
6-9 days before symptom onset	97	97	50.0
3-5 days before symptom onset	109	164	39.9
Within 2 days before symptom onset	122	257	32.2
Within one week after symptom onset	105	343	23.4
Over one week after symptom onset	20	49	29.0

Serial interval

The mean serial interval, calculated from symptom onset in a case to symptom onset in a contact, was 5.5 days; the median serial interval was 4 days (IQR: 1-9). The mean and median serial interval was similar for female and male contacts, but it was higher for the age group 10-19 years (Table 21).

Table 21. Serial interval by age group of contact, Italy, 1 March–31 December 2020

Age group (years)	Mean	Median	IQR
0-9	5.4	5	2-16
10-19	7.2	6	2-23
20-29	5.5	4	2-20
30-39	4.7	4	2-21
40-49	5.1	4	1-24
50-59	5.6	5	1-24
60-69	5.4	4	1-23
70-79	4.8	3	0-22
80-89	4.8	3	0-16
≥90	4.3	5	0.75-11

IQR: interquartile range.

Time intervals

The total mean time from symptom onset to testing was 4.4 days and the median was 3 days (IQR: 2-6). For details by age group and sex see Table 22.

The total mean time from symptom onset to isolation of a COVID-19 case (both cases and contacts who became cases) was 1.38 days and the total median was 1 day (IQR: 0-3). For details by age group and sex see Table 23.

Table 22. Time from symptom onset to testing, by age group and sex, Italy, 1 March–31 December 2020

Age group (years)	Females			Males		
	Mean	Median	IQR	Mean	Median	IQR
0-9	2.9	2	2-16	3.1	3	2-18
10-19	4.0	3	2-29	3.8	3	2-30
20-29	4.3	3	2-28	4.2	3	2-30
30-39	4.2	3	2-30	3.9	3	2-30
40-49	4.8	3	2-30	4.2	3	2-28
50-59	4.7	3	2-30	4.6	3	2-30
60-69	4.9	3	2-29	4.6	3	2-29
70-79	4.3	3	2-29	4.4	3	2-30
80-89	4.8	5	2-26	4.3	3	2-27
≥90	5.1	7	2-26	4.3	3	2-18

IQR: interquartile range.

Table 23. Time from symptom onset to isolation of a COVID-19 case, by age group and sex, Italy, 1 March–31 December 2020

Age group (years)	Female COVID-19 cases			Male COVID-19 cases		
	Mean	Median	IQR	Mean	Median	IQR
0-9	-1.0	-1.0	-1 to 1	0.0	0	0 to 0
10-19	2.8	2.5	0.5 to 6	3.2	3	2.25 to 8
20-29	0.5	2.0	-1 to 6	3.8	2	0 to 30
30-39	3.2	3.0	1.75 to 11	1.8	2	0 to 10
40-49	2.5	1.5	0 to 18	2.0	1	0 to 11
50-59	2.1	3.0	0 to 20	2.6	1	0 to 19
60-69	0.3	1.0	-0.75 to 6	1.6	1	-1 to 10
70-79	-0.7	0.0	-1 to 3	0.2	0	-2 to 10
80-89	-1.2	0.5	-0.25 to 12	-0.8	0	-1 to 3
≥90	-5.0	-4.0	-5.5 to 3	-8.0	-8	-13 to 2

IQR: interquartile range.

Spain

The initial data set included 14 665 case–contact pairs, but was restricted to the 12 979 that occurred during the study period (July-October 2020). Another 55 observations were removed, as they occurred in an LTCF and were not linked to a single index case but rather to a setting. The remaining 12 924 case–contact pairs described in this analysis correspond to 3 652 cases and 9 368 contacts, as some contacts are linked to more than one case.

Data on sex was not available for analysis. Overall, contacts were younger than cases. The age distribution of cases and contacts is shown in Table 24 and Figure 8. There were 543 contacts with date of birth missing that were excluded from the age calculation.

The mean number of contacts per COVID-19 case was 3.5 and the median was 3.0 (IQR: 2.0-4.0). Table 25 and 26 show the mean number of contacts, as well as the median and IQR, by age group of cases and contacts, respectively. The majority of contacts reported the household as the context of exposure and family as the relationship to the case (Table 27 and 28).

Table 24. Number of COVID-19 cases and contacts by age group, La Rioja, Spain, 12 July–31 October 2020

Age group (years)	Number of cases	Number of contacts
0-9	200 (5.8%)	859 (9.7%)
10-19	369 (10.8%)	1,416 (16.0%)
20-29	438 (12.8%)	1,184 (13.4%)
30-39	398 (11.6%)	996 (11.3%)
40-49	599 (17.5%)	1,306 (14.8%)
50-59	589 (17.2%)	1,265 (14.3%)
60-69	369 (10.8%)	830 (9.4%)
70-79	255 (7.5%)	537 (6.1%)
80-89	161 (4.7%)	332 (3.8%)
≥90	44 (1.3%)	100 (1.1%)
Median (IQR)	45.3 (26.6-59.4)	39.5 (19.4-56.4)

IQR: interquartile range.

Figure 8. **Age distribution of COVID-19 cases and contacts, La Rioja, Spain, 12 July–31 October 2020**

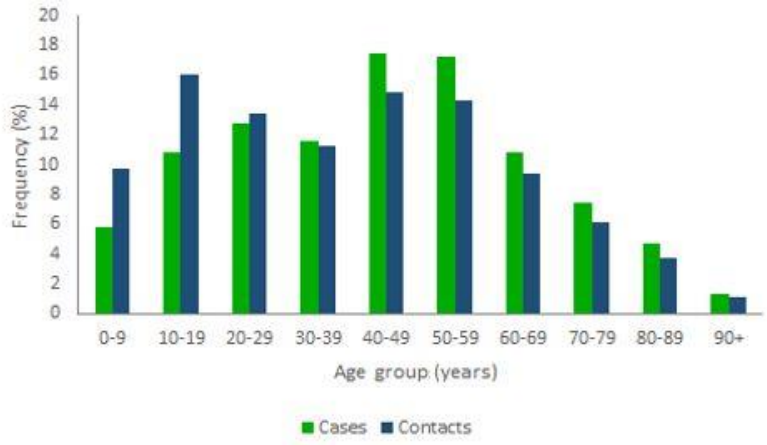


Table 25. **Mean, median and interquartile range (IQR) of contacts per COVID-19 case, by age group of cases, La Rioja, Spain, 12 July–31 October 2020**

Age group (years)	Mean number of contacts per case	Median number of contacts per case	IQR
0-9	3.8	3	2-5
10-19	4.9	4	3-6
20-29	4.2	3	2-6
30-39	3.7	3	2-5
40-49	3.5	3	2-4
50-59	3.2	3	2-4
60-69	2.7	2	1-3
70-79	5.6	2	1-4
80-89	3.4	3	2-4
≥90	2.7	2	1-4

Table 26. **Mean, median and interquartile range (IQR) of contacts per COVID-19 case, by age group of contacts, La Rioja, Spain, 12 July–31 October 2020**

Age group (years)	Mean number of contacts per case	Median number of contacts per case	IQR
0-9	1.5	1	1-2
10-19	1.8	1	1-2
20-29	1.6	1	1-2
30-39	1.5	1	1-2
40-49	1.4	1	1-2
50-59	1.4	1	1-2
60-69	1.4	1	1-1
70-79	1.3	1	1-1
80-89	1.4	1	1-1
≥90	1.3	1	1-2

Table 27. Mean, median and interquartile range (IQR) of contacts per COVID-19 case, by context of exposure, La Rioja, Spain, 12 July–31 October 2020

Context of exposure	Mean number of contacts	Median number of contacts	IQR
Healthcare centre	1.6	1	1-2
Socio-healthcare setting	6.2	4	1-6
Household	2.8	2	1-3
School/educational setting	4.3	3	1-5
Workplace	2.1	1	1-3
Other	2.9	2	1-4
Unknown (not missing)	2.0	1	1-2

Table 28. Mean, median and interquartile range (IQR) of contacts per COVID-19 case, by relationship, La Rioja, Spain, 12 July–31 October 2020

Relationship	Mean number of contacts	Median number of contacts	IQR
Family	2.7	2	1-3
Friend	2.9	3	2-4
Other	2.4	1	1-3
Social/healthcare worker	2.4	1	1-3

Attack rate

The total attack rate among primary contacts (i.e. contacts of a COVID-19 case) was 36.5% (n = 4 723), 51.3% (n = 6 635) of contacts had a negative test and 12.1% (n = 1 566) did not have a test result. The attack rate increased by age (Table 29) and was higher between household and family contacts (Table 30 and 31).

There were only 235 contacts with a reported date of symptom onset and a test date. The total mean time from symptom onset to testing was 5.0 days and the total median was 4.0 days (IQR: 3.0-6.0 days).

Table 29. Attack rate by age group of contacts, La Rioja, Spain, 12 July–31 October 2020

Age group (years)	Became a COVID-19 case	Did not become a COVID-19 case	Attack rate (%)
0-9	443	887	33.3
10-19	742	1,309	36.2
20-29	529	1,129	31.9
30-39	508	840	37.7
40-49	704	1,125	38.5
50-59	753	990	43.2
60-69	442	625	41.4
70-79	291	388	42.9
80-89	231	238	49.3
≥90	80	52	60.6

Table 30. Attack rate by relationship, La Rioja, Spain, 12 July–31 October 2020

Relationship	Became a COVID-19 case	Did not become a COVID-19 case	Attack rate (%)
Friend	162	1 005	13.9
Family	2 570	3 343	43.5
Other	170	487	25.9
Social/healthcare worker	12	19	38.7

Table 31. Attack rate by context of exposure, La Rioja, Spain, 12 July–31 October 2020

Context of exposure	Became a COVID-19 case	Did not become a COVID-19 case	Attack rate (%)
Healthcare centre	8	17	32.0
Socio-healthcare setting	84	84	50.0
Household	2 468	3 115	44.2
School/educational setting	8	213	3.6
Workplace	33	169	16.3
Other	234	1 107	17.4
Unknown (not missing)	25	51	35.4

Lessons learned and discussion

In this project, we computed contact tracing indicators based on data from Ireland, Italy and Spain. We encountered several challenges when analysing the contact tracing data from different countries. The information gathered was used to identify the variables that should be collected in order to evaluate the performance of a contact tracing system and to understand COVID-19 transmission dynamics.

Our results suggest that regular contact tracing data analysis and calculation of indicators can facilitate a better understanding of the pandemic and of the impact of the implemented response measures. The lessons learned can support public health authorities to enhance the use of contract tracing data when developing or harmonising standard data sets to calculate contact tracing indicators (see below). The proposed set of essential variables and set of suggested variables to calculate contact tracing indicators are useful for understanding transmission dynamics in the population, understanding locations or settings of high transmission, and measuring the impact of mitigation measures (Tables 32–34).

Proposed actions to enhance the use of contact tracing data

The following options can support public health authorities to enhance the use of contact tracing data:

- Conduct data collection using digital tools that allow the data to be exported into common formats (e.g. .csv, .xlsx).
- In the absence of a common national database, perform analysis at regional and local levels regularly and share the results to allow for assessment and learning from regions with different epidemiological situations and response policies.
- To easily recognise adjustments in the data set, keep a dated log of changes (including changes in definitions and data collection methods, as they arise).
- Maintain an up-to-date codebook with details of the contact tracing data (variable name, short description, data type and coded values) that can be shared with contact tracers and data analysts in order to improve understanding and communication around contact tracing data.
- Support the development of a standardised list of definitions for contact tracing data at the European level.
- Give priority to the following indicators: the number of contacts per location (e.g. municipality) and setting (e.g. household, workplace), and the proportion of contacts that become positive (attack rate) by exposure category, age, location and setting.

Gaining access to the data was a lengthy process and the analysis was not straightforward due to a lack of standardised data collection, with significant variations in the data collected and their formats. In Italy and Spain, contact tracing data are collected at the regional and local levels and are not shared regularly with the national authorities. This subnational feature represented a challenge for the data collection required to carry out this project. In all three countries, a substantial delay was experienced before the data was accessible. The analysed data were received in three different formats: spreadsheets, ad-hoc formats downloaded from the Go.Data platform and ad-hoc formats downloaded from national/regional digital platforms built specifically for COVID-19 contact tracing. Data within and between countries were provided from different digital platforms, which meant that additional time was needed for data management to harmonise the data before starting the analysis.

Data collection should be conducted using digital tools that allow the data to be exported into common formats (e.g. .csv, .xlsx). Such harmonisation of data collection and analysis processes is needed to facilitate more effective targeting of response measures and to assess the progression of the pandemic. In the absence of a common national database, analysis at regional and local levels should be performed regularly and the results should be shared to allow for assessment and learning from regions with different epidemiological situations and response policies.

To easily recognise adjustments in the data set, it is important to keep a dated log of changes (including changes in definitions and data collection methods, as they arise) to accommodate evolving knowledge of the pandemic. Furthermore, an up-to-date codebook with details of the contact tracing data (variable name, short description, data type and coded values) that can be shared with contact tracers and data analysts in order to improve understanding and communication around contact tracing data.

The aim of this work was to explore the main challenges in analysing contact tracing data and to identify areas for improvement. The data show many differences between countries; however, from this exploratory work it is difficult to disentangle whether this is due to differences in data collection or in transmission dynamics. The use of different definitions in data collection was identified as a barrier to the comparability of contact tracing data. This is particularly relevant for some variables (e.g. the exposure setting). We found that how setting was coded varied greatly from one public health unit to another. This is probably due to the difficulty of assigning infection acquisition to a particular setting. It would be useful to have a standardised list of definitions for contact tracing data at the European level.

Not all of the collected data was useful for the analysis. Although the data yielded important operational information to assist local contact tracing, not all of it was essential for calculating indicators to monitor transmission dynamics or to inform mitigation measures. Therefore, we suggest prioritising the following indicators:

- the number of contacts per location (e.g. municipality) and setting (e.g. household, workplace), and
- the proportion of contacts that become positive (attack rate) by exposure category, age, location and setting.

This information can be used to identify high-risk settings and to inform mitigation measures in a defined area. Mitigation measures can be further informed by calculating additional indicators on transmission dynamics, such as the median time interval between symptom onset in a COVID-19 case and symptom onset in a contact that becomes symptomatic (serial interval) or the attack rates among contacts stratified by age and sex. Once mitigation measures are in place, the effect of the measures over time can be measured by monitoring the number of contacts per case, stratified by sex, age and exposure setting.

Table 32 and Table 33 describe the essential variables required to calculate contact tracing indicators. Table 34 describes suggested variables that could be included in contact tracing data collection to help calculate a wider set of contact tracing indicators.

Table 32. Essential contact tracing variables for COVID-19 cases

Variable	Description	Indicator
Age (years)	Age at the time of the event	• Number of contacts per case, stratified by age of the case • Attack rate among contacts, by age of the case
Sex	Sex	• Number of contacts per case, stratified by sex of the case • Attack rate among contacts, by sex of the case
ID	Unique identifier	Operational field
Link field between case and their contacts	A unique field that enables linkage of cases and their contacts (e.g. the same identifier repeated for the case and their contacts)	Operational field
Address of residence	By country, region, county or other location	Number of cases by geographical location
Epidemiological date	The earliest of the following dates (if available): date of symptom onset, laboratory specimen collection date, laboratory received date, laboratory reported date, date of diagnosis or surveillance notification date	• Number of contacts per case over time • Attack rate among contacts over time
Reached by contact tracers	Case successfully contacted for contact tracing purposes	• Number of contacts identified • Proportion of contacts traced
Vulnerable population	A list of populations considered vulnerable based on age, medical conditions, social backgrounds, etc.	Number of cases in vulnerable populations
Most likely transmission setting	Potential transmission setting categories are context specific and may include: travel, healthcare, school, mass gathering, etc.	Number of cases per transmission setting

Table 33. Essential contact tracing variables for contacts

Variable	Description	Indicator
Age (years)	Age at the time of the event	• Number of contacts per case, by age of contact • Attack rate among contacts, by age of contact
Sex	Sex	• Number of contacts per case, by sex of contact • Attack rate among contacts, by sex of contact
ID	Unique identifier	Operational field
Link field between case and their contacts	A unique field that enables linkage of cases and their contacts (e.g. the same identifier repeated for the case and their contacts)	Operational field
Address of residence	By country, region, county or other location	Number of contacts by geographical location
Laboratory result	• Positive, negative or inconclusive • The result is essential for determining if the contact has tested positive and has turned into a case	Attack rate
Vulnerable population	A list of populations considered to be vulnerable based on age, medical conditions, social backgrounds, etc.	Number of close contacts in vulnerable populations
Exposure setting	• A list of the settings or locations where the contact could have been exposed to the case. • Minimal list of exposure settings: - Household - Workplace - Educational setting - Healthcare setting - Congregate setting (including LTCFs)	• Number of contacts per case, by exposure category • Attack rate among contacts, by exposure category

Table 34. Suggested contact tracing variables for cases and contacts

	Variable	Description	Indicator
Case	Symptom onset	Date of symptom onset in the case	Serial interval
	Date of testing	Date of testing	Proportion of cases that had contact tracing implemented within 24 hours of case identification
	Date and time of laboratory result	Date and time of the laboratory result	
	Date and time case informed	Date and time case was informed of their COVID-19 test result and information on close contacts was collected	
	Date of end of follow-up	Date when the case was discharged from the service (end of isolation)	Duration of isolation for case
Contact	Symptom onset	Date of symptom onset in the contact	Serial interval
	Last exposure to the case	Time of last exposure to the COVID-19 case or ongoing exposure	Attack rate by time exposure relative to symptom onset
	Time contact informed	When contact was informed that they had been exposed to a COVID-19 case	Proportion of contacts that were reached within 24 hours of identification
	Date of testing	Date of testing	Attack rate among contacts over time
	Active/passive follow-up	Active/passive follow-up	Proportion of contacts actively/passively followed-up for quarantine period
	Date of end of follow-up	When the contact was discharged from the service	Duration of quarantine for contact

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Annex

Table 1A. Contact tracing indicators developed by the ECDC contact tracing team, May 2020

Indicator	Data	Use
Number of contacts per case: • By exposure category • By age of case and contacts • Over time	Number and ages of contacts per case, stratified by exposure category and time stamped	• Impact of containment measures on contact patterns • Mixing patterns by age in the community to inform measures (e.g. kids with grandparents)
Attack rate among contacts: • By exposure category • By when exposure occurred relative to symptom onset • By age • By location or reported setting of exposure	• Proportion of contacts that became a case • Information on timing of symptom onset in case • Information on setting of exposure (e.g. gym, choir; does not have to be actual geographical location).	• Ability to refine definitions of high and low risk contact exposure • Ability to understand locations or settings of high transmission to inform mitigation measures
Proportion of new cases arising from known contacts	Number of newly diagnosed cases overall and whether they had already been identified as a contact of a known case	Efficacy of contact tracing
Location of contacts and cases	Location of residence or location/setting of exposure	Whether contact patterns occur between different areas of the country or in specific settings (to inform mitigation measures)
Serial interval	Time window from symptom onset in a primary case to symptom onset in any of their contacts (secondary case)	Understanding of transmission dynamics
Time from symptom onset to testing/isolation	• Duration from symptom onset to testing and isolation over time among all newly identified cases, stratified by whether they are known contacts of a previous case • Information on extent of contact tracing operations over time (proportion of newly identified cases traced, proportion of new cases that are known contacts of a previous case)	Impact of contact tracing operations in reducing the duration of infectiousness of cases in the community
Proportion of cases where contact tracing was implemented within 24 hours of case identification	Time between case testing positive and contacts notified	Speed of contact tracing operations
Proportion of contacts identified and reached	• Number of contacts identified • Number of contacts who are reached by phone or message	Efficiency of contact tracing
Proportion of contacts actively / passively followed for quarantine period •	• Number of contacts identified • Number of contacts regularly communicated with during follow-up period, by type of communication (active/passive)	Efficiency of contact tracing
Attack rate among secondary contacts relative to primary contacts	• Number of contacts of cases and proportion of these that test positive later • Number of contacts of contacts and proportion of these that test positive	Whether recommendations to contacts of how to reduce transmission are effective (i.e. whether or not they are followed)

Table 2A. Data fields collected in each country

Country	Data fields	
	Case	Contact
Ireland	Number of cases by age and sex	Number of contacts by age and sex
	Serial interval (time from symptom onset in a primary case to symptom onset in a secondary case)	Mean and median number of close contacts per case, by age of the case and by transmission source
	Mean time from symptom onset in cases to testing	Attack rate by age group of the case, by age group of contacts, by context of exposure to the case, by symptom status of the case, by date of exposure relative to symptom onset in the case
	Time interval between PCR testing and cases being informed of the results	• Mean number of days from the primary case testing positive to their close contact being informed • Proportion of close contacts informed less than 48 hours from the case testing positive
Italy	Number of cases by age and sex	Number of contacts by age and sex
	Serial interval (time from symptom onset in the primary case to symptom onset in the secondary case)	Mean and median number of close contacts per case, by age of the case
	Mean time from symptom onset in cases to testing	Attack rate by age group of contacts, by context of exposure, by when exposure occurred relative to symptom onset
	Time from symptom onset to isolation	• Attack rate among contacts of contacts, by age group and by when exposure occurred relative to symptom onset • Proportion of contacts with recorded date for when they were reached • Proportion of contacts with recorded date for when their follow-up ended • Proportion of contacts that had contact tracing implemented within 24 hours of identification, by date of epidemiological interview (if reported) • Proportion of contacts that had contact tracing implemented within 24 hours of identification, by start date of follow-up (if reported)
Spain	Number of cases by age	• Number of contacts by age • Mean and median number of close contacts per case by age of the case, by age of the contact, by relationship (e.g. friend, family, other) and by context of exposure • Attack rate by age of contacts, by context of exposure and by relationship

The fields collected by all three countries were: number of cases by age, number of contacts by age, mean and median number of close contacts per case by age of the case, attack rate by age of contacts and attack rate by context of exposure.