Original Article

Journal of Infection Prevention

Journal of Infection Prevention
2022, Vol. 23(5): 228–234

DOI: 10.1177/17571774221107754
jip.sagepub.com
SAGE

COVID-19 contact tracing in the hospitals located in the North Denmark region: A retrospective review

Dorte Fromberg[1], Nina Ank[1] and Hans L Nielsen[2]

Abstract

Background: The Department of Infection Control, at our University Hospital conducted contact tracing of COVID-19 positive patients and staff members at all hospitals in the North Denmark Region.

Aim: To describe the contact tracing performed during the COVID-19 pandemic in the Region and its outcomes.

Methods: Data from each contact tracing were collected prospectively during 14 May 2020–26 May 2021. Data included information about the index case (patient or hospital staff member), presentation (asymptomatic vs symptomatic), probable source of transmission (community-acquired or hospital-acquired), number of close contacts and if any of these were SARS-CoV-2 PCR-test positive.

Findings: 362 contact tracing were performed. A total of 573 COVID-19 positive cases were identified among 171 (30%) patients and 402 (70%) staff members. 192 (34%) of all cases were tested due to symptoms of COVID-19, whereas two-third were tested for other reasons including outbreak and systematic screening tests. A total of 1575 close contacts were identified, including 225 (14%) patients and 1350 (86%) staff members. 100 (6%) close contacts, including 24 patients and 76 staff members, were infected with SARS-CoV-2, of which 33 (43%) staff members was positive at day 0 i.e. the same day as being identified as close contacts.

Discussion: We found a three to one of close contacts to each index case, but only 6% became SARS-CoV-2 positive, with a surprisingly high number of those identified at day 0. Our data confirm that regular testing of patients and staff will identify asymptomatic carriers and thereby prevent new cases.

Keywords

The COVID-19 pandemic, SARS-CoV-2, coronavirus, contact tracing, close contacts, infection control

Date received: 26 October 2021; accepted: 30 May 2022

Background

Contact tracing (CT) is of major importance in order to prevent spread of Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) in a hospital setting (WHO, 2021a). SARS-CoV-2 spreads between people in several different ways including via respiratory infectious particles from infected persons when they cough, sneeze, speak or breathe and are in close contact with other people (WHO, 2021b).

Studies have shown that healthcare professionals have higher levels of COVID-19 antibodies in contrast to the general population, and staff employed in clinical wards had higher titres than staff working in non-clinical wards (Iversen et al., 2020; Varona et al., 2021). Rapid identification of SARS-CoV-2 positive patients and hospital staff members have been shown to reduce transmission of SARS-CoV-2 and limit the number of new COVID-19 cases in the hospital setting (Keeling et al., 2020; Kucharski et al., 2020; Schneider et al., 2020).

The Danish Health Authority was responsible for the Danish COVID-19 strategy based on international recommendations (ECDC, 2020, Sundhedsstyrelsen, 2020, WHO, 2021a). This also included CT at the Danish Hospitals, to

[1]Department of Clinical Microbiology, Aalborg University Hospital, Aalborg, Denmark.
[2]Department of Clinical Medicine, Aalborg University, Aalborg, Denmark.

Corresponding author:
Hans L Nielsen, Department of Clinical Microbiology, Aalborg University Hospital, Hobrovej 189000 Aalborg, Denmark.
Email: halin@rn.dk

limit transmission of SARS-CoV-2 and reduce the disease burden and pressure on the Danish healthcare system. By May 2020, to maintain the pandemic under control, the Danish Health Authority recommended systematic CT and quarantine of close contacts (CC) to COVID-19 cases, both in the healthcare system and in the community (Sundhedsstyrelsen, 2020c).

In the North Denmark Region, CT at the hospitals was performed by the Department of Infection Control, located at our University Hospital. This included forward contact tracing (FCT) by identifying and isolating all patients and staff members the SARS-CoV-2 positive index cases could have passed the virus on to, and backwards contact tracing (BCT) trying to identify the potential source of infection (Bradshaw et al., 2021; ECDC, 2020).

The aim of this study was to describe the CT programme in the hospital setting and describe numbers of CC and whether any of these were subsequently tested positive for SARS-CoV-2, and we wanted to assess the value of BCT and the implementation of an immediate day 0 test of CC.

Methods

Demographics and study period

The North Denmark Region is the smallest of the five Danish Regions with 590,403 inhabitants. The three main Hospitals (on 11 sites) in the Region have a total of 1348 beds with approx. 13,350 employees (including employees paid by the hour), representing practically all medical specialities. The study period was from 5 May 2020 to 26 May 2021.

Definition of index case and additional cases

An index case was defined as the first patient or staff member with a positive PCR-test for SARS-CoV-2. Additional cases (patients and/or staff member) were SARS-CoV-2 positive cases linked in 'time and place' to the index case, but did not meet the definition of a CC (see below).

Definition of close contacts

Close contacts were defined in accordance with the guidelines given by The Danish Health Authority (Sundhedsstyrelsen, 2020c). In brief, for hospitals a CC was defined as a person having had physical contact with a COVID-19 case (index or additional), having had direct contact with infectious secretions of a COVID-19 case, or being within 1 m (2 m from 19 January 2021) of a COVID-19 case for more than 15 min. Healthcare workers and others (e.g. porters, laboratory technicians) who had participated in the care of a patient with COVID-19 and who had not used personal protective equipment (gloves, gown, face mask and eye protection) as recommended were defined as CC. However, by 22 January 2021 healthcare workers who wore a face mask without eye protection in the close contact was not defined as CC but as low risk contact (LRC) if COVID-19 had not been suspected at the time of contact (Sundhedsstyrelsen, 2020d). Both CC and LRC were tested on day four and day six after last exposure to the index case, but CC only were quarantined immediately after they were identified. The quarantine was terminated with a negative SARS-CoV-2 PCR-test on day four (day six from 19 January 2021) after last exposure.

Contact tracing, outbreak and systematic testing

For every single index case, a CT was performed, see Supplemental Figure 1. All CT was documented in a separate case report form (CRF) by an infection control nurse. Hospitalized patients who were SARS-CoV-2 positive after admission and as such were not isolated upon admission were included, whereas no CT was performed if a patient was hospitalized due to COVID-19 and immediately isolated upon the admission. Both index and additional cases followed the same isolation precautions at the hospital (or self-isolation if discharged) and each were given a unique identification number in the CRF.

Outbreak testing was performed as part of the BCT with SARS-CoV-2 PCR-testing of all CC at day 0 (i.e. the same day the index case was identified) and by testing all other patients and staff members on the ward at day 0. However, outbreak testing and test of CC at day 0 was not performed if the index case had been exposed to COVID-19 away from their workplace or in the community. Outbreak testing continued with an interval of 7 days if additional cases were identified or any CC tested positive.

Systematic screening tests of health care staff working at departments with vulnerable patients was recommended from July 2020, as part of a nation-wide recommendation, and from 3 February 2021 systematic testing of all hospital employees was performed once a week.

Source of transmission

For all index and additional cases, the most likely source of transmission was critically evaluated by the infection control nurse and categorized into four: community-acquired (CA), e.g. being exposed away from the hospital (workplace), hospital-acquired (HA) (patients only), work-related (hospital employees only) or unknown. An outbreak was defined as two or more cases assessed to be connected in 'time and place' or if a CC tested positive for SARS-CoV-2 (Sundhedsstyrelsen, 2020c).

Data collection and presentation

For the full overview of the data sources, see Supplemental Table 1. Data for number of PCR-tests performed in Denmark, number of positive PCR-tests, number of hospitalized COVID-19 patients was obtained from the national reference laboratory Statens Serum Institut (available online; www.ssi.dk/covid19data).

Data from all CT reports were manually entered in a spreadsheet including reason for testing (e.g. screening at admission, symptoms at the time of testing) and status at the time of contact tracing (symptomatic, asymptomatic or unknown).

Contact tracing with or without any CC were compared and for significant variables prevalence ratios (PR), including 95% confidence interval (CI), were calculated to

highlight certain characteristic between groups. CT with CC were further divided in to two groups with those who had negative or positive test for SARS-CoV-2, respectively. No ethical approval was needed as all data were fully anonymized due to the General Data Protection Regulation (GDPR) without any personally identifiable data.

Results

Contact tracing in the hospitals in the North Denmark region

A total of 362 index cases was identified during the study period, and for every single index case a CT was performed. Two-hundred-twenty-one additional cases were identified, giving a total of 573 cases among 171 (30%) patients and 402 (70%) staff members.

For hospitalized patients the probable source of transmission was CA for 89 (52%), HA for 46 (27%) and unknown for 36 (21%), respectively. For staff members, the probable source of transmission was CA for 96 (24%), work-related for 48 (12%) and unknown for 258 (64%), respectively.

Please see, the Supplemental Figure 2 for the number of SARS-CoV-2 tests being performed, number of positive individuals, number of hospitalized patients and CT being performed during the study period in the North Denmark Region.

Reasons for SARS-CoV-2 PCR-tests

All the 573 cases were identified by numerous different reasons for getting a SARS-CoV-2 PCR-test, see Table 1. Twenty-five (14.6%) patients and 167 (41.5%) staff members had symptoms of COVID-19 at the time CT was performed. Sixty-three (36.8%) patients were positive by screening at the hospital admission, and 37 (21.6%) patients and 79 (19.7%) staff members were identified by the outbreak testing, respectively. Fifty-seven (14.2%) staff members and one patient (0.6%) were identified by systematic screening testing, respectively. Finally, 10 (5.9%) patients and 50 (12.4%) staff members were tested positive as they had been CC to a COVID-19 contagious person outside the hospital setting.

Number of close contacts and low risk contacts

A total of 1575 CC was identified, including 225 (14%) patients and 1350 (86%) staff members. They were equally distributed between the three main hospitals relative to number of hospital beds and hospital staff (data not shown). One-hundred (6.3%) CC was COVID-19 positive, including 24 patients and 76 staff members. Quite surprisingly, 33 (43%) staff members were test-positive in the BCT with a positive test at day 0, whereas 32, four and seven of the staff members were tested positive at day 4, 6 and 7–10, respectively. In total, 173 LRC were identified (all staff members), of which five (3%) were positive for SARS-CoV-2 (the exact day for the positive testing were missing).

Contact tracing with or without close contacts

Overall, the 362 CT reports could be divided into five groups; (I) CT with no CC (n = 120), (II) CT with one or more CC (n = 171), (III) CT with additional cases but no CC (n = 9), IV) CT with additional cases and CC (n = 24), and V) CT with additional cases with SARS-CoV-2 positive CC (n = 38), see Supplemental Table 2.

We compared the characteristics of 129 (36%) CT without CC and 233 (64%) with CC, and calculated prevalence ratio (PR) with 95% confidence interval (CI) for relevant variables, see Table 2, left columns. The 171 patients were distributed with 26 in the group without CC and 145 in the group with CC, while the distribution of the 402 staff members was higher in the group without CC.

Comparing the two groups regarding reasons for COVID-19 testing, there was a higher proportion of individuals in the CT without CC who were tested as 'close contact community' PR 1.95 (95% CI; 1.40–2.72), and by systematic screening test PR 1.66 (95% CI; 1.15–2.39) compared to individuals in the CT with CC. In contrast, there was only four persons tested positive in outbreak tests in the CT without CC, compared to 112 persons in the CT with CC. Both 'symptoms of COVID-19', and 'screening at hospital admission' as reason for tests were equally distributed in the two groups.

At time of CT, the relative number of symptomatic and asymptomatic individuals was evenly distributed between the two CT groups. A relative high number of COVID-19 infections was categorized as CA in CT without CC (PR 2.04 (95% CI; 1.54–2.7) compared to CT with CC. For the CT without CC there were only 4/140 (3%) cases where the transmission was located to the hospital, whereas CT with CC had a significant higher proportion of HA and work-related cases.

Contact tracing with test-negative versus test-positive close contacts

The 233 CT with CC could be separated into 195 (84%) and 38 (16%) SARS-CoV-2 PCR test-negatives and positives CC, including 272 and 161 cases, respectively, see Table 2, right columns. Overall, there was an even distribution of patients and staff members between the two group. Overall, almost half of the cases (48%) in the CT with test-positive CC were identified due to outbreak testing, whereas 12% of cases in the CT with test-negative CC were identified due to systematic screening testing.

Interestingly, 84 (52%) cases in the group of CT with test-positive CC was categorized as asymptomatic, whereas 109 (40%) of cases were asymptomatic in the CT with negative

Table 1. The different reasons for SARS-CoV-2 testing are listed for patients and staff members included in the 362 contact tracing reports.

	Patients (n = 171)	Staff members (n = 402)
Symptoms	25 (14.6%)	167 (41.5%)
Close contact community	10 (5.9%)	50 (12.4%)
Outbreak test	37 (21.6%)	79 (19.7%)
Systematic screening test	1 (0.6%)	57 (14.2%)
Random find*	1 (0.6%)	27 (6.7%)
Unknown	14 (8.2%)	13 (3.2%)
Screening at hospital admission	63 (36.8%)	
Intra/interhospital transfer	4 (2.3%)	
Screened at return to hospital after home leave	2 (1.2%)	
Discharge to nursing home	12 (7.0%)	
Test at nursing home	2 (1.2%)	
Close contact–work		3 (0.8%)
Low risk contact		5 (1.2%)
Contact tracing APP		1 (0.3%)

*Where the patient or staff had been tested predominantly for safety reasons.

CC. However, 35 individuals in the CT with test-negative CC were categorized as 'unknown' due to missing data, so this may have influenced the proportion as some of them might have been asymptomatic also.

Finally, the source of transmission was unknown for half of the cases in both groups. For the remaining half there was higher relative number of CA cases and lower HA cases in the CT with test-negative CC.

Discussion

This is the first major retrospective review of the CT carried out in the North Denmark Region. All 362 CT were performed according to the national guidelines by an infection control nurse, and a total of 573 COVID-19 positive cases were identified. Only one-third of all cases were identified due to symptoms of COVID-19, whereas two-thirds were tested for other reasons including screening at admission and outbreak and systematic screenings test. The probable source of transmission was CA for half of the patients, whereas for staff members the source of infection was unclear in almost two-thirds of the cases. A total of 1575 CC were identified, a seventh consisting of patients and the majority of hospital staff. We found a relative high number of CC to each index case (3:1), but 6% only became subsequently SARS-CoV-2 positive.

In Denmark, the responsibility for infection control is mainly organized at each hospital by local infection control nurses and clinical microbiologists (Kolmos, 2001). However, the department of infection control in the North Denmark Region is organized as a single unit with a regional function at all hospitals in the region, and to our knowledge the department was involved in all CT and data were collected systematically in every report.

The risk for patients and staff to become infected with SARS-CoV-2 depended on the risk of exposure and obviously linked to the total prevalence of infected individuals in Denmark. Our data showed that CT with CC had a significantly higher proportion of hospital-acquired cases. There were several reasons why the 573 COVID-19 cases were tested. About one-third of the cases were tested because they had symptoms. Sixty-three patients were hospitalized for other reasons than COVID-19 and therefore not isolated at first. However, they were later test-positive in screening test taken at hospital admission, and these patients posed a risk of COVID-19 transmission at the wards, especially in the first hours or days during hospitalization until the positive test result was available.

By outbreak testing 116 cases were identified, of which 68% were staff members. The nation-wide recommended systematic screening test of employees resulted in identification of 57 cases. In February 2021, the systematic testing of staff members became more consistent, when the strategy changed to testing once a week. On the other hand, there was no recommendation for systematic testing of staff 14 days after they were fully vaccinated. Therefore, the number of

Table 2. Overview of the 362 COVID-19 contact tracing (CT) in The North Denmark Region. CT without any close contacts (CC) are presented (n = 129) to the left and compared to CT with CC (n = 233) to the right. Prevalence ratio (PR), including a 95% confidence interval (CI) are presented, where relevant, with CT without any CC as reference. To the right, CT with CC are presented in those with negative (n = 195) and positive COVID-19 tests (n = 38), respectively, with CT with test-negative CC as reference.

	CT without any CC (n = 129)	CT with CC (n = 233)	PR (95% CI)	CT with test-negative CC (n = 195)	CT with test-positive CC (n = 38)	PR (95% CI)
Cases	140	433		272	161	
Patients	26	145	0.54 (0.36–0.79	89	56	0.97 (0.83–1.13)
Staff members	114	288	1.87 (1.27–2.75)	183	105	1.04 (0.89–1.21)
Reasons for testing						
Symptoms	48	144	1.04 (0.76–1.40)	94	50	1.06 (0.91–1.23)
Close contact community	26	34	1.95 (1.40–2.72)	29	5	1.4 (1.19–1.64)
Outbreak test	4	112	0.2 (0.04 0.31)	34	78	0.41 (0.31–0.55)
Systematic test	22	36	1.66 (1.15–2.39)	33	3	1.52 (1.34–1.73)
Random find[a]	8	20	1.8 (0.64–2.16)	18	2	1.46 (1.24–1.73)
Unknown	17	10	2.79 (2.01–3.88)	8	2	—
Screening at hospital admission	11	52	0.69 (0.40–1.21)	43	9	1.38 (1.19–1.6)
Intra/interhospital transfer	0	4	—	3	1	—
Screened at return to hospital after home leave	0	2	—	1	1	—
Discharge to nursing home	1	11	—	7	4	—
Close contact–work	0	3	—	2	1	—
Low risk contact	0	5	—	0	5	—
Contact tracing APP	1	0	—	0	0	—
Test at nursing home[b]	2	0	—	0	0	—
Status at the time of contact tracing						
Symptoms	59	200	0.88 (0.66–1.18)	128	72	1.04 (0.9–1.2)
Asymptomatic	63	193	1.01 (0.76–1.35)	109	84	0.83 (0.71–0.97)
Unknown	18	40	1.31 (0.87–1.98)	35	5	1.45 (1.26–1.67)
Geographical location for transmission						
Community	69	116	2.04 (1.54–2.7)	103	13	1.67 (1.48–1.89)
Hospital (patients only)	1	44	0.084 (0.012–0.59)	18	26	0.63 (0.44–0.9)
Work at hospital (staff only)[c]	3	46	0.23 (0.078–0.71)	10	36	0.32 (0.18–0.56)
Unknown	67	227	0.91 (0.75–1.1)	141	86	0.98 (0.85–1.13)

[a]Where the patient or staff had been tested predominantly for safety reasons.
[b]People sting at a nursing home and tested there, who had hospital contact led to contract tracing at the hospital.
[c]A patient was employed at the hospital, the source of transmission was assessed to be at the workplace.

employees tested regularly may have decreased during the end of Spring (2021) as more staff became fully vaccinated.

The 225 patients identified as CC were due to stays in dormitories with other COVID-19 positive patients, but also to the fact that patients were in close contact with various staff members during daily care, examinations and treatments. The 1350 staff members identified as CC could be explained by the direct patient contact with unsuspected cases and difficulties keeping distance between colleagues as noted earlier. The same individual may have been identified as CC more than once in different CT during the study period. In addition, one could speculate that a general anxiety for spread of COVID-19 among both hospital staff members and employer could lead to identification of more CC just to be on the safe side.

In accordance, with the National recommendation all CC were isolated for 4 days (6 days from the January 19th.) after last exposure. If a SARS-CoV-2 PCR-test taken at day four was negative the isolation could be suspended (Sundhedsstyrelsen, 2020c). The WHO recommends that CC are isolated for a total of 14 days to minimize risk of onward transmission (WHO, 2021a). In addition, WHO advises that if there is adjustment to a shorter duration of isolation, this must be done with a risk assessment of health

risk in the society compared with the advantages for a shorter isolation period in relation to society, socially and economically (WHO, 2021a). A study by Wells et al.(2021) demonstrated that quarantine for 6 days combined with test at day six were equally safe compared to 14 days of isolation without testing. The quarantine for up to four or 6 days in Denmark must have resulted in a significant loss of labour. With 1350 staff members quarantined as CC meant that approx. 10% of all hospital staff members in our region were quarantined. Therefore, some wards experienced a significant loss of the workforce (personal communication) during the pandemic. However, only 76 of the quarantined CC among staff were infected with SARS-CoV-2.

Kucharski et al.(2020) demonstrated by a mathematical model of individual-level transmission based on data from 40,162 participants that the combination of self-isolation, household quarantine and manual contact tracing of all CC could reduce the ongoing spread by 64%. These elements were also fundamental in the Danish strategy, and our department of infection control played an important role in the contact tracing at the hospitals. Intrahospital spread of SARS-CoV-2 has been demonstrated in several reports (Paltansing et al., 2021; Quigley et al., 2021; Schneider et al., 2020; Strand et al., 2021). Therefore, rapid isolation of cases and identification of CC is a cornerstone in the control of the pandemic. We found that almost nine out of 10 wards (data not shown) experienced CT. Primarily, wards with patient care were affected, whereas some wards with no patients (hospital administration etc.) were not affected and this could be explained by the fact that some the staff worked from home during the pandemic.

Kojaku et al.(2021) evaluated the effectiveness of BCT and demonstrated that it was crucial to prevent the onward spread of COVID-19. Our BCT resulted in a surprisingly high number of 33 CC who were SARS-CoV-2 PCR-test at day 0. In fact, we cannot rule out the fact that those who tested positive at day 0 might have been the 'true' index case. Only 11 CC tested positive on day six or later and fortunately they did not cause further transmission. One-hundred-sixteen cases were identified by outbreak testing, underscoring the importance of identification of the source of the infection.

By 28 October 2020, a legal requirement was issued in Denmark for the use of face mask in healthcare settings and this meant that patients and staff had to wear face masks on all public areas in the hospitals to prevent transmission from asymptomatic carriers (Sundhedsstyrelsen, 2020a). There has been reports from other hospitals about outbreaks where the introduction of face mask both as infection prevention between patient and staff, but also from staff to staff has been a contributing factor in stopping outbreaks (Çelebi et al., 2020; Schneider et al., 2020). Whether the introduction of the face mask has had an effect in terms of reducing the spread of infection in the hospitals in our region was beyond the scope of this study, but some CT showed that the use of face mask resulted in fewer CC due to use of face mask by the diseased.

Transmission of SARS-CoV-2 from an asymptomatic person has been demonstrated in several studies (Harrison et al., 2020; Lombardi et al., 2020; Rivett et al., 2020). At the time of the performance of the CT almost half of the index cases were asymptomatic. Some of these might have felt asymptomatic at the time of testing, however, when the positive test result was received, they might have realized that they have had a few symptoms earlier on. Other cases were truly asymptomatic at time of testing but developed symptoms later on. The number of asymptomatic cases was higher in the group of CT with positive CC. Individuals who tested positive in outbreak test was presumed to have been asymptomatic at time of testing and likewise the CC that were tested positive on day 0. Our data confirm that regular testing of patients and staff will identify asymptomatic carriers and thereby prevent new cases, in line with previous studies (Holmes et al., 2021; Strand et al., 2021).

A limitation in this study was the lack of COVID-19 sequencing data and a directly genetic linkage between cases could not be made. Therefore, our data of whether the patients and staffs became infected in the community or hospital/work could not be confirmed, nor could we link data to variants of COVID-19. Due to the legislation, all data was anonymized and therefore we did not have information of which individual staff members were doctors, nurses or belonged to another group of healthcare workers. Another limitation was is that there was not a registration of the total numbers of individuals tested (missing numerators) in the outbreak testing regimes. Furthermore, there was no registration of the number of systematic testing being performed, as the systematic testing regime was on voluntary basis. Therefore, the number of hospital staff members being tested were unknown.

In conclusions, we found a three to one of CC to each index case, but 6% only became subsequently SARS-CoV-2 positive, with a surprisingly high number of those identified at day 0. Only one-third of all cases were identified due to symptoms of COVID-19, whereas two-thirds were identified by other reasons including outbreak tests and systematic screening tests. Our study demonstrated a value of BTC and importance of attempting to identify the primary case. Fast identification and isolation of new cases and BCT will have implications for the handling of the COVID-19 pandemic in the hospital setting.

Acknowledgements

We would like to express our gratitude to all infection control nurses involved in the CT programme in the North Denmark Region during the study period.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship and/or publication of this article.

ORCID iDs

Dorte Fromberg https://orcid.org/0000-0003-3150-0393
Nina Ank https://orcid.org/0000-0001-7149-3752
Hans L Nielsen https://orcid.org/0000-0002-2370-417X

Supplemental Material

Supplemental material for this article is available online.

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