An overview of the establishment of a national contact tracing programme: a quality improvement approach in a time of pandemic [version 1; peer review: 4 approved with reservations]

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Abstract

Background: With the onset of the coronavirus disease 2019 (COVID-19) pandemic, the Irish health system needed a contact tracing and management intervention at a national level to undertake high volume, low complexity contact tracing. This paper describes the establishment and first year of a national Contact Management Programme (CMP) in Ireland, its core components, outcomes on key measures (coverage, timeliness, and training) and learnings from the process.

Methods: CMP is centred on four steps, 1) case: rapid notification to a person of a result and provision of advice, 2) contacts: rapid identification of contacts, 3) control: rapid public health management of contacts, which includes testing and 4) active follow-up of close contacts with additional testing and public health advice reminder SMS and calls. The outcome measures used in this study are: 1) The proportion of all Irish cases contact traced through the CMP (Coverage), 2) the time taken to complete the 3 types of CMP calls (timeliness), 3) number of contact tracers trained and their feedback (training).

Results: 246,666 positive cases were recorded using the CMP between...
17th March 2020 and 30th April 2021, with contact tracing successfully completed for 237,759 cases, representing 99% and 96%, respectively, of the 248,529 cases notified in Ireland up to the 30th of April 2021. The average time taken for contact tracing to be completed was 29.4 hours (95% CI 28.9, 29.9) and the median was 16.8 hours (approximate 95% CI 15.9, 17.7).

**Conclusion:** Using the Quality Improvement (QI) approach, the Health Service Executive (HSE) successfully established and scaled up a Contact Management Programme that rapidly notified results to people and traced their close contacts. CMP contributed to the success of the Irish health service in managing the pandemic. CMP slowed COVID-19 transmission and lessened the impact on health services capacity.

**Keywords**
Contact management programme, Contact tracing, COVID-19, Quality Improvement

This article is included in the Coronavirus (COVID-19) collection.
Introduction

The coronavirus disease 2019 (COVID-19) pandemic is a global health emergency and has placed unprecedented pressures on healthcare systems around the world. As of 20th December 2021, there are 273,900,334 confirmed cases of COVID-19, including 5,351,812 deaths worldwide. Ireland has also suffered a loss of 5,835 lives and a total of 656,600 confirmed cases of COVID-19 as of 20th December 2021 highlighting the magnitude of the problem. Contact tracing is a core component in the management of infectious disease outbreaks and has been a part of the strategies of various countries to battle the COVID-19 pandemic. To stop the spread of COVID-19, the World Health Organization (WHO) recommends finding and testing all suspected cases, isolating, and treating confirmed cases and identifying close contacts of the confirmed cases for quarantine and observation. Countries should implement measures suited to their epidemiological conditions and system capacities while learning from success stories including China, Singapore, and South Korea who have demonstrated that identification and management of cases and their close contacts are effective practices.

Studies have shown that reducing tracing delays by shortening the time to trace contacts and prompt testing and isolation of positive cases can enhance contact tracing effectiveness while also reducing reproduction numbers. In most situations, efficient contact tracing and case isolation can significantly control a new outbreak of COVID-19 within 3 months. In addition to this, digital contact tracing through apps allows for instant notifications and has the potential to reduce the number of cases using finite resources.

There are eight regional Departments of Public Health in Ireland and under normal circumstances, each region manages and contact traces infectious diseases (IDs). The Health Protection Surveillance Centre (HPSC) coordinates nationwide outbreaks in collaboration with the eight regional Medical Officers of Health (MoH)/Departments of Public Health and Northern Irish authorities as required. However due to the rapid spread of COVID-19, coordination between the Departments of Public Health became challenging. Contact tracing services in departments with small numbers of staff and large urban populations became overwhelmed. There was a need for a contact tracing and management intervention at a national level to undertake high volume, low complexity contact tracing in Ireland. Members of the National Quality Improvement (QI) team, who also had expertise in public health, identified an opportunity to apply a QI approach to design and implement a national Contact Management Programme (CMP) at pace and scale.

The aims of the CMP are to rapidly identify and close chains of transmission of COVID-19 and collect essential surveillance data, thereby slowing COVID-19 transmission in Ireland and lessening the impact on health system capacity, in addition to freeing-up the Departments of Public Health to focus on complex public health issues. The aim of the paper is to describe the establishment of the CMP, its core components, outcomes on key measures (coverage, timeliness, and training) and learnings from the process since its establishment up till its first year of operations (May 2021).

Methods

Context

This study is reported using Revised Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) guidelines. On 11th March 2020, the Chief Executive Officer (CEO) of the Health Service Executive (HSE) Ireland directed the Chief Clinical Officer (CCO) to establish national level contact tracing. A team with expertise in QI (National Quality Improvement Team), programme development (National Women and Infants Programme) and public health infectious disease management was established. The CMP design was based on the Model for Improvement, a QI method which centres around the development of improvement ideas with a clear aim, measures to know whether the aim has been achieved and small tests of change using PDSA (Plan Do Study Act) iterative cycles. The design of the CMP was an iterative process based on international best practices. Although the CMP closely mirrors these guidelines, the implementation using QI approaches in the Irish context is novel. Figure 1 maps CMP design onto the Model for Improvement. The four-step process blueprint of CMP was created using process flow mapping, a lean methodology tool. The national framework for improving quality in HSE guided the implementation of the QI approach for the CMP.

Intervention

CMP drivers are leadership and governance, collaboration, training, IT System, contact tracing centres, patient engagement and national standardisation process. The four key steps of the CMP are rapid notification to a person of a result and provision of advice, rapid identification of contacts of confirmed cases, rapid public health management of contacts of confirmed cases and active follow-up of close contacts. These steps are presented in Table 1.

Table 1

| CMP primary drivers | The primary drivers identified in establishing the CMP and their impact on CMP are outlined in the following sections. |

Leadership and governance. The HSE senior leadership team prioritised and supported the CMP and clinical leaders from all disciplines advocated its use. The CMP Programme Lead was empowered to make decisions and recruit resources. A consultant in public health was recruited as the CMP Medical Officer of Health. Clear governance structures were established and documented to track high-level decisions and organisational charts were developed and updated regularly.

Collaboration. Collaboration with stakeholders across the HSE (National QI Team, National Women and Infants Health Programme and other agencies), the Defence Forces, universities and others across the public and private sector was key to the rapid establishment of the CMP. Many across these sectors
volunteered for redeployment to assist national efforts. Initially, several public health stakeholders raised concerns around possible risk of lower quality of contact tracing in CMP. For many regional Departments of Public Health that were able to manage contact tracing for a relatively low volume of cases, the use of CovidCare Tracker (CCT) IT system seemed to be tedious. The CMP leadership continuously collaborated with these Departments of Public Health to resolve concerns and developed processes to better fit their requirements.

**Education and training.** A CMP induction programme was developed to meet the urgent and large-scale requirement to train people in contact tracing. The programme prepared newly redeployed staff to work in the contact tracing centres (CTCs). The programme was co-designed with public health physicians, educationalists and QI facilitators and was tested with the first group of contact tracers. The programme was initially delivered face-to-face but moved to virtual delivery supported by a teaching university’s virtual learning platform. The programme consisted of self-directed learning, facilitated interactive virtual sessions, video role plays, audio presentations, CCT instructional videos and user manuals. A staff support component was integrated into the programme to support contact tracers in undertaking new roles in a rapidly evolving environment. The programme and its delivery were continually evaluated and adapted to reflect participant feedback. Caller scripts guide and support the CTC contact tracers in undertaking the different types of calls. Rapid PDSA cycles were employed to test and refine caller scripts which played a vital role in further script development in response to evolving public health policy and guidance, new updates to the CCT and recurring issues and scenarios.

**IT system.** A national web-based Contact Tracing IT system was designed to enable contact tracing for different people (for example clinicians breaking the bad news of a positive result, and non-clinicians collecting contact information). This bespoke system allows contact tracing to take place in any location, enabling safe distanced working. It collects and stores epidemiological and case management information to inform management of the pandemic nationally.

The HSE Office of the Chief Information Officer (OoCIO) working with the CMP team, used agile development methodology

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**Figure 1. Design of the Irish Contact Management Programme (CMP).** CMP design based on the Model for Improvement. COVID-19=coronavirus disease 2019.
Table 1. Four steps of CMP (Establishment-May 2021). CMP = Contact Management Programme, CTC = Contact Tracing Centre, CCT = CovidCare Tracker, DPH = Department of Public Health, SMS = Short Message Service, COVID-19 = Coronavirus disease 2019.

<table>
<thead>
<tr>
<th>Step</th>
<th>Purpose</th>
<th>Phone Call or Text Message</th>
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| 1-Case | Rapid notification to a person of a result and provision of advice | **Pre-Call 1 Positive Text:** Text from CMP to notify the person of their test result if positive and to await contact from CTC  
**Positive Call 1:** Phone call from CTC call handler to notify the person of their test result if positive  
• Checks if specialised contact tracing is required\(^a\)  
• Checks if person is a healthcare worker\(^b\)  
• Checks if previously positive\(^c\)  
• Asks about symptoms\(^d\)  
• Collects case surveillance data  
• Provides self-isolation advice  
• Enters demographic and surveillance data on CCT  
Note. If call handler does not have a clinical background or sufficient experience, they do not undertake call 1  
**Negative Text 1:** Text from CMP to notify the person of their test result if not detected  
**Indeterminate Letter 1:** Letter from CMP to notify the person of their test result if inconclusive, and to advise of requirement to contact their referring doctor |
| 2-Contacts | Rapid identification of contacts of confirmed cases of COVID-19 | **Call 2:** Phone call from CTC call handler to case to collect contacts  
• Phone call can be undertaken at same time as call 1 or later depending on expertise and clinical background of call handler  
• Establishes if level of contact reaches threshold for close contact  
• Collects the names and mobile phone numbers of the person’s close contacts and settings where they may have generated close contacts  
• Enters contact details and settings on CCT  
• Complex contacts or settings are routed to DPH using functionality on CCT |
| 3-Control | Rapid public health management of contacts of confirmed cases | **Pre-Call 3 Close Contact SMS** to notify close contacts immediately to restrict their movements and to invite them to use the ‘Request a Test’ online portal to receive public health advice and request COVID-19 test online  
**Call 3: Phone call to close contacts**  
• Close contacts can be identified at Call 2, through Public Health investigation of outbreaks or through the Covid Tracker App. Regardless of source these contacts enter the Call 3 queue on CCT for follow up.  
• Call handler does not require a clinical background  
• Refers for testing as soon as possible (known as Day 0 or as soon as possible)  
• Checks if previously positive or fully vaccinated\(^e\)  
• Checks if specialised contact tracing is required\(^f\)  
• Checks if person is a healthcare worker\(^g\)  
• Collects symptom information  
• Provides self-isolation advice if symptomatic or advice on restricted movements if asymptomatic |
| 4. Active follow up | **Active follow up**  
• Reminder text messages with public health advice sent to close contact until their last date of restricted movements\(^h\)  
• Refer for a second test (known as scheduled) on the tenth day following contact with case or fourteenth day following onset of symptoms in case if the contact has ongoing exposure to the case |

\(^a\) The person is referred for specialised contact tracing where there is a greater level of complexity such as living in a congregated residential setting such as a nursing home or direct provision centre, associated with an outbreak.  
\(^b\) If the person is a healthcare worker, they are asked to contact their line manager or occupational health department to inform them that they have tested positive for COVID-19 and they are referred to DPH for contact tracing of occupational contacts. Other contacts are collected through CMP  
\(^c\) If positive in previous 6 months and asymptomatic, contact tracing not required  
\(^d\) The person is advised that if they start to feel unwell, but it is not an emergency to call their GP or to phone an ambulance if it is an emergency.  
\(^e\) If positive in previous 6 months or if fully vaccinated and asymptomatic no testing or restriction of movements is advised  
\(^f\) The person is referred for specialised contact tracing if they are an inpatient in a hospital or are living in a congregated residential setting such as a nursing home or direct provision centre.  
\(^g\) If the person is a healthcare worker, they are asked to contact their line manager or occupational health department to inform them that they have has close contact with someone who has tested positive for COVID-19  
\(^h\) Active follow up is extended to 17 days in case of ongoing exposure, such as a household contacts
to release the first version of the CovidCare Tracker (CCT) in only 6 days. The CCT supports aspects of COVID-19 care by providing an end-to-end system of a person’s COVID journey. It links to multiple other systems to support efficient and robust data collection and management of COVID-19 cases and contacts. It links to SwiftQueue (HSE’s online appointment system) to schedule testing. It integrates with Twilio (company that send the SMS) to communicate all results and public health advice via SMS. Two web portals have been developed. Request a Test portal enables self-service receipt of public health advice and booking of tests for close contacts to compliment contact tracer delivered contact tracing in normal times but can be used to replace contact tracer calls if there is a large surge in cases, as occurred in December 2020. Trace your Contacts portal has been developed to replace call 1 and 2 as a contingency if the contact tracing programme becomes so overwhelmed that these calls cannot be made.

CMP identifies the business processes required, in collaboration with public health and other stakeholders. Such rapid pace of development inevitably led to a system that initially had minimal functionality and was ‘clunky’ to use. However, the CCT continues to evolve to both improve its user interface based on feedback, to implement new functionality including outbreak management and source investigation/retrospective contact tracing and to move to a more automated approach to contact tracing.

CCT is also used by all Departments of Public Health and allows flow of information and referrals to occur between CMP and departments. The CCT contact tracing module captures demographic details for cases, contacts, and case surveillance data, in close collaboration with the national surveillance centre, HPSC, which is used to inform national policy. CCT also captures data such as the number and timeliness of interventions.

Contact tracing centres (CTCs). The CMP communicates with thousands of contacts per day through physical and virtual (working from home) contact tracing centres. Contact tracers in each centre are supported by on site ‘supersusers’ (experts in using CCT) and clinical leads. Each centre has its own operations manager, and a national CTC operations team coordinates across the centres. Nine CTCs spread geographically across the country were established in wave one to conduct contact tracing. These volunteer centres were replaced by permanent centres with staff recruited into the roles after first wave of the pandemic.

Patient engagement. Patient and staff engagement methods and forums developed by the National Quality Improvement team in the preceding years are being conducted virtually during the pandemic and were used to capture patient and public feedback and perspectives on proposed changes. Engagement with patient groups shaped the direction of contact tracing and the language used in calls and text messages to ensure the wording was clear, understandable, and meeting the needs of cases and contacts.

National standardised process. The key foundation on which this national contact tracing programme was built was the ‘4 Step Contact Tracing Process’ (Table 1). This provided the blueprint on which all the teams worked, ensuring all activities were pointing in the same direction.

Measures

The key measures in four domains chosen to demonstrate outcomes of CMP for this study are coverage, timeliness, testing and training.

- **Coverage** refers to the proportion of all Irish cases contact traced through the CMP between March 17th 2020 and April 30th 2021. The number of cases recorded on the CCT was compared with data reported by the Health Protection and Surveillance Centre to determine 1) number and proportion of all cases of COVID-19 managed on CCT, 2) number of contacts managed by CTCs and by Departments of Public health using CCT.

- **Timeliness** refers to the time taken to complete the 3 types of CMP calls the maximum number of calls made to cases and contacts by the CMP on a single day between March 17th 2020 and April 30th 2021. Call timestamps from the CCT were used to calculate 1) time to complete calls 1, 2, and 3, and 2) time to complete contact tracing. The time taken to complete call 1 was defined as the time between case upload to the CCT and the case being marked as informed on the CCT and includes overnight hours. The time for call 2 was defined as the time between call 1 completion and the time that the contact tracing was recorded as complete for the case (call 2) and includes overnight hours. The time for call 3 was defined as the time between a close contact being captured on the CCT during call 2, and the time that the call to the contact was marked as complete and includes overnight hours. The time for contact tracing to be completed was defined as the time between a case being uploaded to the CCT and the time when their last close contact was informed and includes overnight hours.

- **Training** refers to the number of new contact tracers trained between March 2020 to March 2021. CMP Induction Evaluation Data was used to determine 1) number of people trained, 2) feedback from people trained.

Patient and public involvement

Patients or the public were not directly involved in the design, or conduct, or reporting, or dissemination plans of our study.

Analysis

Statistical analysis was performed using R (version 4.0.5). Descriptive statistics provided include the proportion of cases managed by CMP and the mean and median times taken for
calls to be completed with 95% confidence intervals. Line charts have been used to illustrate the results.

Ethical considerations
The processing of data for the purpose of surveillance, investigation, prevention, and control of infectious diseases including contact tracing is permitted under the Infectious Diseases Regulations, 1981. Case and contact information are treated as confidential information. Call handlers sign a confidentiality form, the CCT is accessed by secure log in, and Data Privacy Impact Assessments have been submitted and approved by the Data Protection Commissioner. The aggregated and anonymised data is published daily in epidemiology reports of COVID-19 in Ireland.

Results
In total, 246,666 positive cases have been recorded on the CCT between 17th March 2020 and 30th April 2021, with contact tracing successfully completed for 237,759 cases, representing 99% and 96%, respectively, of the 248,529 cases notified in Ireland up to the 30th April 2021. The other cases were managed by Departments of Public Health or Occupational Health Departments, outside the CMP process. There were 681,904 close contacts captured on the system between 17th March 2020 and 30th April 2021. The CCT also recorded 86,717 complex contacts or settings which were referred to Departments of Public Health for management. The busiest day for the CMP was 4th January 2021, with 7,518 calls made to cases to inform them of their diagnosis and collect details of their contacts (combined call 1&2). CMP coverage outcomes are presented in Figure 2. Timeliness outcomes are summarised in Figure 3. The average time taken to complete ‘call 1’ was 14.9 hours (95% confidence Interval [CI] 14.8, 15.0) and the median time was 5.9 hours (approximate 95% CI 5.6, 6.3). The average time taken to complete ‘call 2’ was 4.9 hours (95% CI 4.7, 5.1) and the median was 0.8 hours (approximate 95% CI 0.6, 0.9). The average time to complete ‘call 3’ was 6.9 hours (95% CI 6.8, 6.9) and the median was 1.0 hours (approximate 95% CI 0.9, 1.1). The average time taken for contact tracing to be completed was 29.4 hours (95% CI 28.9, 29.9) and the median was 16.8 hours (approximate 95% CI 15.9, 17.7). The difference in mean and median is largely impacted by cases entering the system at night-time when CTCs were not working.

The length of time taken to complete calls decreased during the first five months of the CCT’s lifespan as CMP efficiency increased and the number of cases and contacts decreased in line with the implementation of national restrictions. The rise in case and contacts numbers during the second surge in September and October was associated with an increase in time taken to complete calls. At the end of December 2020, Ireland experienced its third and by far largest wave with case numbers increasing tenfold in less than 2 weeks. Using the lessons learned from the second surge, the contact tracing process was rapidly adjusted. Call 1 and 2 were combined into one call and the Request a Test portal replaced call 3, until the point at which testing of close contacts had to be paused due to testing capacity. Throughout this surge, phone calls to cases, identification of contacts and communication via SMS of contact status was maintained.

A total number of 3,834 contact tracers were trained between March 2020 to March 2021. This excludes contact tracers who returned for refresher training. Initially the training was delivered face to face during the first phase of CMP induction.

![Figure 2](https://example.com/figure2.png)

**Figure 2.** Contact Management Programme (CMP) coverage (March 2020 - May 2021). Number of cases and close contacts managed through CMP.
Later, these sessions were offered remotely. Evaluation found that the contact tracers found the content, delivery, and design of the training informative, comprehensive, and beneficial. Majority of those trained found the programme to meet their expectations and felt well prepared to work in a CTC. The results are summarised in Figure 4. With the increasing complexity of calls, the education and training team now offer discussion sessions to contact tracers to consolidate learning and build confidence in the contact tracing workforce.

The demonstrate that the establishment of the CMP led to a drastic increase in the number and proportion of all cases of COVID-19 being managed centrally. This intervention enabled contact tracing to be undertaken by people with no previous experience in public health. Given the very small number of public health experts in Ireland prior to the pandemic, the CMP was responsible for allowing contact tracing to continue throughout the pandemic. In addition, CMP freed up the specialised experts within Departments of Public Health to undertake other complex COVID work. The PDSA approach has made the process scalable and to date, there have been 16 releases adding enhancements to improve the CMP process. Some other major enhancements include the introduction of a self-service booking portal and plans to introduce source investigation to identify and manage outbreaks more efficiently.

**Discussion**

This paper describes the establishment of the CMP, its core components, outcomes on key measures and learnings from the process. Across the world, government policies towards contact tracing vary greatly. Country responses to contact tracing can be categorised as no tracing, limited tracing, and comprehensive tracing. Ireland along with a few other countries such as China, Australia, Japan, conducted comprehensive contact tracing. The testing and tracing strategy of the Irish health system has proved successful in identifying cases of COVID-19. Through the application of a QI approach, a scalable contact tracing system was rapidly developed. In close collaboration with regional Departments of Public Health, the Contact Management Programme ensured that cases and contacts were appropriately managed in a streamlined and sustainable process. The work was fast paced with new structures, services and initiatives often introduced in a matter of days. Leadership and coordination were provided by National QI Team and National Women and Infants Health Programme, working with colleagues in Public Health and across the HSE and other agencies.
In the absence of collaboration and coordination with other areas, contact tracing efforts of public health alone may quickly overwhelm the team’s capacity. Collaboration across departments and coordination at the national level was an important aspect of this approach as well. Decisive leadership, a rapid response, good coordination, understanding the socio-economic and health dimensions of the population emerged as a key factor in determining success of COVID-19 pandemic response. The learning from the CMP aligns with this evidence as leadership and governance enabled rapid mobilisation of resources and empowered the teams.

For a meaningful impact, contact tracers need to be trained in not only script-based guidelines, clarifying signs, symptoms and public health advice but also soft skills such as patience and empathy. The CMP education and training team quickly trained a large number of contact tracers to assume this responsibility. Person engagement through different forums also contributed to the iterative improvement of scripts. This also supports the current evidence that suggests community engagement can be an important bottom-up approach in the COVID-19 response and its improvement. Optimising the coverage of testing, timeliness of tracing coverage, reducing tracing delays by using app-based technologies has a potential of preventing up to 80% of all transmission and enhances the effectiveness of contact tracing. The outcomes of the CMP show that CMP managed 96% of the contacts centrally and combined with other public health preventative measures, played a leading role in curbing transmission.

For contact tracing to be a valuable public health measure, the majority of the secondary cases need to be detected and isolated before they become infectious along with other public health control measures. The use of technology can facilitate the achievement of this target. Evidence suggests that countries more successful in managing the disease burden of COVID-19 quickly developed and deployed digital technologies to support pandemic management. In Asian countries including China, Taiwan, and South Korea, contact tracing apps proved to be effective in supporting the contact tracing processes. This was observed in the CMP as well where the CovidCare Tracker app served as an effective and scalable tool to connect the public with the CMP, greatly enhancing the capacity and speed of contact tracing. However, high-tech tools and digital contact tracing are not a replacement for contact tracing done by trained contact tracers. CMP also reflects this and is centred around the importance of trained contact tracers. This human aspect of the process has proved to be critical in ensuring people understand public health advice and gathering important feedback for process improvement. However, an implication of this human element of the contact tracing process is its resource intensiveness. One study predicts that every new case requires an average of 36 individuals to be traced which places huge burdens on public health departments.

The pandemic response to contact tracing has highlighted the efficacy of the QI approach in enabling rapid testing, measurement and multiple PDSAs leading to a more efficient ways of working. Using the QI approach strengthened the CMP by making it easily scalable, with each change being tested and evaluated and the learning assimilated in the process. The modelling of CMP on QI principles is a unique approach to pandemic management and may have potential for transferability to future pandemic planning.

Current evidence on the COVID-19 outbreak has established the importance of contact tracing in containing the virus and
curtailing widespread transmission and it is expected to play an important role in avoiding an increase in transmission when public health measures are deescalated. CMP along with supplementary public health measures has proven to be critical in achieving and maintaining epidemic control in Ireland and will also inform the knowledge base and preparedness for responding to any emergencies in future.

Strengths and limitations
The key strength of CMP is the people. People and teams with key skills were rapidly redeployed and recruited into different areas. These teams together with other HSE and non-HSE people, allowed for this function to be operational and make up to 5000 calls in a day in during the first wave. Another strength of the CMP is its ability to adapt and respond to the changing environment using QI methods. The key limiting factor in CMP was time. Time constraints led to low engagement with the eight regional Departments of Public Health initially. The lack of time to plan and test the IT system before each release meant that technical glitches went live which caused difficulties for users. Another challenge was the frequently changing requirements requiring implementation in days. Other limitations include the lack of availability of data from regional Departments of Public Health and the absence of a unique patient identifier which limits the ability to link datasets across Ireland.

Conclusion
Ireland is one of few countries to continue comprehensive contact tracing throughout the pandemic. Using the QI approach, the HSE successfully established and scaled up a Contact Management Programme that rapidly notified results to people and traced their close contacts. The integration between the CovidCare Tracker, the COVID Tracker Ireland app, Self-Service Portals and automated SMS has led to further optimisation of contact tracing. CMP contributed to the success of the Irish health service in containing the three waves of the COVID-19 pandemic. A bespoke IT system and standardised training and support allowed for non-public health staff across the country to effectively undertake a task here to fore undertaken by public health staff under direct Public Health Physician supervision. The approach, processes and tools used in this national programme can provide direction to other countries wishing to implement a similar programme.

Data availability
The data used in this study cannot be shared publicly due to data protection concerns. Even after de-identification, some data may still be identifiable particularly during periods with low case numbers. However, the data can be accessed directly through the Central Statistics Office’s (CSO’s) COVID-19 Data Research Hub. The researchers requesting data should contact the CSO researcher liaison via email (c19researchinfo@cso.ie). More details on the process are available here.

Acknowledgments
We thank all our colleagues who have contributed to contact tracing and the design of a national contact tracing programme, whether redeployed, volunteered and more recently employed for their work in contact tracing; whether working in contact tracing centres, Departments of Public Health or in the CMP national management and design teams.

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Overall, the manuscript provides valuable insights into the establishment and implementation of the Contact Management Programme (CMP) in Ireland during the COVID-19 pandemic. The authors have effectively described the core components of the CMP, its outcomes on key measures, and the learnings from its implementation. The manuscript analyses the coverage, timeliness, and training aspects of the CMP. However, a few areas could be further improved to enhance the manuscript's quality and readability. Below are my suggestions:

General suggestions for the abstract:
○ Ensure that the abstract is concise and focuses on the key findings and implications of the study.

○ Avoid using approximate confidence intervals in the abstract.

○ Consider incorporating specific details about the learnings from the processes mentioned in the background, which could enhance the manuscript's relevance and applicability.

Introduction:
The introduction provides an overview of the COVID-19 pandemic and its impact on healthcare systems, specifically highlighting the situation in Ireland. To align the study period with the COVID-19 situation and provide a contextual introduction, you can consider making the following revisions to the manuscript:

○ Suggest beginning the manuscript by providing a brief overview of the global COVID-19 pandemic, emphasising the period from March 2020 to April 2021 as the study period. Highlight key events or milestones during this timeframe that influenced the public health response to the pandemic, such as the declaration of a pandemic by the World Health Organization, the implementation of various control measures, and the emergence of new variants.

○ Provide a clearer context: The manuscript could benefit from a more concise and explicit introduction that sets the stage for the relevance and significance of the CMP:
Describe the scale and impact of the COVID-19 crisis during the study period. Include relevant statistics such as the number of confirmed cases, hospitalisations, and deaths in the study area or country.

Clearly articulate the unique challenges faced during the COVID-19 pandemic, such as surges in cases, overwhelmed healthcare systems, or changes in public health strategies.

Highlight the need for an effective contact tracing and management program and the gaps in existing strategies that the CMP aimed to address. This will help readers better understand the specific problem the CMP was designed to solve.

By incorporating the COVID-19 context and magnitude of the crisis into the introduction, you will set the stage for the study and provide a comprehensive understanding of the circumstances under which the Contact Management Programme was implemented.

**Methodology and implementation details:**

- The manuscript briefly mentions using a Quality Improvement (QI) approach and developing a web-based Contact Tracing IT system (CovidCare Tracker). However, more in-depth explanations of the QI methodology, including specific tools and techniques, would enhance the manuscript's rigour. Suggest elaborating on how the QI approach facilitated the iterative development and continuous improvement of the CMP and how it contributed to the successful implementation of the program.

- Similarly, providing additional details about the development and implementation of the CovidCare Tracker and its apps, its functionalities, and integration with existing systems would be beneficial because the contribution of these information technology systems is emphasised in conclusion (consider including this information as supplementary materials).

- Expand on the health systems perspective: It would be beneficial to provide a more detailed discussion on the impact of the CMP on the overall health system in Ireland. This information could include insights into how the CMP has improved coordination between departments, optimised resource allocation, and enhanced the overall efficiency and effectiveness of the contact tracing process.

- Strengthen the discussion on data privacy and ethics: Given the sensitive nature of contact tracing and handling personal health information, it is crucial to address the ethical considerations and privacy safeguards in place during the implementation of the CMP. Discuss the measures taken to protect patient confidentiality and ensure compliance with data protection regulations. Additionally, mention any feedback or concerns raised by patients regarding data privacy and how these were addressed.

- To further enhance the manuscript from health systems and quality improvement perspective, it would be valuable to include information about the contact tracers themselves. Here are some suggestions for additional details you could consider adding and highlight the changes that took place based on challenges faced throughout the pandemic (consider including as supplementary material):
  - Recruitment process
Training program: Highlight the collaboration with public health physicians, educationalists, and quality improvement facilitators in designing and delivering the training.

Staffing and capacity: Discuss how the recruitment process was managed to ensure adequate contact tracers to handle the volume of cases and contacts. Mention any challenges faced in terms of staffing and how they were addressed.

Roles and responsibilities: Explain the roles and responsibilities of contact tracers within the CMP. Detail their specific tasks, such as making calls to cases and contacts, providing information and guidance, documenting interactions, and escalating complex cases to public health departments.

Support and supervision: Discuss the support mechanisms in place for contact tracers. Describe the role of on-site “superusers” who provided guidance and assistance and the involvement of clinical leads. Highlight any regular supervision or debriefing sessions conducted to ensure the well-being and effectiveness of contact tracers.

Collaboration and communication: Emphasise the importance of collaboration and communication among contact tracers, public health departments, and other stakeholders. Describe how contact tracers interacted with other healthcare professionals, public health officials, and the IT team responsible for developing and maintaining the contact tracing system.

Including these details about the contact tracers will provide a comprehensive understanding of the human resources involved in the CMP and highlight the importance of their role in achieving the desired outcomes.

**Results.** To improve clarity and address important considerations in the results section, you can consider the following suggestions:

- Clarify percentages: Instead of using “99%” and “96%” without context, provide more specific information to enhance clarity. For example, you can specify that “99% of cases were notified within x days” or “96% of cases had contact tracing done for follow-up within x days”. By adding the relevant timeframe and outcome, readers will have a better understanding of the results.

- Reporting the average number of contacts per case (coverage): It is a valuable metric for understanding the extent of contact tracing efforts. Reporting this measure can provide insights into the workload and resource requirements for contact tracers and the potential impact on disease transmission.

- Based on the statement that “the difference in mean and the median is largely impacted by cases entering the system at night-time when contact tracing centres (CTCs) were not working”, conducting a subgroup analysis of cases that came in before and after operating hours would be a valuable approach to explore this issue further. This subgroup analysis would help determine whether the difference in mean and median times is indeed influenced by cases reported during non-operating hours. It could also shed light on the potential need for expanded or adjusted operating hours to ensure prompt contact tracing.
and response, regardless of when cases are reported.

- Explain the change in the case definition of case-contact: Figure 2 suggests a potential change in the case definition of case-contact. Discuss any updates or modifications in the criteria used to identify and classify cases and contacts that may have occurred after August 2020. This will help readers interpret the trends in case-to-contact ratios over time.

- Missing confidence intervals and disjointed line graph (Figure 3): Mention missing data as a disjointed line graph and discuss any potential impact this may have on interpreting the findings.

- Define complex COVID-19 work: Provide a clear description of what is meant by “complex COVID-19 work” in the context of the study. Explain the specific tasks, challenges, or scenarios that are considered complex. Additionally, it would be beneficial to provide more detailed findings/discussions on the impact of the CMP on the overall health system in Ireland. This could include insights into how the CMP has improved coordination between departments, optimised resource allocation, and enhanced the overall efficiency and effectiveness of the contact tracing process.

- By incorporating these revisions, the Results section will provide a more comprehensive and understandable presentation of the study findings, addressing important considerations and providing clear explanations where needed.

Discussion:

- Include a discussion on challenges and limitations: While the manuscript focuses on the successes and outcomes of the CMP, it would be valuable to acknowledge and discuss the challenges encountered during its establishment and implementation. Addressing potential limitations, such as resource constraints, scalability issues, or data privacy concerns, will provide a more comprehensive picture of the program's effectiveness and inform future improvements.

- Discuss the transferability (or generalisability) of findings: To enhance the manuscript's impact, consider discussing the CMP's transferability and findings beyond the specific national context. Reflect on the potential applicability of the CMP framework, QI methodologies, and technology-enabled contact tracing to other countries or regions facing similar public health emergencies. This will broaden the manuscript's relevance and increase its potential for wider adoption.

Strengthen the conclusion and implications:

The manuscript's conclusion could be strengthened by concisely summarising the key findings and their implications. Emphasise the practical lessons learned from the CMP and how they can inform policy decisions, public health interventions, and healthcare system improvements in post-pandemic scenarios. Consider also discussing future directions for research or potential areas for further exploration based on the insights gained.

In conclusion, the manuscript provides a valuable account of the establishment and evaluation of a National Contact Management Programme during the COVID-19 pandemic. Addressing the suggested areas for improvement, particularly in providing a clearer context, expanding on methodology and implementation details, discussing challenges and limitations, considering transferability, and strengthening the conclusion, will enhance the manuscript's impact and make
it more valuable to a broad audience.

Overall, I commend the authors for their contributions and recommend this manuscript for indexing with the suggested revisions.

**Is the work clearly and accurately presented and does it cite the current literature?**
Partly

**Is the study design appropriate and is the work technically sound?**
Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**
Partly

**If applicable, is the statistical analysis and its interpretation appropriate?**
Yes

**Are all the source data underlying the results available to ensure full reproducibility?**
No source data required

**Are the conclusions drawn adequately supported by the results?**
Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Health systems, resilience, case study

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 23 May 2023

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Editorial Note from HRB Open Research - 25th May 2023: An earlier text of this report was published in error. The text has now been updated.
Generally, this is a well written report describing the general procedures and the evolution of some key performance indicators of a national contact tracing program for COVID-19. We would like to congratulate everyone involved in the program for their efforts, and the authors for investing the time to write up lessons learnt.

One does get the feeling that the report was either written a long time ago, or did not include the most recent literature. This needn’t be a problem if it is clearly stated that it describes experiences up until a certain point.

Also, it makes a few statements which we consider too strong, and suggest softening/nuancing (see below).

Lastly, information on what exactly the training of tracers entailed, and how exactly these tracers experienced that training is not clearly reported. We would appreciate more details there. If these materials are not confidential, they could be added as Supplementary Information, which would be a useful resource for public health officials in the future.

Some specific, and generally minor comments per section:

GENERAL
- I suggest to use the past tense in the introduction, methods and results.

INTRODUCTION
- "In most situations, efficient contact tracing and case isolation can significantly control a new outbreak of COVID-19 within 3 months**: I suggest specifying that "Early modelling studies suggested that ..."

- " In addition to this, digital contact tracing through apps allows for instant notifications and has the potential to reduce the number of cases using finite resources**: suggest leaving this sentence out or specifying more clearly what exactly is meant by digital contact tracing: sending results, alerting contacts or digital proximity tracing using the google apple exposure notification framework? It also sounds odd to speak of the potential of digital contact tracing, rather than its merits and limitations, 3 years after large scale rollouts for COVID-19.

METHODS
- Suggest to add or refer to the definition of a contact, and the contact tracing window.
- Please describe the method used to obtain confidence intervals for timeliness, as reported in Results.

RESULTS
- I don’t understand the 99% and 96% numbers. Were 99% of the registered cases uploaded into CCT? Or were 99% of the cases registered in CCT successfully traced? Were 96% of the contacts successfully traced? Does that mean sending a message, a successful phone call or something else?

- Figure 2 is described as showing the coverage of CMP. However, it reports absolute numbers of cases and contacts. A better measure of coverage over time would be the changing proportion of reported cases recorded on CCT.
I suggest adding the average number of contacts per case (and to fig 2), as a crude marker of whether the population was generally collaborative with contact tracing and whether restrictions altered contact patterns. If you have individual level data, it would be great to also add the fraction of cases reporting at least 1 contact, as marker of active participation.

There seems to be a mistake in the dates of fig 2, as they jump from 6-9-20 to 13-9-21.

In figure 3, some error bars and data points seem to be missing for no obvious reason. Please describe why this is the case in the legend. If there are missing datapoints (for example, unknown delays for some cases), the way they were handled and reported should be described in Methods.

“The difference in mean and median is largely impacted by cases entering the system at night-time when CTCs were not working.” Is this supported by your data, or is it an interpretation, perhaps to be moved to the Discussion section?

“... the Request a Test portal replaced call 3...”: does this mean that the timing of using this portal was reported as the timing of call 3 for these contacts?

Fig 4 only shows the number of contact tracers trained, not how they evaluated the training, as it is referenced in the text. Suggest adding aggregate responses to that figure or a supplementary file for completeness. It would also be great to add training materials as SI as a resource for colleagues in future emergencies.

“The demonstrate that the establishment...”: I guess this is a typo which could be “The results demonstrate that the establishment...”

“... a drastic increase in the number and proportion of all cases of COVID-19 being managed centrally”: From my understanding, no data are reported on the proportion of cases managed centrally before or in the early stages of CMP. Therefore, the current results to me demonstrate a high number and a high proportion, rather than an increase relative to a baseline.

"plans to introduce source investigation to identify and manage outbreaks more efficiently": does this relate to COVID-19 or other pathogens? If COVID-19, this is probably outdates?

DISCUSSION

“Ireland along with a few other countries such as China, Australia, Japan, conducted comprehensive contact tracing"14": I don't see from this manuscript or from other sources (e.g https://ourworldindata.org/covid-testing-contact-tracing) that Ireland conducted particularly comprehensive contact tracing along with this small list of other countries. You could write "Ireland was one of many countries investing heavily in comprehensive contact tracing, along with notable example such as China, Australia and Japan " or similar?

“The testing and tracing strategy of the Irish health system has proved successful in identifying cases of COVID-1915": this is a broad, non-specific statement (what does success mean in this context?), which is not supported by an assessment of case identification/under-ascertainment.
The previous two sentences could just be deleted to focus on the QI part.

"In the absence of collaboration and coordination with other areas, contact tracing efforts of public health alone may quickly overwhelm the team's capacity." By focusing explicitly on coordination, this statement seems to ignore many other factors that can lead to an overwhelmed tracing system (transmissible variants, high contact rates, low compliance by the population etc). Suggest softening the statement, for example "coordination with other areas can be expected to contribute to a contact tracing operation not becoming overwhelmed".

"by using app-based technologies has a potential of preventing up to 80% of all transmission and enhances the effectiveness of contact tracing": this again feels odd to talk about potential and invites questions on exactly what is meant. Suggest at least nuancing with "as per early modelling studies" or similar.

"played a leading role in curbing transmission": suggest nuancing, e.g. "is likely to have played an important role in curbing transmission" as no formal assessment of this question present in the manuscript (e.g. influence on Reff/counterfactual analysis).

"The modelling of CMP on QI principles is a unique approach to pandemic management": this is quite a strong statement. Most public health organisations (hopefully) went through improvement cycles. Suggest nuancing, e.g. "The modelling of CMP on QI principles may have potential for transferability to future pandemic planning."

"Current evidence on the COVID-19 outbreak has established the importance of contact tracing in containing the virus and curtailing widespread transmission and it is expected to play an important role in avoiding an increase in transmission when public health measures are deescalated." seems a bit outdated in the current context.

CONCLUSION:

"Ireland is one of few countries to continue comprehensive contact tracing throughout the pandemic." This statement seems too strong, see above.

All the best to the authors and congratulations for your CT operation.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Public health, epidemiology, clinical medicine.

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.

Reviewer Report 23 May 2023
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Virginia Zweigenthal
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This is an interesting and useful report on the development and outputs of the Irish case and contact tracing system over the Covid-19 pandemic. It demonstrates that leadership at a national level engaged with and recruited skilled personnel to develop the programme which was then modified over time using quality improvement methodology. It demonstrates excellent and timely coverage and training of staff, while also indicating complexities encountered.

Some specific questions:
1. It would be useful to hear how they see that this initiative contained the epidemic in view of SARS-CoV-2 being aerosolly transmitted. What is the counterfactual in the Irish setting? Was the contact tracing part of the C&CT in retrospect seen as having impact?

2. How did they manage complex cases - those who were deteriorating; contacts of deceased cases (did these flag in their system?).

3. What proportions of contacts later became cases?

4. Initially contact tracers were volunteers? Who were these volunteers? Later they were employed? What were the pre-requisites to become a contact tracer?

5. Mention was made that there were no unique patient identifiers? Does this mean that the system could not engage with the patient information systems? How could one then determine the outcome (deaths, recovery) of cases? Do the authors have recommendations about this?
6. The introduction is phrased in the present tense. It should be in the past tense (as no longer a threat of international concern).

7. The timeliness paragraph in methods: There is much repetition. Could this be made more succinct.

8. Figure 3. There are CIs for some of the points but not for all. Can this be rectified.

9. Finally, are some of the tools developed available for dissemination? This may be useful for other country settings who struggled to get a contact tracing system up and running, particularly as this system used a QI approach which would make it useful for other country settings. Any recommendations to the WHO?

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
No

Are the conclusions drawn adequately supported by the results?
Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Public health medicine. I worked in the South African Case and contact tracing system. Areas of research include public health education.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 08 December 2022

https://doi.org/10.21956/hrbopenres.14702.r32832
This is a qualitative case study on the impact of quality improvement on contact tracing program of Ireland. The paper presents details of the Ireland's contact management program and its quality improvement measures and efforts. While it presents a large amount details on how the QI works, I don't see how each components of QI actually are limited to the improved outcomes. For instance, it writes:

"The learning from the CMP aligns with this evidence as leadership and governance enabled rapid mobilisation of resources and empowered the teams."

Without comparing such practice with some other practices, it is difficult to attribute the improvements to these factors. In other words, the causal relationship is not well established.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
No source data required

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Health Policy, Public Health, Public Administration, Public Policy, Comparative public policy and administration

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.