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JOHANNESBURG

STAFF PERCEPTIONS OF THE COVID-19 CONTACT TRACING SYSTEM IN THE EKURHULENI HEALTH DISTRICT, 2020

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Declaration

I, Mazvita Naome Muropa Mberi, student number 9901201F, declare that this Research Report is my own, unaided work. It is being submitted in fulfillment of the requirements of the Master of Medicine (Public Health Medicine) degree in the University of the Witwatersrand, Johannesburg. The work has not been submitted before for any degree or examination at this or any other University.

Signature of Candidate: 

Name of Candidate: Mazvita Naome Muropa Mberi

6th day of October 2022, in Johannesburg

Dedication

Thank you, God, for never leaving my side and for making all grace abound towards me: your love increasingly astounds me.

I dedicate this work to my husband, Moreblessing Mberi and my daughters Munesushe and Matidashe for giving me the space and time to pursue my dreams and lovingly supporting me throughout my journey.

Thank you to all the friends and family who continued to encourage me when times were tough, and I was ready to give up.

Abstract

Background: COVID-19 Contact tracing has been shown to avert outbreak propagation by preventing secondary infections from COVID-19 cases. There is a paucity of information on implementing functional, effective contact tracing. **Objectives:** The aim of our study was to study contact tracing implementation and the barriers and facilitators of contact tracing implementation in the Ekurhuleni Health District (EHD). **Methodology:** A total of 118 Contact tracers (CTs) completed self-administered questionnaires, and 22 managers were interviewed. **Results:** Equipment availability (54/118, 45.8%), accurate client information (85/118,72.0%), client cooperation (47/118, 39.8 %) and willingness to engage with health services (40/118, 33.9%), effective planning and communication (33/118, 28,.0%) were important facilitators to finding and following up contacts and managing symptomatic contacts. **Conclusions**: Data quality and resource availability were key barriers or facilitators to contact tracing implementation for both managers and tracers. The use of telephonic contact tracing methods was perceived to improve tracing efficiency, while physical contact tracing was perceived to improve tracing effectiveness. **Recommendations:** Early, effective community engagement, staff support, and the availability acceptable, effective information management systems and guidelines will facilitate better contact tracing implementation in the future.

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List of Acronyms and Abbreviations

CDC	Centre for Disease Control and Prevention (USA)
COE	City of Ekurhuleni
COVID-19	Disease caused by the SARS-CoV-2
CT	Contact Tracer
DHIS	District Health Information System
DOH	Department of Health
EHD	Ekurhuleni Health District
GPS	Global positioning System
IP	Incubation Period
KZN	KwaZulu Natal
NICD	National Institute for Communicable Disease
PDOH	Provincial Department of Health
PHEIC	Public Health Emergency of International Concern
PnUO	Pneumonia of Unknown origin
PT	Physical Tracer
REDCap	Research Electronic Data Capture
RDP	Research and Development Blueprint
SA	South Africa
SARS-C0_V-2	Severe Acute Respiratory Syndrome Coronavirus 2
SD	Standard Deviation
TT	Telephonic Tracer
USA	United States of America
WHO	World Health Organization

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Introduction

Background

The World Health Organization (WHO) China Office was informed about a pneumonia of Unknown Origin (PnUO) on the 31st of December in 2019. This PnUO was later named coronavirus-19 (COVID-19) disease and was reported to be caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS- CoV-2).(1–3) The WHO declared the COVID-19 to be a Public Health Emergency of International Concern (PHEIC) on the 30th of January 2020, and the disease spread rapidly across continents to reach pandemic levels.(1,4–6) On the 5th of March 2020, South Africa (SA) became the 4th country in Africa to report its first COVID- 19 case.(5,6) By 17 March 2022, globally over 460 million COVID cases had been reported with over 6 million deaths.(7) Africa had reported 8 million COVID-19 cases and 170684 deaths while SA had reported 3694504 cases and 99725 deaths. Four COVID-19 waves, that were driven by the emergence of new SARS-CoV-2 variants, had also been reported in the continent and in SA by March 2022.(7–9)

In 2020, WHO recommended that countries should use a multipronged approach to prevent the mortality and morbidity from the disease and minimize the number of new cases that derive from each confirmed case.(1,10) Contact tracing, together with early testing, isolation and care of cases was recognized by WHO, in 2021, to be a key strategy for reducing COVID-19 transmission thus reducing morbidity and mortality from the disease.(11) Studies have found that 81% of COVID-19 cases develop mild symptoms and pre-symptomatic transmission of the coronavirus is possible.(12) With the Sars-CoV-2 having a reproductive rate (R_0) ranging from 1.9 to 6,47 and an incubation period (IP) mean and median ranging between four to six days, there is high transmissibility of the coronavirus.(12) Transmission can be covert due to commonly mild, non-specific symptoms of COVID-19.(12) Contact tracing has been an integral part of COVID-19 containment in many countries including Thailand, Nigeria, Rwanda, Uganda and South Africa.(13,14)

The South African COVID-19 guidelines recommended that all contacts of COVID-19 cases must be identified and advised to quarantine for 14 days from the date of exposure.(15,16) Contacts of COVID-19 cases had to remain reachable during the time of quarantine and be followed up actively or passively. Active symptom monitoring is when the Department of Health (DOH) reaches out daily to the COVID-19 contact, while passive monitoring requires the COVID-19 contact to self-monitor and report daily on the designated provincial digital platform.(16,17) Active contact monitoring information was captured daily on the contact follow up forms and then

captured on the NICD or other database. Digital applications or platforms (Apps), such as the "Mpilo App", "Telkom track and trace" and "District Health Information System (DHIS) contact tracing tool" were available for use in different SA provinces. The Mpilo application enabled a COVID-19 contact to self-monitor and self-report (passive contact follows up) for COVID-19 symptoms. (16,17) Contacts that became unreachable, stopped self-reporting or who developed COVID-19 symptoms had to be visited in their homes and tested for COVID-19 (16,17). Below is the South African contact tracing process flow diagram:

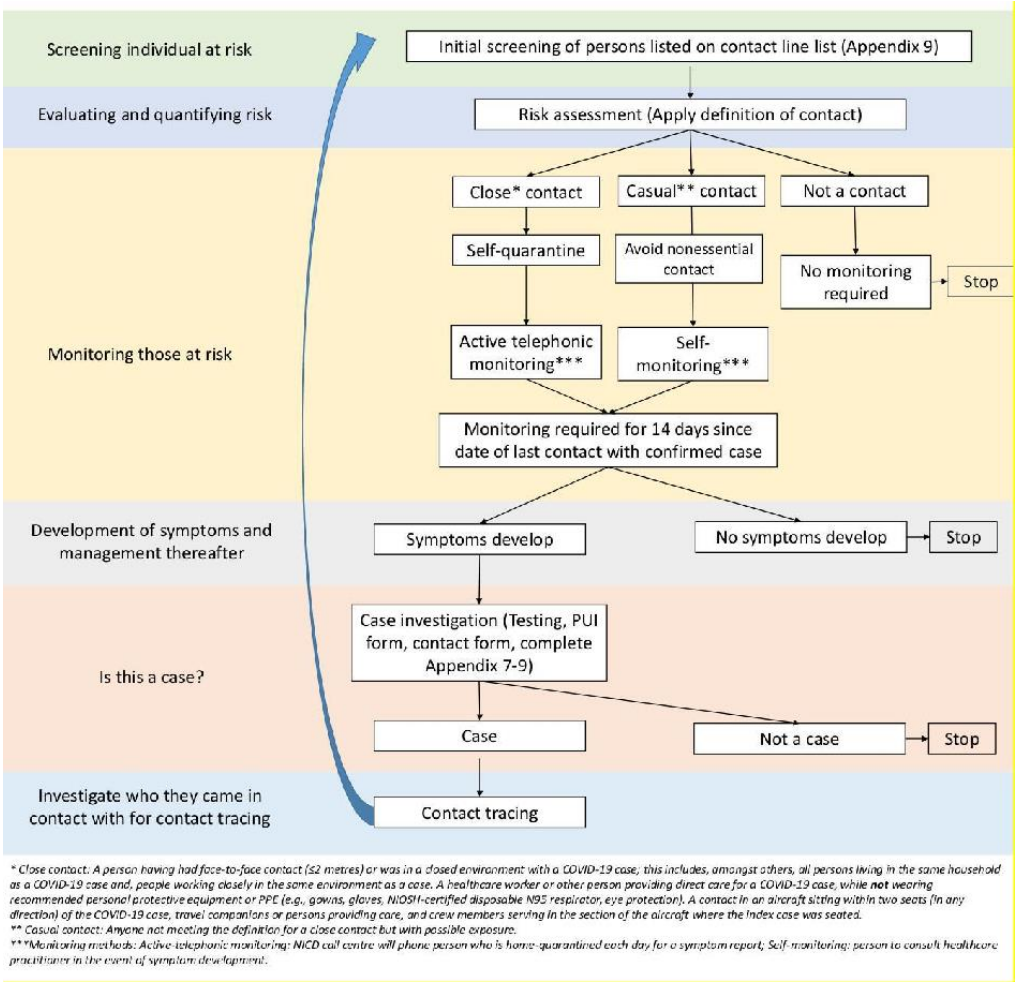


Figure 1: South Africa contact tracing flow diagram (19, 22)

Contact tracing elements include case and contact identification, tracing and following up of contacts over the quarantine period for identification of any developing symptoms and early referral for testing. (18–20) The WHO recommends that quarantine of COVID contacts should be supported to ensure that contacts that are quarantined have access to all necessities including food, water, health care, financial and psychosocial support. The WHO also raises the issue of prior engagement with communities about the need for quarantine, and the need for assessments to ensure that people are quarantined in appropriate settings.(21) Tracing data also needs to be collected, consolidated, monitored and evaluated in order to inform outbreak response

improvements.(10,20) This study aims to investigate how contact tracing was implemented in one of the South African health districts and identify perceived barrier and facilitators of implementation.

Literature Review

Contact tracing Facilitators and Barriers

Contact tracing is able to break the chain of COVID-19 transmission, Modelling studies have shown that the contact tracing of 50% to 90% of contacts, depending on the organism's R_0 in the population, can result in outbreak control within 3 months, however, not all countries can successfully implement the strategy (22,23). Where R_0 was 1.5, 2.5 or 3.5, contact tracing of at least 50%, 70% and 90% respectively, was required in order to avert the outbreak. (22) The ability to find contacts and the speed at which symptomatic contacts are found and quarantined, affects the success of the contact tracing system in averting the COVID- 19 outbreak. (22,23) The number of initial cases, the percentage of contacts that are traced and the R_0 of COVID-19 therefore impact contact tracing effectiveness(22). A randomized controlled mixed method study done in an Ebola outbreak found that delays from identification of a case or contact, to the time of being traced has been found to be due to health system and other issues such as remote location, network coverage issues, logistic issues.(24) In South Africa a modelling study found that COVID-19 R_0 was 3.22 in March 2020, and decreased to below 2, after the mandatory national lockdown and subsequently increased to 3.27 with the relaxing of the lockdown in the last three months of 2020.(25).

Contact tracing has been implemented differently in different settings. In some African countries including Nigeria, Rwanda and Uganda, factors such as leveraging on information technology and partner funding and support and ongoing communication and decentralization were some facilitators of implementation. (14) Some best practices in contact tracing implementation in South Africa included the repurposing of a central provincial database to track the COVID-19 outbreak, community education initiatives and the deployment of community health workers to support contact tracing in the province.(14) In Sierra Leone inadequate training and supervision of contact tracers, poor mechanisms for selection of contacts, community non- participation and the lack of a complete, well managed contact tracing database posed challenges for contact tracing implementation.(26) A WHO descriptive study of the West African Ebola outbreak reported that challenges that resulted from insufficient human, financial and logistical resources and the inability to access affected communities impeded contact tracing activities.(18) Conversely, training of contact tracers and contact tracing supervisors, logistical support and supervision of contact tracing teams and robust information management systems are critical for effective contact

tracing implementation. (18,19)

A study that interviewed the United States Centers for Disease control and prevention (CDC) staff that worked in various countries in the West African Ebola contact tracing systems found there was community apprehension about getting isolated or quarantined, disease related stigma and contact persons' unwillingness and unavailability for follow-up. which hindered contact tracing activities.(19) Community stigma, mistrust and misinformation were also barriers to COVID-19 contact tracing in Nigeria, United States of America (USA) and in some European countries, and surveys showed that up to 25% of the population were not willing to provide their COVID-19 contacts' information.(14,23) A modelling study done in France found that it was simple to rapidly engage most close COVID-19 contacts, however, it was difficult to back-trace contacts who were strangers, such as co-travelers on public transport.(27) Staff members reported that community engagement and education, the use of contact tracing strategies which are contextually sensitive and engaging respected community members, local officials and religious groups could improve trust, decrease community anxiety and improve marginalized community participation.(18,19)

Overwhelming contact tracing workload, poor adherence to quarantine and isolation requirements and inability to remember contacts have also been reported to be barriers to contact tracing.(14,23,28) Telephonic contact tracing was reported to possibly inhibit health care workers' ability to establish rapport with clients, thus inhibiting cases from disclosing their contacts.(28) In Senegal tracing staff were assigned to follow up the same contact over their follow up time in order to build relationships and improve client engagement in the tracing process.(19) Staff anxiety about contracting COVID-19 and limitations in testing capacity have also been reported to be possible barriers to contact tracing implementation.(14,19) A systematic review showed, however, that resilience, social support and coping behaviors facilitated the preservation of psychological wellness among health care workers during the COVID-19 pandemic.(29) Non- accessibility of some affected communities also impeded contact tracing efforts in some settings.(26) Other reported barriers to contact tracing include the lack of contact person addresses, locations that had no street addresses and the physical safety of contact tracers as they visited communities as they were sometimes perceived to have an increased risk of having COVID-19.(19)

Contact tracing Information

Contact tracing information should be accessible and accurate and must be able to inform public health decision making.(18,27,30) Evidence from Sierra Leone showed that contact tracing of Ebola cases and contacts was 63% using the mobile application, while only 39% of reported cases

were traced using the paper-based contact tracing tools. Paper based data collection is reported to often have errors and missing data, and the introduction of mobile application data collection and information management tools improved timeliness and quality of contact tracing data, despite connectivity challenges in some settings.(24) As numbers of cases and contacts to be traced increase, evidence shows that it becomes essential for appropriate digital tools and information system software to be used for efficient tracing data management.(31,32) A French modelling study suggested that there are instances where COVID-19 spreads rapidly and disables manual (paper based) contact tracing's ability to contain the outbreak.(28) There are, however, mixed results about whether automation, manual or partially automated can lead to more effective contact tracing.(31,32) User engagement, voluntary equitable access and high uptake is required for electronic tools to be effective and issues such as non-integration of outbreak response tools into outbreak information platforms and exclusion of contacts that have no access to cellphones or technology required to access the tools can compromise tracing effectiveness.(10,20,32) Though automation can simplify contact tracing by increasing time efficiency and accuracy of large datasets, they cannot replace contact tracing teams.(10) The effectiveness of tools also need to be ensured and principles of data protection and privacy need to be adhered before implementation.(32–34)

Problem Statement

One of the WHO strategic objectives in averting the COVID-19 pandemic is to limit human-to-human transmission by effectively implementing evidence-based public health measures such as investigation of COVID-19 clusters, contact tracing, supported quarantine and early testing of symptomatic contacts and population COVID-19 vaccination.(35,36) Contact tracing is critical for the containment of infectious disease epidemics including the COVID-19 pandemic. As COVID-19 case incidence persists globally and in SA, contact tracing continues to be an essential part of the outbreak control strategy.(18,37–40) Contact tracing, like most activities that translate into public health impact, is challenging and complex, however, when effectively implemented, it ensures close follow up of all COVID-19 close contacts and allows for early quarantine of close contacts and rapid identification, testing and isolation of new cases in order to minimize secondary infections from COVID-19 cases, thus averting outbreak propagation.(15,39–41) There remains, however, a paucity of information on contact tracing implementation strategies that can guide future outbreak response contact tracing activities.(18)

Study Justification

The WHO Research and Development Blueprint (RDP) team that met in February 2020 resolved to accelerate COVID-19 related research aimed at curtailing the unprecedented COVID-19

pandemic and which also contribute to and facilitate learning which will inform future epidemic responses.(42) A COVID-19 contact tracing system was implemented in the Ekurhuleni Health District (EHD) as per WHO COVID-19 strategic objectives.(35,36) The processes, challenges, barriers, and facilitators of contact tracing implementation have not been described or evaluated locally or nationally, as has been observed internationally. In line with the RDP resolutions, this study's findings and recommendations will be used to inform contact tracing system strengthening in Ekurhuleni and other health districts now and in the future. (42)

Research Question

What are tracing and management staff perceptions, about COVID-19 contact tracing implementation, and factors that facilitated or were barriers to EHD contact tracing implementation?

Aim

This study aimed to investigate COVID-19 contact tracing management and tracing staff's perceptions about COVID-19 contact tracing implementation in EHD and explore staff members perceptions about the facilitators and barriers to COVID-19 tracing implementation in the EHD.

Objectives

1. Determine perceived barriers and facilitators to COVID-19 contact tracing in EHD as reported by the EHD contact tracing staff that provided personal COVID-19 contact tracing services.
2. Determine perceived barriers and facilitators to COVID-19 contact tracing in EHD from the perspective of the EHD contact tracing management and technical support staff.
3. Describe perceptions about the EHD contact tracing system, from the perspective of contact tracers and contact tracing managers and technical support staff.

Definitions

The following terms and definitions were used in this study:

Contact Tracers (also called tracers): Staff members that are allocated to trace individuals that have been in close contact with a COVID-19 case within 14 days of the case being diagnosed with the disease (15,43)

Physical tracers: Staff members that are allocated to trace COVID-19 cases and contacts by physically visiting them in the community (15,43)

Telephonic tracers: Staff members that are allocated to telephonically trace and follow-up COVID-19 cases and contacts (15,43)

COVID-19 close contact: A person who had face to face contact (< 2 meters) or was in a closed environment for at least 15 minutes with a COVID-19 case, without appropriate personal protective equipment, 14 days before or after the case's COVID-19 diagnosis. (15,43)

Fidelity: The degree to which a an intervention is implemented as it is prescribed in the original protocol(44)

Feasibility: The extent to which a new innovation can be successfully carried out within a given setting(45)

Adaptation: Changes to the planned implementation strategy/or intervention during the course of the intervention(46)

Acceptability: The perception among implementation stakeholders that the intervention is agreeable, palatable and satisfactory (45)

Methods

Study design

This was a cross-sectional quantitative and descriptive study.

Study setting

This study was conducted in the Ekurhuleni Health District, which is one of the Metropolitan districts in the Gauteng Province of South Africa. Ekurhuleni Health District is in the eastern side of the Gauteng province and is of the made up of three sub-districts namely the East, South, and North sub- districts The district has a population of approximately 3,2 million people living in approximately one million households. Personal health services are delivered by both the provincial and municipal health services.(47) EHD is one of Gauteng Province's most densely populated districts and was one of the key districts involved in the initial pandemic response in South Africa, as it houses the largest International Airport in South Africa. The district is termed the "workshop of SA" as it has the largest density of manufacturing companies in one area.(48) Gauteng has had the largest COVID-19 burden. The Ekurhuleni Health District had a lower burden of COVID-19 cases when compared to the other two metropolitan districts which were reported to have a high burden of COVID-19 with more than 10 cases per 100000 population in May 2020. (49,50)

Study population

The study population included contact tracer team members who provided personal contact tracing services to COVID-19 contacts and other health care workers who may or may not have provided contact tracing services directly to the population but were assigned or functioned as managers, supervisors or coordinators in the Ekurhuleni contact tracing system. We will refer to tracer team members as contact tracers or tracers and the other management and supervisory staff as managers. There were 258 contact tracers who were providing physical and/or telephonic contact tracing services, where COVID-19 contacts were traced in the community at their places of residence or work. There were 130 staff members that were managing, coordinating, and supporting the contact tracing system at district, sub-district, and facility levels. These staff members included 7 district level managers, 12 sub-district level managers, and 111 facility managers, from both the City of Ekurhuleni (COE) and from the Ekurhuleni provincial department of health (PDOH).

Study sample

Contact tracer sample sizes were calculated using Open Epi at 95% confidence interval, with a 5% error margin and design effect of one. Our targeted sample size for contact tracers was 132.(50) Stratified sampling was used to recruit contact tracers from the district, subdistrict and from both COE and EHD health facilities, however, due to fact that only a limited number of facilities were extensively involved in district COVID-19 contact tracing all contact tracers that were eligible to participate in the study were approached to participate in the study in order to achieve our sample size. All district, sub-district and facility-based contact tracers that were available on the day of visiting the district, sub-district offices or health facility were engaged and invited to participate in the study. In instances where contact tracers worked shifts multiple site visits were done to include contact tracing staff from all shifts.

The CT manager sample sizes were calculated using Open Epi at 95% confidence interval, with an anticipated proportion of 5% and design effect of 1. Our calculated sample size was 47. We approached all the 19 district and sub-district managers for inclusion into the study. Sub-district coordinators then identified facilities that were implementing contact tracing. These facilities were stratified by governance structure (COE versus provincial DOH facilities) and the sub-district they are in. We planned to visit 10 facilities in each of the three sub-districts, which would allow us to consecutively sample a total of 30 facility managers, that would represent all the district facility managers. We therefore targeted to perform key informant interviews with 49 managers in total. Managers of facilities that were involved in contact tracing, as identified by sub-district coordinators, and qualified to be included in the study were approached for inclusion into the

study.

A. Contact tracers' inclusion criteria:

1) All contact tracing staff that were involved in either physical or telephonic contact tracing in the EHD district and sub-district, since the beginning of the COVID-19 epidemic.
2) Contact tracing staff should have provided direct personal contact tracing services to the EHD population for at least two weeks since the beginning of the COVID-19 epidemic.

B. Contact tracing staff exclusion criteria:

1) Contact tracing staff that have not performed contact tracing for more than two weeks in EHD.

C. Inclusion Criteria for managers

1) Staff members that have managed, coordinated, or technically supported COVID-19 contact tracing teams for at least two weeks cumulatively, since the beginning of the COVID-19 epidemic in EHD
2) COVID-19 managers should have spent at least two weeks managing, supervising, coordinating, or supporting staff that is performing contact tracing work in EHD.

D. Managers and supporting staff exclusion criteria:

1) Managers that are involved in the planning of this study or were part of the district study approval committee.

Data Collection

Two semi-structured questionnaires were used in this study for data collection. One self-administered questionnaire (Appendix 3) was for contact tracers and one interview guide for contact tracing managers (Appendix 4). The questionnaires were developed on the secure, web-based REDCap platform which is hosted by the University of the Witwatersrand.(51) Both questionnaires were pre-tested with three COVID contact tracers and three tracing managers from a different district. The questionnaires were then amended to improve clarity and validity of the questions in both tools.

The investigators engaged the district, sub-district, and facility managers for permission to interview them and for available and eligible contacts tracers in their place of work to complete the self-administered questionnaire. District, sub-district, and facility visits were then scheduled. Contact tracers that performed contact tracing in the district who qualified for inclusion in the study but were no longer employed in the district, sub-districts or facilities were engaged on a one-

to-one basis. Meetings were scheduled for completion of questionnaires by those tracers that were willing to participate in the study. Contact tracers were screened prior to completing self-administered to ensure that they met the inclusion criteria and had no reason to be excluded. Study information was given, and hard copies of the self-administered questionnaire were given to contact tracers that had signed informed consent to participate in the study, for completion. COVID-19 contact tracing managers were given information about the study, and those that consented to participate in the study were interviewed.

Data management and statistical analysis

Data from the contact tracers' paper-based self-administered questionnaire was captured and stored in the secure web-based REDCap platform.(51) Data was exported to StataCorp 2019 for cleaning and statistical analysis.(51,52) Quantitative data was described using proportions for discrete data and means or medians for continuous data. Open ended responses were described and categorized into codes then themes. Chi square, Fischer's exacts test and regression analysis were done to determine associations and distribution differences. P values less than 0.05 were considered to be significant. Interview data was transcribed into MS word documents and quantitative data was captured onto an Excel spreadsheet for analysis. Documents were stored in a password protected one drive platform. Quantitative data was exported to StataCorp 2019 and descriptive analysis was performed. Both inductive and deductive methods were used to describe and then categorize data from open ended questions to determine perceived barriers and facilitators to contact tracing and its implementation in EHD.

Ethical Considerations

Research Ethics approval was received from the University of the Witwatersrand Human Research Ethics Committee and permission to perform research was also granted by the EHD health research committee. Only participants who sign informed consent to participate in the research were included in the study. All participant identifiers, and study information, were kept confidential and have been stored in the secure password protected REDCap and the researcher's university based protected one drive storage platform.(51)

Results

A total of 118 Contact tracers completed the self-administered questionnaire. A total of 121 out of the 258 (46.9%) of contact tracers could not be found or were not on duty at the time of visiting facilities, and 19 participants (7.4%) were excluded from the study because they did not satisfy the inclusion criteria. We therefore had a 46% response rate (118/258). Face to face interviews were done with 22 managers using a semi-structured interview guide. This represented a 45% response rate (22/49). We will present results from the contact tracers self-administered questionnaire in the first results section, then present tracing managers' key informant interview results in the second results section. Facilitators and barriers that were described could have been described as a barrier or a facilitator. If the absence of the factor was seen as a barrier, it means the presence of the factor was a facilitator, we therefore either demarcate a factor as a barrier or facilitator in the presentation of our findings.

Results: Contact Tracers

Contact Tracers' background

The CT's had a median age of 39 with an Interquartile range (IQR) of 32 to 46 years and 82% of them were female (96/118, 82%). Most contact tracers (78/118, 66%) were employed by the PDOH, and 36% were enrolled nursing assistants. Other staff categories that were doing contact tracing included environmental health practitioners, clerical staff, health promoters and counsellors. Close to three quarters (85/117, 73%) had other work duties that they had to perform in addition to contact tracing duties. Results are shown in table 1 below.

Table 1: Contact Tracer staff attributes, EHD, 2021

Variable	**Category**	**Distribution**	
		n	**%**
Staff Category	Professional Nurses	26	22.6
	Community Health worker	13	11.3
	Enrolled Nursing Assistants	41	35.7
	Other	35	30.4
Employer Name	Department of Health	78	66.1
	City of Ekurhuleni	24	20.3
	Other	16	13.6
Place of Work	District	17	14.4
	East sub-district	50	42.4
	North sub-district	26	22.0
	South sub-district	25	21.2

Variable	Category	Distribution	
Employee Duties	Only Contact tracing duties	32	27.4
	Contact tracing + other duties	85	72.6

Contact Tracers' skills and work experience

Almost half of the CTs that participated in the study had performed both telephonic and physical contact tracing (54/118, 47%), while 43 CTs (37%) had performed only telephonic contact tracing and 19 CTs (16%) had only done physical contact tracing. Approximately Half of the CTs had contact tracing experience prior to COVID-19(59/117, 50%) and had done CT for more than one year (61/116, 53%). When scored out of three, we found that average COVID-19 knowledge perception was 2.1/3 (median:2, IQR:1-3) and COVID-19 tracing test score was 2.3/3 (median: 2, IQR 2-3). CT knowledge perception had an average of 1.9/3 (median: 2, IQR: 1-3) and CT knowledge test score was 1.7/3 (median:2, IQR:1-2). Results are shown in the below Table 2. Chi squared tests of homogeneity showed us that there was no difference in the distribution of COVID-19 knowledge when compared to COVID-19 test scores (p=0.637) and there was also no difference in the distribution of CT perception of tracing skills when compared to CT contact tracing test scores (p=0.785). This shows that the CTs perception with COVID-19 and CT knowledge were consistent with their test scores in the relevant subject.

Table 2: Contact Tracer skills and work experience, EHD, 2021

Variable	Category	Distribution	
		n	%
Previous CT experience	No	58	49.6
	Yes	59	50.4
COVID-19 training	Informal	46	40.4
	Formal	68	59.6
COVID-19 knowledge Perception	Basic	42	36.2
	Intermediate	21	18.1
	Advanced	53	45.7
CT Knowledge Perception	Basic	51	43.6
	Intermediate	31	26.5
	Advanced	35	29.9
Time performing COVID-19 CT	<3 months	18	15.5
	>/=3months and < 1 year	37	31.9
	>/=1 year	61	52.6
Contact tracing training	Informal	66	57.4

Variable	Category	Distribution	
		n	%
	Formal	49	42.6
COVID-19 knowledge test score (/3)	1	14	11.9
	2	53	44.9
	3	51	43.2
CT knowledge test score (/3)	0	7	5.9
	1	35	29.7
	2	59	50.0
	3	17	14.4

Contact tracing implementation preparedness

A Likert type scale was used to ask contact tracers whether agreed or disagreed with statements around contact tracing feasibility, availability of support and guidelines, clarity of roles and responsibility, adequacy of contact tracing time and rewards of doing contact tracing. CTs responses are shown in the below Table 3. The highest mean scores were achieved for clarity of roles and responsibilities (score: 3.9/5) and work support (score: 3.8/5) which shows that tracers felt they had clear roles and responsibilities and they had good work support. Conversely tracers' perceptions were that they were not well rewarded for the tracing work they did, as shown by the much lower mean score (2.6/5).

Table 3: Contact Tracer scores for perception of contact tracing preparedness, EHD, 2021

Variable	Min	Max	Mean	Standard Deviation	Fischer's test (COE vs DOH) p value
CT was easy to do	1	5	3.3	1.10	0.092
Guidelines were available	1	5	3.4	1.11	1.000
Work support was available	1	5	3.8	1.00	0.601
My roles and responsibilities were clear	1	5	3.9	0.99	0.054
Time to accomplish duties was sufficient	1	5	3.3	1.17	0.156
I felt well rewarded for doing COVID-19 CT activities	1	5	2.6	1.24	0.749
CT Equipment and/or tools were available	1	5	3.1	1.29	0.230

Ease of finding and following up COVID-19 cases and contacts

Contact tracers were asked how difficult or easy it was to find a COVId-19 contact, how much time it usually took to find a contact, once contact had been identified, and what proportion of contacts, they believed they had followed-up over the quarantine period. Responses (Table 4) were scored out of five, with five representing the most desirable outcome for effective contact tracing. CTs' scores were highest for timeliness of finding contacts (4.1/5), followed by following-up contacts (3.9/5) and then finding contacts (3.2/5). Refer to table 4 below. Only a third (36/109, 33%) of tracers perceived finding contacts to be easy and over three quarters (97/116, 84%) of tracers believed that most contacts were found within 3 days after being identified. CTs were asked what proportion of contacts they believed had been followed up over the quarantine period and 75%, (87/116) felt that more than 50% of contacts had been followed up over the quarantine period.

Table 4: Finding and following up COVID-19 cases and contacts, EHD, 2021:

Variable	**Participant Response (score)**					**Mean**	**SD**
Ease of finding contact	**Extremely Difficult**	**Difficult**	**Neither**	**Easy**	**Extremely Difficult**		
	3 (2.8)	21 (19.3)	49 (45.0)	27 (24.8)	9 (8.3)	3.2	0.94
Time (days) from contact identification to finding contact	**>7**	**5-7**	**4-5**	**2-3**	**1**		
	7 (6.0)	5 (4.3)	7 (6.0)	46 (39.7)	51 (44.0)	4.1	1.09
% Follow up over quarantine period	**None**	**< 50%**	**50%**	**> 50%**	**All**		
	7 (6.0)	9 (7.8)	13 (11.2)	41 (35.3)	46 (39.7)	3.9	1.22

Managing COVID-19 contacts with "severe" COVID-19 symptoms

The questionnaire asked what CTs would do if a contact reported that they had a cough and could not breathe well. Tracers were expected to report and refer or facilitate referral for such cases. Most CTs (102/114, 89%) were able to recognize that a client who is coughing and having difficulty breathing required medical attention and reported that they would refer or facilitate referral of such cases. Responses to the question are shown in Figure 2, below. CTs reported that having access to a facility or facility-based team, facility or community-based clinician, coordinator, or supervisor, and/or field team to whom all symptomatic cases were referred or reported, facilitated better symptomatic case management.

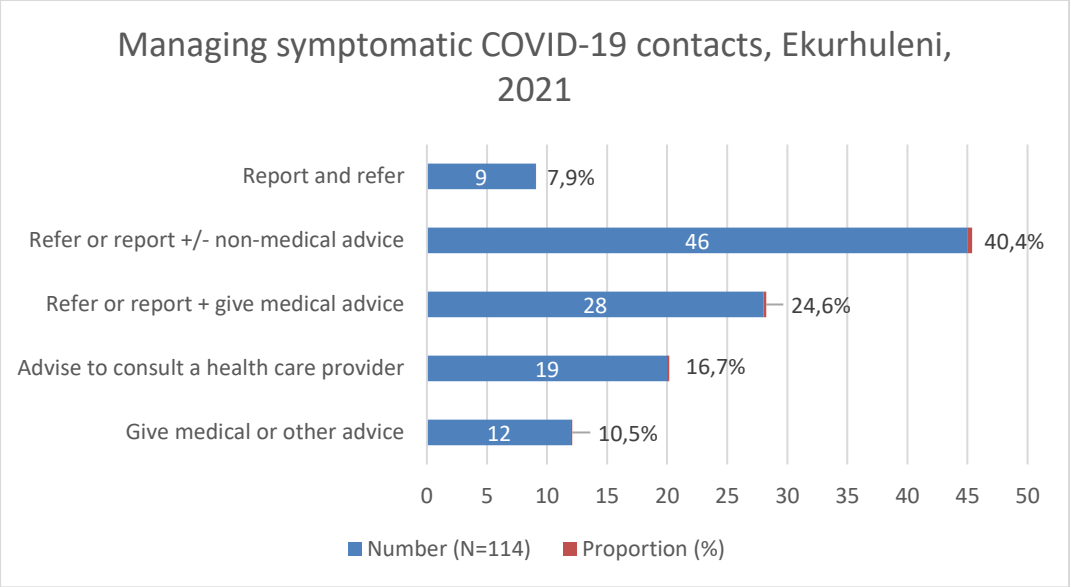


Figure 2: Managing symptomatic COVID-19 contacts, EHD, 2021

Contact Tracing reporting

Most CTs stated that their tracing activities were reported daily, using paper-based forms which were submitted onsite, sent by WhatsApp, or emailed to the designated receiver of the tracing reports, who was a data capturer, team leader, supervisor, manager or coordinator as shown in Table 5 below.

Table 5: Contact tracing reporting, EHD, 2021

Main platforms used for reporting	**Proportion (N=116)**		**Timeliness of reporting**	**Individual or team report is sent to**	**Other media/tools used for reporting**
	n	**%**			
Email	17	14.7	Daily	Coordinator COVID team group Data Capturer Managers Supervisors Team Leader	Use of tracing register Excel spreadsheet Mpilo Telephonically
Electronic database	16	13.8			
Paper forms	80	69.0			
WhatsApp	31	26.7			
>1 mode (31/116)	31	26.7			

Contact Tracing Tools

Contact tracers were asked how difficult or easy it was to use different COVID-19 electronic tools. Contact tracers perceived the paper-based tools (3.9/5) to be the most user-friendly tools, followed by DHIs (3.7/5) and COVID connect (3.7/5), then Telkom track and trace (3.4) respectively. Mpilo App (3.2/5) was perceived to be the least user-friendly contact tracing App. Most CTs (87/116,

74%) used the paper-based tools, with less than a quarter reporting using DHIS tool (25/116, 21%), Mpilo App (18/116, 15%), Telkom Track and Trace App (13/116, 11%), and COVID-Connect App (5/116, 4%). CTs also used other apps and tools including Excel spreadsheets and Global positioning system (GPS) App to support their contact tracing activities. Tracers commented that paper-based or electronic tools were useful, as they enabled safe storage of information in one place and information could be found when needed. CTs also found value in the tools, most notably paper-based tools, as they provided guidance for performing contact tracing and made contact tracing work easier. The GPS tool was perceived to be useful for locating patients.

Table 6: Contact tracers' perception of ease of use of departmental CT tools, EHD, 2021

Tool/App	Contact tracer Responses (score)					Mean score	SD
	Extremely difficult (1)	Difficult (2)	Neither (3)	Easy (4)	Extremely easy (5)		
Paper Based	4	9	10	51	23	3.9	0.94
DHIS	1	3	14	25	5	3.7	0.80
Mpilo	3	7	19	21	4	3.2	0.96
Telkom Track &trace	3	4	18	14	4	3.4	0.95
COVID Connect App	1	3	13	17	6	3.7	0.91

CTs reported that challenges with using paper-based tools included that there was often photocopying or printing challenges which led to the unavailability of the required stationery. Paper-based tools could also be lost or spoilt. Challenges experienced with the use of electronic tools included internet connection challenges, lack of airtime to be able to access apps and the challenge of making time to learn how to use the digital tools. Though tracers did cite the potential for electronic tools to improve work efficiency, they reported that the use of these tools, most notably the Mpilo App was time consuming. According to the CTs Mpilo App had too many variables to enter, and data that had been entered on the apps could not be retrieved for reporting.

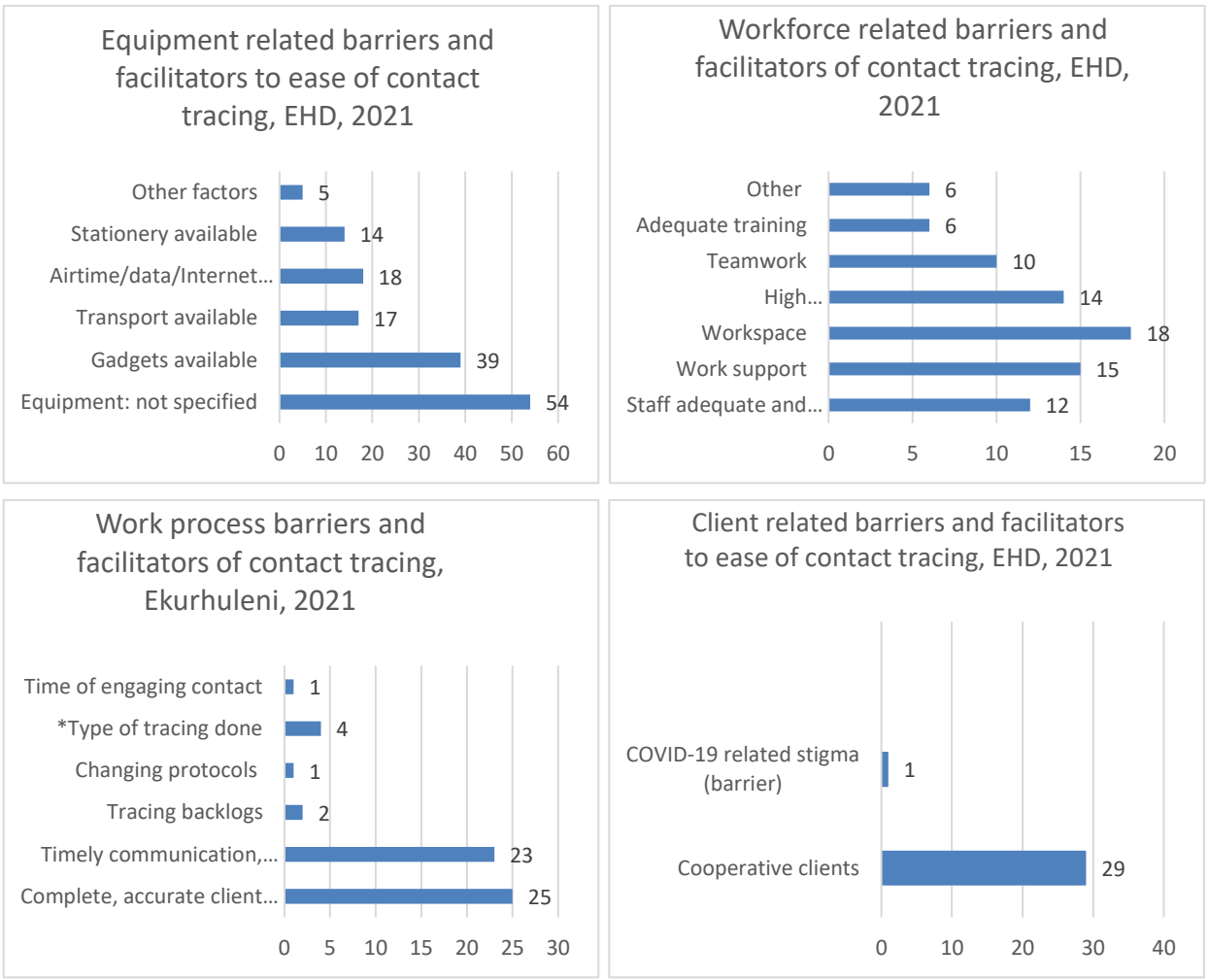
"Sometimes it was difficult or time-consuming to retrieve the information because the app did not save the information ……" **(Tracer 108)**

Contact tracers' perceptions of barriers and facilitators of Contact tracing

Reported barriers and facilitators to contact tracing were categorised into equipment, workforce, work processes and client related factors. This introductory paragraph gives a summary of findings that will be presented in the following sections. The availability of adequate, well-motivated staff, telephone access and transport availability were the some of the most frequently cited facilitators of contact tracing. Having high workloads and competing work responsibilities were important workforce related barrier to contact tracing. The availability of complete and accurate case and contact details was shown to be key to contact tracing, and there were differing perceptions about how the type of contact tracing that was implemented impacted contact tracing. Some CTs felt that physical contact tracing facilitated more effective contact tracing but was a barrier to reaching higher numbers of clients, while some felt that telephonic tracing was efficient, as it facilitated higher numbers of contacts to be reached. Client factors were the most cited as barriers or facilitators to contact tracing implementation were having cooperative clients and tracing clients that were in the same geographic location. Stigma was an issue that was cited often as a barrier to contact tracing. The perceived barriers and facilitators for different aspects of contact tracing are presented in the following sections.

Ease of implementing contact tracing: Contact tracer perceptions on barriers and facilitators

Contact tracers were asked what factors that they believed made contact tracing easier or more difficult. The lack of equipment was the most cited barrier to contact tracing ease, with client cooperation, availability of accurate client information and timely communication and planning being the second, third and fourth most cited facilitators or barriers respectively. Below are graphs illustrating contact tracers' responses.



Key

*Dissonant findings among tracer perceptions

Gadgets include Telephones, Cell phones, Tablets and/or Computers

"Other" equipment included GPS, PPE, Testing kits

"Other" workforce factors include contact tracer attributes, working in a familiar geographic area, receiving bad news and availability of a driver

Figure 3: Barriers and facilitators to ease of implementing contact tracing, EHD,2021

Most tracers responded that the "lack of equipment" was a barrier to ease of contact tracing, however, telephones and electronic gadgets were the most common equipment related barrier to ease of contact tracing, with bottlenecks especially experienced during peak times when case and contact numbers would be higher. The lack of transport, data, internet, airtime, and stationery were

other barriers to ease of contact tracing.

"Sometimes there isn't enough equipment, and the peak has a lot to do…" **(Tracer 25)**

"The difficulty is we don't have enough phones to trace, we have to wait for each other, therefore you don't finish your work on time" **(Tracer 43)**

Workspace availability was the most cited workforce related facilitator of ease of contact tracing.
Sharing rooms disrupts work as patients become irritable when they hear background noises" **(Tracer 6)**

Other facilitators were the availability of work support, teamwork, personal staff motivation including getting paid, staff training and dedication, human resource and driver availability. High workloads and competing work priorities were cited commonly as barriers to ease of contact tracing. Client associated barriers to contact tracing that were reported included aggressive, rude, and difficult clients as well as COVID-19 related stigma.

"Unwillingness of clients to participate, stigma, phones are switched off, gates are locked" **(Tracer 53)**

The lack of accurate contact information was the most cited process related barrier to ease of contact tracing. There was a dissonance in contact tracers' perceptions of how the type of contact tracing that is done affects contact tracing. Some CTs felt that physical tracing enabled ease of CT, however, some felt that telephonic tracing facilitated easier contact tracing.

"Wrong phone number and wrong physical address, it's hard to do my job" **(Tracer 89)**

"Home visits: able to see for yourself" **(Tracer102)**

"Clients that are far cannot be physically traced. Telephonic tracing is easier but physical tracing is better" **(Tracer 108)**

Finding Contacts: Contact tracer perceptions on barriers and facilitators

Contact tracers were asked what made finding COVID-19 contacts easier or more difficult. Figure 4 illustrates responses given by contact tracers. The overwhelming majority of contact tracers reported that incomplete and inaccurate client data was a barrier to finding COVID-19 contacts. Client cooperation and the type of contact tracing that was done were the second and third most cited barriers and facilitators to finding contacts. Facilitators to finding contacts that were equipment related included the availability of electronic gadgets, internet, transport, and stationery.

Key

*Dissonant findings among tracer perceptions

Gadgets include Telephones, Cell phones, Tablets and/or Computers

Figure 4: Barriers and facilitators to finding COVID-19 cases and contacts, EHD,2021

CTs felt that working in areas that they were familiar with made it easier to find contacts. Contact tracer attributes such as professionalism, approach and attitude towards clients, skills in getting all information were also perceived to be facilitators to finding contacts.

"When explain the reason for your call, most contacts are willing to listen and cooperate" **(Tracer 44)**

"Knowing the area makes it easy because you find the address easily" **(Tracer 50)**

There were differing perceptions about the most effective type of tracing for finding contacts, with seven tracers mentioning that physical tracing was a facilitator, six tracers mentioning that telephonic tracing was a facilitator and three reporting that both physical and contact tracing needed to be done to ensure contacts were found. Other work processes that were reported to be facilitators for finding contacts included using a cell phone rather than a landline and tracing being done at specific times including around 0900hrs or outside of work hours. Having large tracing backlogs or competing work demands and using paper-based tracing tools were cited as barriers to contact tracing.

Cooperation of clients was a key facilitator and barrier to contact traing. Tracers reported that clients were uncooperative, including being aggressive, locking gates and not picking their phones when tracers tried to reach them, being dishonest and being unwilling to engage. Dealing with a minor was reported to have been a barrier to finding contacts by one contact tracer. Some clients did not know about contact tracing, and some felt contact tracers were infringing on their privacy. Other clients opted to only share family details and not other contacts' information. Below are some of the statements that were given by CTs.

"Sometimes they think we are scammers and some people are uncomfortable to give (their) contacts" **(Tracer 31)**

"People refuse to give information because they (have) never heard about tracing team" **(Tracer 24)**

"The (COVID-19) case may feel that their privacy is violated by contacting them (the contacts)" **(Tracer 29)**

"(Clients) only give family contacts as their contacts" **(Tracer 103)**

Tracers reported that the finding of the index case was key to finding the contacts and that it was key for the index COVID-19 cases to be cooperative. The inability to access households due to incorrect or incomplete client contact information with no alternative contact details was another barrier to finding contacts. Some tracers suggested that collection of data by testing clinicians led to data gaps and some corroborated that when contacts' information was available to them, and contacts were contacted directly without having to source data from the cases it facilitated easier finding of cases.

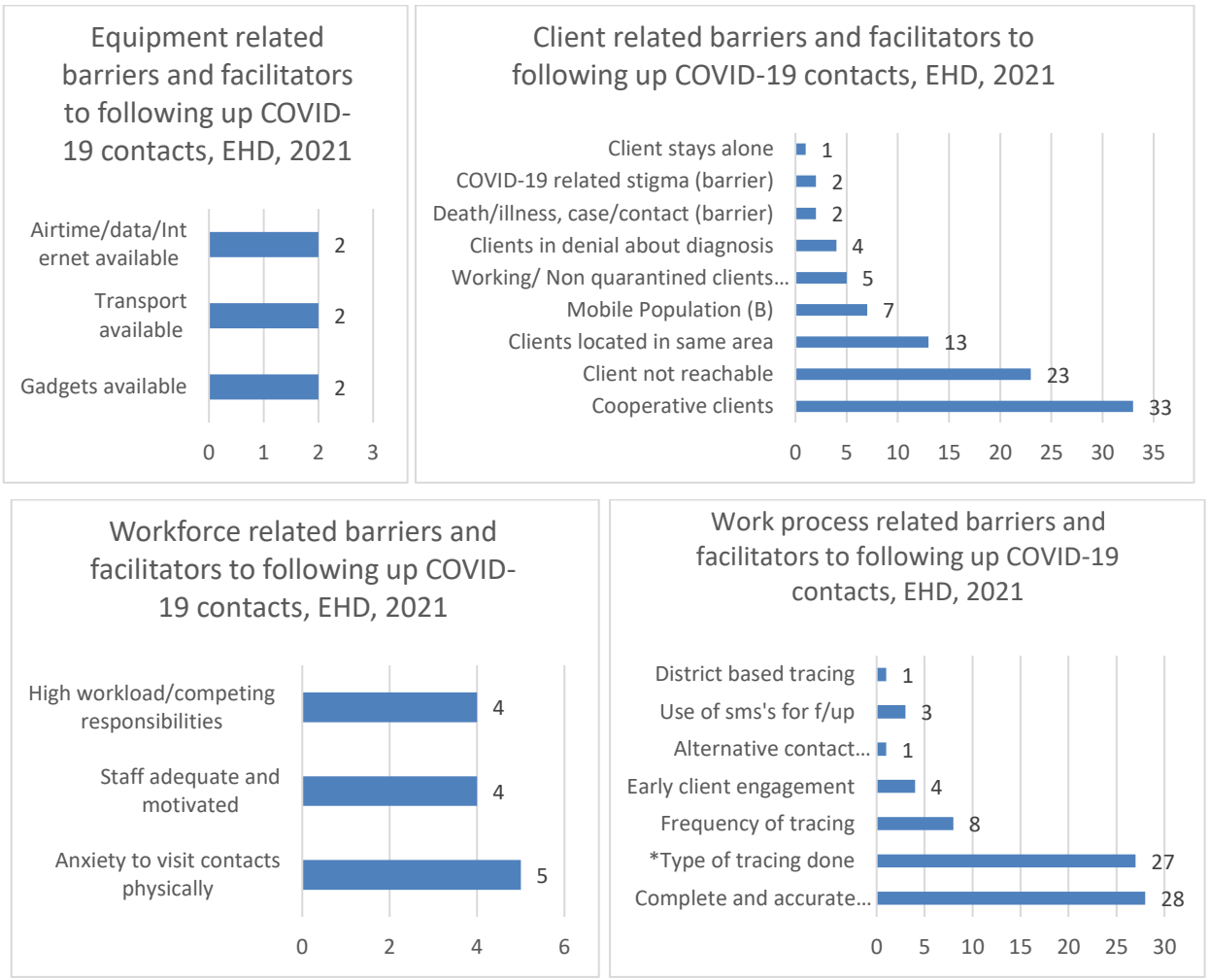
"The requesting doctors do not collect alternative contact (details)" **(Tracer 33)**

"Contacts are usually more willing to direct us to their homes if they are contacted first(directly)"

(Tracer 40)

Following up contacts: Contact tracer perceptions on barriers and facilitators

Contact tracers were asked what they thought made it easy and difficult to follow contacts over the quarantine period. The most cited facilitators to being able to follow up contacts included client cooperation, access to accurate information and the type of tracing done. Figure 6, below shows contact tracer responses



Key

*Dissonant findings among tracer perceptions

Gadgets include Telephones, Cell phones, Tablets and/or Computers

Figure 5: Barriers and facilitators to following up COVID-19 contacts, EHD,2021

Availability of gadgets (cellphones or tablets), transport, airtime or data, and PPE were reported as facilitators to following up contact tracers. Similarly, workforce related factors such as high workloads, having other duties and staff shortages were reported as barriers to being able to

follow-up contacts. Good contact tracer communication skills and the ability to create good relationship with the contact were reported to be facilitators of contact tracing follow-up.

"Too many COVID-19 contacts in a short space of time" **(Tracer 38)**

"Creating a relationship with the patient made the clients trust me" **(Tracer 102)**

A few CTs reported that they were anxious to do physical tracing for many reasons including being "scared" to enter some houses (personal safety) and being worried that they might to meet with clients that have severe symptoms. Almost a quarter (28/118, 23.7%) of contact tracers reported that the availability of accurate and complete client information, with available alternative contact details facilitated contact follow-up. There were also differing perceptions regarding the contact tracing type that enabled follow-up of COVID-19 contacts. Most tracers felt that telephonic tracing or doing both telephonic and physical contact tracing enabled better follow up of contacts, however, a few tracers having the perception that physical facilitated for follow-up. Conversely some tracers perceived physical tracing or telephonic tracing to be a barrier to follow-up. Contact tracers reported that phoning contacts daily was a barrier to follow up and suggested that following up on alternate days or at 3-day intervals would facilitate effective case and contact following-up. Contact tracers also suggested that district based (centralized) follow-up and the use of SMS's for following up may also facilitate follow-up. Some tracing challenges that were reported were around the enforcement of COVID-19 regulations, with some suggesting that legislation needed to be ammended.

"Some move around, even go shopping" **(Tracer 64)**

(Making) "Self-isolation being compulsory by law" **(Tracer 27)**

Client factors were the most cited barriers and facilitators for contact follow-up. Perceived facilitators for follow-up included cooperative clients and those that are knowledgeable, empowered, who trusted the system and who appreciated being followed up. Conversely barriers that were reported included client factors such as client unavailability, clients that change phone numbers, hang up phone calls, are unwilling to be monitored, complaints about too many calls, or calls going to voicemail and clients that locked their gates rendering their households inaccessible. Tracers also reported that aggressive, impatient, rude, annoyed clients were a barrier to contact follow-up. Informing clients about the monitoring process early, patients that remained in one residence during quarantine, situations where contacts and cases were in one family or other residence, and clients that tested positive during follow-up facilitated better contact follow-up. Conversely, clients in "denial" and contacts that stayed alone was cited as a barrier to contact follow-up. COVID-19 stigma and lack of community engagement were cited as barriers to contact follow up. Following up contacts in the same household as cases facilitated easier following up

contacts.

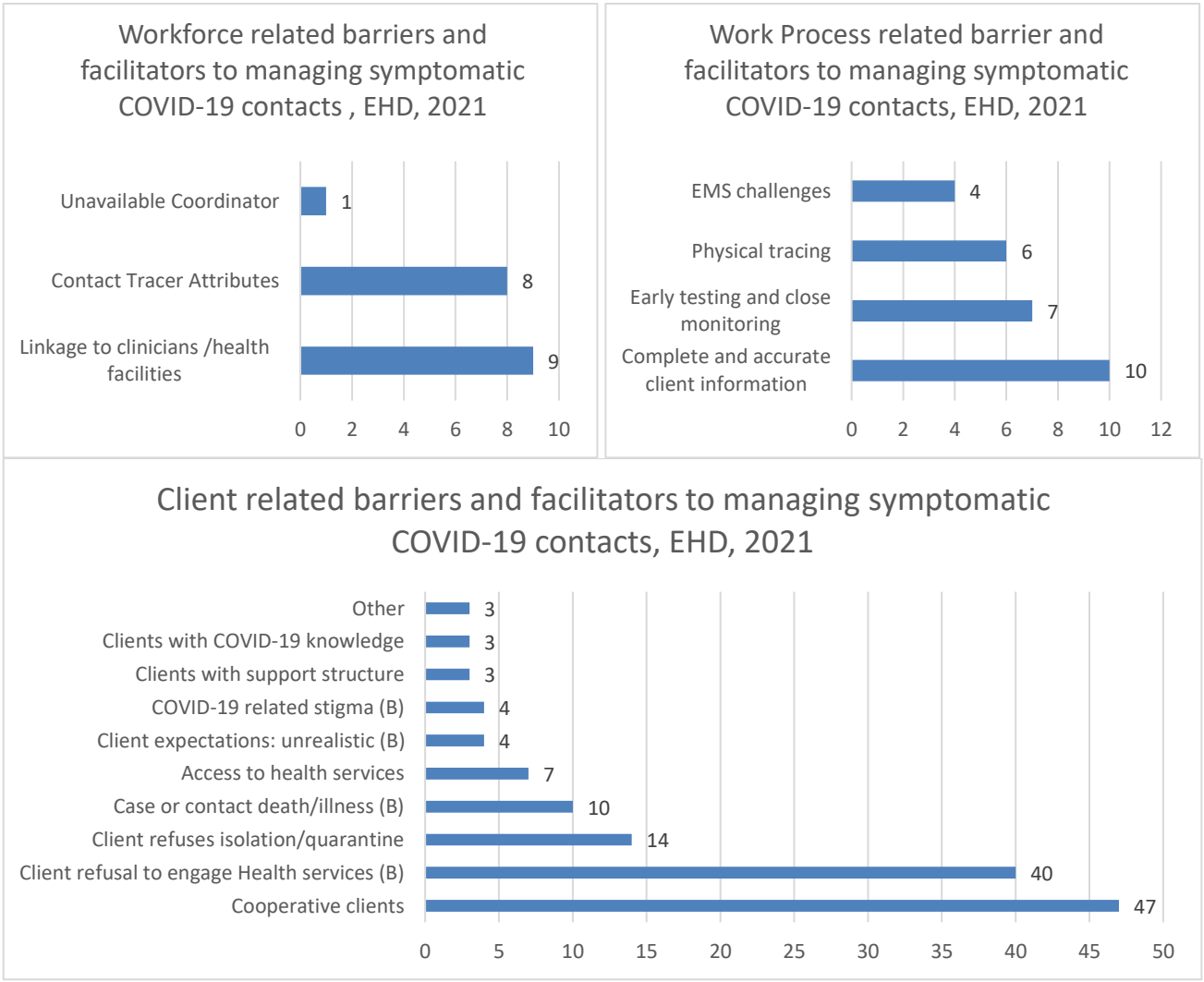
"Rude clients, some were in denial, people who came from private facilities reported to be negative, but turned out to be positive" **(Tracer 98)**

"One family member would speak for all the other contacts in the family, and we didn't have to call everyone in the family for follow-up" **(Tracer 110)**

"To educate the community, they don't want to open the gate" **(Tracer 34)**

Managing contacts with COVID-19 symptoms: Contact tracer perceptions on barriers and facilitators

CTs were asked what made it easier and more difficult to manage symptomatic COVID-19 contacts. Client related factors were cited by most tracers to be an important barrier to managing symptomatic contacts, most notably uncooperative cases and client refusal to engage with health services. Tracer responses are illustrated in the below figure 6



Key

Gadgets include Telephones, Cell phones, Tablets and/or Computers

"Other" client related barriers and facilitators included patients that were not found and clients that "panicked"

Figure 6: Barriers and facilitators to managing symptomatic COVID-19 contacts, EHD,2021

CTs reported that teamwork among tracers and between health service providers such as in health facilities led to better linkage to clinical care, however accessing emergency medical services and delays in patient pick up were perceived to be barriers to good symptomatic patient management. Supportive and available coordinators, facility managers, clinicians or other staff in nearest health facility were facilitators for better management of contacts with COVID-19 symptoms. Conversely, lack of transport and clinics that did not receive symptomatic patients were perceived to be barriers to symptomatic patient management.

"Being in touch with health facilities. Giving patients emergency numbers, Education" **(Tracer 97)**

"Patients calling us after we have handed them over to the nurses and doctors because they are not allowed to get into facilities" **(Tracer 108)**

Contact tracer attributes, including communication skills and the ability to explain processes, listen to contacts and be vigilant when communicating with client were reported to be facilitators of good management of symptomatic patients. Contact tracers perceived that tracing patients physically, early testing, close monitoring and access to emergency services were facilitators of good management of symptomatic contacts. Early home testing was perceived to facilitate good symptomatic client management, however, client expectations were sometimes unrealistic, where some contacts expected to receive clinical care in their homes.

"The easiest way (to manage symptomatic patients) is when the coordinators arrange transport and organize professional nurses to test the contacts at their homes" **(Tracer 46)**

"(Challenge is) when the patient is requesting for oxygen, and you cannot help him or her" **(Tracer 17)**

Multiple client factors were perceived to be barriers to managing symptomatic COVID-19 contacts including clients that refused to be referred, followed up or tested for COVID-19 and those that refused to be quarantined, denied having symptoms, lied about COVID-19 status, or were uncooperative. Other perceived barriers to symptomatic patient management included situations where a patient was very ill and unable to communicate or a symptomatic contact that had acute anxiety or panic episodes.

"Some did not want to test, they say "it's just a flu" **(Tracer 83)**

"They become anxious; they don't want to go to the hospital" **(Tracer 64)**

Cooperative, knowledgeable clients that were transparent and/or engaged and those with good support structures were perceived to facilitate good symptomatic contact management. Giving health education about COVID-19 symptoms before client developed symptom was also perceived

to enable better management of symptomatic clients.

Factors associated with contact tracing outcomes

Univariate and then multiple variable regression analysis was performed to determine factors that were associated with different outcomes. We found that tracers that only did physical contact tracing were less likely to report that contact tracing was easy to do (OR:0.25, p=0.020), while telephonic contact tracers were more likely to report that it was easy to find contacts (OR:4.38, p=0.022). Telephonic tracers were more likely to have used electronic tracing tools (OR: 3.28, p=0.023), as were sub-district North contact tracers (OR:3.39, p=0.004) and tracers that were not DOH or COE employees (OR:3.67, p=0.054).

Table 7: Multivariable regression analysis for contact tracing outcomes (Ease of doing contact tracing and use of electronic tools), EHD, 2021

Variable	**Category**	**Univariate**		**Multivariable Analysis**	
		OR	**p**	**OR**	**p**
Outcome variable: Ease of doing contact tracing					
Contact Tracing Type	Both Physical and telephonic	1			
	Telephonic	0.95	0.911		
	Physical	0.32	0.043	0.25	0.020
Outcome variable: Use of other (non-paper-based) CT tools					
Place of Work	District	1			
	East	1.33	0.616		
	North	1.42	0.577	3.39	0.044
	South	0.444	0.213		
Contact tracing type	Both Physical and telephonic	1			
	Telephonic	1.80	0.170	3.28	0.023
	Physical	0.64	0.420		
Employer	DOH	1			
	COE	0.62	0.334		
	Other	2.69	0.112	3.67	0.054

Contact tracers that had previous contact tracing experience (OR:3.43, p=0.018), who had been doing contact tracing for more than a year (OR:2.66, p=0.071) and who worked in the South sub-district (OR:4.88, p=0.003) were more likely to report that they found it easier to find COVID-19 contacts. Contact tracers that worked in the East sub-district (OR:2.58, p=0.036), that had been

tracing for more than a year (OR:2.84, p=0.023) and that were female (OR:4.30, p=0.024) were more likely to report that they took less than 2 days to find contacts. On univariate analysis contact tracers who have received formal contact tracing training (OR:2.74, p=0.025) and tracers with previous tracing experience (OR:2.97, p=0.010) had better manage symptomatic cases. There were no factors that were associated with better management of symptomatic patients on multivariable analysis

Table 8: Multivariable regression analysis for contact tracing outcomes (ease and time to finding contacts and symptomatic contact management), EHD, 2021

Variable	**Category**	**Univariate**		**Multivariable Analysis**	
		OR	**p**	**OR**	**p**
Outcome: ease of finding COVID-19 contacts					
Contact Tracing Type	Both Physical and telephonic	1			
	Telephonic	1.23	0.662	4.38	0.022
	Physical	3.07	0.046		
Contact tracing experience before COVID-19	No	1			
	Yes	3.20	0.008	3.43	0.018
Time doing COVID-19 contact tracing	< 1 year	1			
	>1year	1.72	0.197	2.66	0.071
Place of Work	District	1			
	East	1.22	0.766		
	North	0.63	0.564		
	South	4.50	0.033	4.88	0.003
Outcome: Time to finding COVID-19 contacts					
Sex	Male	1			
	Female	2.39	0.078	4.30	0.024
Place of Work	District	1			
	East	4.28	0.014	2.58	0.036
	North	2.57	0.150		
	South	1.22	0.758		
Time doing COVID-19 contact tracing	< 1 year	1			
	>1year	2.15	0.046	2.84	0.023

Variable	Category	Univariate		Multivariable Analysis	
		OR	p	OR	p
Outcome: Management of severe COVID-19					
Place of Work	District	1			
	East	1.65	0.394	1.96	0.184
	North	1.90	0.332		
	South	1.67	0.812		
Contact tracing training	Informal	1			
	Formal	2.74	0.025	2.04	0.149
Contact tracing experience before COVID-19	No	1			
	Yes	2.97	0.010	1.96	0.165

The data also suggests that COE staff were less likely to report the highest percentages of contacts were followed up (OR: 0.34, p=0.068), and South sub-district staff were more likely to report the highest percentages of contacts that were followed up (OR:2.47, p=0.075)..

Table 9: Multivariable regression analysis for contact tracing outcomes(contact tracing follow-up), EHD, 2021

Variable	Category	Univariate		Multivariable Analysis	
		OR	p	OR	p
Outcome: Proportion of COVID-19 contacts followed up over the quarantine period					
Employer	DOH	1			
	COE	0.28	0.020	0.34	0.068
	Other	0.35	0.092		
Place of Work	District	1			
	East	2.53	0.148		
	North	1.72	0.441		
	South	3.00	0.115	2.47	0.075

Results: Contact tracing managers

Characteristics of Contact tracing managers

Most managers were female (18/22, 81.82%) and they had a mean and median age of 50 years, with an interquartile age range of 42-57years. Most managers had been involved in contact tracing for more than a year (19/22, 86.86%), and half of the managers were not normally involved with contact tracing but were allocated to support contact tracing (11/22, 50.00%) Other Demographic Characteristics are shown in Table 8 below:

Table 10: Characteristics of Contact tracing managers

Variable	Category	Distribution	
		n	%
Staff Category	District managers	3	13.6
	Sub-district Managers	6	27.3
	EPI Coordinators	3	13.6
	Facility managers	10	45.5
Employer Name	Department of Health	14	63.6
	City of Ekurhuleni	8	36.4
Time involvedCOVID-19 contact tracing	<1 year	3	13.6
	>1 years	19	86.4
Place of Work	District	3	13.6
	East	9	40.9
	North	4	18.2
	South	6	27.3
Employee Duties	Contact tracing is part of job spec.	11	50.0
	Contact tracing not usually job spec	11	50.0

Contact tracing managers perceptions of contact tracing preparedness

Managers were asked to score, out of five, their perceptions on how well supported and equipped they were, how clear their roles and responsibilities were, and whether they felt they had access to tools and adequate time to perform duties. We found that managers scores were highest for how well equipped they were (3.6/5) and lowest for adequacy of time to perform their duties (2/5). When Fischer's tests of difference in score distributions between COE and DOH managers was performed, all p values were higher than 0.05, therefore we failed to reject the null of no difference. This showed that there was no significant difference in the perceptions, for all the five items (refer to Table 9), between managers employed in the DOH when compared to those employed by the COE.

Table 11: Managers' scores for perception of contact tracing preparedness, EHD, 2021

Variable	Min	Max	Mean	Standard Deviation	Fischer's test (COE vs DOH) p value
Support in Contact tracing role	1	5	3.4	1.14	0.905
Equipped to perform CT duties	2	5	3.6	1.14	0.493

Variable	Min	Max	Mean	Standard Deviation	Fischer's test (COE vs DOH) p value
Clear roles and Responsibilities	2	5	3.5	0.93	0.917
Access to all tools required to be able to perform CT duties	1	4	3.2	1.07	0.632
Time capacity to do Contact tracing work	1	5	2.0	1.10	0.791

Most tracing managers undertook training themselves and facilitated training for staff members, both on the novel (COVID-19) pathogen and on contact tracing, at the beginning of the district outbreak.

"we were never trained for a pandemic, and now here overnight there is this thing we do not know about (it). We had to (go and be) first be educated about (this), the disease itself. And even the contact tracing had (to like, okay,) some days this is the situation, tomorrow it is that situation, and at the end of the day you have to work it out yourself as the manager…….so, it was a learning curve for everybody." **(IG1)**

The contact tracing process

District level managers reported that there was an initial lack of communication and engagement with the district as COVID-19 cases were identified in communities, which would have informed the district and enabled more informed decision making. Later there was interference from multiple decision makers at district and higher level, including politicians. This negatively impacted the ability of district to prepare, plan, monitor and make decisions to avert the COVID-19 disease outbreak locally.

"there was not enough information in the first place as to say what am I supposed to do. And who are the people that I am supposed to work with. Are they the doctors or the nurses or environmental or who? And, if now we are working, what is it that we are supposed to do there? And, if we have done that, whom are we supposed to tell? And after telling that person, then what will be our next step? ……Much as it might be a new disease, but some of the principles, or some of the rules still apply to some conditions or some processes that needs maybe to be followed" **(IG17)**

"I don't feel in control of the outbreak. Do you see what I'm saying? When we have, let's say example, a measles outbreak, we will go to that area, identify population, take action, control it. For the next three months, look how the movement is, and then we can see that, no, the cases

have stopped. They've gone on. But with this one, I think we, as CDC (communicable disease control) teams, not me alone, as CDC (communicable disease control) teams, we ended up not, you know, it's difficult when you think you know what you're doing, but because you are required, you know, to be reporting every five minutes, you lose control of the outbreak. Now, you are running after figures and reporting, and I think that messed up the whole outbreak." **(IG16)**

"*I used to go out, trace, and then you come back, actually we're locking up at night, 21 hours. You have to go through the tracing (data). At the same time, we used to be called to say there are new people. Those people who are coming from other countries. You have to go there at the Hotel to test so many people. While you are there, somebody has tested and another challenge that would come up is that those people working in the government institutions, they always wanted to take priority."* **IG7**

According to manager responses there were no clear policies that were guiding the district approach to the pandemic. The NDOH developed guidelines and contact tracing for use in the country, however, these contact tracing tools were difficult to use in the district setting and had to be amended for use in the district.

"There were no policies in place that were guiding us." **(IG2)**

"We originally had COVID tools from the national, which were not district friendly. So as a district, we had to make a lot of amendments to suit what we require from the contact tracing. So, with the help of the (Public Health) specialists and the registrars, then we were able to create tools that were friendly for contact tracers out there." **(IG18)**

There was also a delay in increasing district capacity for contact tracing and testing at the start of the outbreak, and this was coupled with unrealistic work expectations such as the expectation that all household contacts should be tested.

"At the end we established a team, yes. But initially, it was just me until the team was there" **(IG18)**

There was initially limited laboratory capacity provincially, so even when tests were done for symptomatic contacts there were delays and sometimes receipt of their test results. This led to district staff being overwhelmed and frustrated, as can be seen from he responses below.

"Remember that the issue of testing was also a challenge. And previously the testing was like, it should be done in a way that it gives results. If now the results are not coming or the specimen it says insufficient, you do not know now what do I do. The person was even fighting for the

first time. Is he going to allow me to take the second swab?..... you have taken the specimen from these clients, now they need results. Maybe the isolation time it is now finish. They need to go back to work or wherever. The results are not there. What do you tell them? You are also frustrated yourself, because now the specimen was sent to the laboratory. You will try to call the coordinator for the lab, she is also not having the answers." **(IG17)**

As with district implementation, initially there was a delay in increasing sub-district resources to enable incorporation of contact tracing into sub-district activities. This delayed access to resources cascaded down to facilities that started conducting tracing earlier in the outbreak.

"In the beginning remember that they were not having cell phones. So, it was also a frustration from their side to say if they want to call, they were also using their personal phones to call you, or you call them on their personal cell phones, and you cannot call them post work hours, because they will say no this is our phones, you cannot use the phones to call us on work related issues, because now the Department refuses to give us the phones." **(IG17)**

" in terms of the resources that needs to be used, it was a problem. We did not have much resources. We were using facility resources." **IG11**

The Contact tracing process was initially centralised in the district head office and then became decentralised firstly to sub-districts offices and then further down to health facilities. At all levels, senior management initially took on the role of doing physical tracing with various staff members, however, as numbers increased there was a realisation that COVID-19 the tracing strategy had to change. Tracing teams were established, and telephonic contact tracing was also initiated. Physical tracer teams usually consisted of a clinician, an administrative staff member and a community health worker or enrolled nursing assistant with a few deviations such as those seen in the South sub-district where health promoters were also part of contact tracing teams. Telephonic contact tracing became the mainstay of tracing and physical tracing was reserved for cases or contacts that could not be found or who developed COVID-19 symptoms. The East sub-district rapidly decentralised to facilities and because the PDOHand COE (local government) spheres of government were very functionally integrated, they had a cohesive strategy of contact tracing implementation in the sub-district which was more effectively implemented.

"At first we were supposed to do the home visits, which we did with …. (DOH) and because the numbers were not as large as subsequently. And then, when then the numbers increased, we did the phone tracing. And then, because the numbers were increasing gradually, we had a meeting to discuss how we can also involve the facilities…… we called the managers to have meetings……. We were sharing actually." **(IG14)**

"When we turned into doing telephonic tracing, it was much easier compared to the physical tracing. So, what we did is that we only do physical tracing to cases that come out from the telephonic tracing, to say this one, they have symptoms. Then, we will only refer those cases that will need testing and need medical check-ups, or something like that." **(IG16)**

There was some delay in the COE and DOH integration in the South sub-district, and reportedly severe staff and other resource constraints within the South COE sub-district office. This resulted in different approaches to contact tracing in the two spheres in the South sub-district initially. The COE utilised health promotion officers for telephonic and physical tracing while the DOH office utilised the centralised district-based telephonic tracing teams. These COE and DOH teams continued to support the South sub-district contact tracing activities, however, there was a cohesive strategy for decentralising contact tracing to health facilities, where both COE and DOH facilities became responsible for contact tracing within the populations that they served.

"The problem is, (the City of) Ekurhuleni Municipality is saying, it's an unfunded mandate. The money has been allocated to province…. but there is no equal distribution of resources. Why I am saying that, the resources that were supposed to come to City of Ekurhuleni, it is a challenge, but with province, there is no challenge. And yet we are told that we are one, so there is no fair equal distribution of resources." **(IG22)**

There was some integration in the North sub-district. Initially the DOH implemented physical and telephonic tracing, which was based in the DOH sub-district offices, with increasing numbers they created multiple contact tracing teams. At facility level, the COE began integrating and increased contact tracing activities. A "cluster strategy" where teams were made up of clinic staff members from different facilities in a geographical cluster of facilities was used. Facility tracing was largely physical contact tracing, however, there were many challenges that arose out of the fact that these facility staff members were still expected to fulfil their facility work responsibilities before they could be released to perform contact tracing activities.

"You will send the list to the cluster. At the end of the day they did not trace. And when you find out why they did not trace, "Ja, no, we were busy in the facilities". ……. There would be those two clusters that are committed, and those clusters that are, yoh, they will just take their list ….my recommendation is just to have one sphere of department of health." **(IG20)**

COE and DOH approaches with regards to facility functionality, were different, as some DOH facilities downscaled the provision of non-COVID-19 related services to accommodate the pandemic while COE facilities largely did not downscale other health services.

The workload was high for facilities and there were staff shortages firstly because staff had to be

allocated from already human resource constrained programmes, but some staff members were also falling ill and having to isolate or quarantine, staff with and without chronic diseases were concerned about contracting COVID-19, especially in the first few months of contact tracing. There was also the issue of competing priorities where human and other resources were needed for other activities such as community testing, vaccination, or outreach services. Facilities found various ways of mitigating these staff shortages including tracing on weekends or after hours, often without being paid for the overtime work hours.

"you had first to brief people and to make them aware of the importance of being part of the team and to be available even after hours, although it was difficult sometimes to some people to be available after hours….. It has been a challenge. People have been demanding to be paid overtime, to work beyond their normal hours. " **(IG21)**

"I remember at some point, we had to have both teams on duty at the same weekend, because the list was just too big. You would find one team has to visit forty-five households and the other team would visit fifty households, and then you get into one household, there are eight or ten people that are close contacts to the index case and all of them are symptomatic. They need to be tested…." **(IG9)**

"*if you do not finish this Saturday, there is a list for Sunday. Then, it means you are adding. So, you must try and make sure that whatever is allocated for Saturday, you will work and finish it, because you do not know. The list for Sunday might even be worse than the one for Saturday."* **IG9**

"What made it easier was the fact that each and every team member had a role to play when it comes to reporting time. Then, we would share and say, take this ten, I will take this ten. Then, we do compile it and then we just combine. Then, it becomes easier, unlike when it is done by just one person. So, all of us, we had a duty when it comes to data. Then, at the end of the day, we all had to sit and compile the report" **IG9**

Managers' perceptions of data collection, quality and use

Most managers (11, 50%) reported that they had used district modified paper-based tracing tools while 18% (4/22) had used the Mpilo app. Less than 10% of managers reported using the COVID-Connect, DHIS, DATCOV and using platforms such as GPS, google sheets and Excel. Managers asked to score their perceptions, out of 10, about the usefulness of the contact tracing tools that they had used, with 10 being an extremely useful tool. Table 10 below illustrates the managers average scores

Table 2: Managers' perceptions of usefulness of contact tracing tools, EHD, 2021

Item	n (%)	Min	Max	Mean (SD)
Paper-based tools	11 (50.0)	4	10	8.4 (3.5)
Mpilo App	4 (18.2)	1	9	3 (4.0)
DHIS tool	2 (9.1)	5	10	7.5 (3.5)

As shown in table 10 above, managers felt that paper-based tools were the most useful, scoring them at 8.4/10. Only two managers had used the DHIS tool, and they scored the 7.5/10 for the usefulness of the DHIS, while the Mpilo App scored 3/10. Various challenges were cited for the low scores given for electronic tools, including internet connectivity challenges, inability to retrieve captured information or reports from the apps and in the case of Excel, issues with distorted data.

(Mpilo App) *"The connection would go off and another thing, it's like when you have captured something here, you cannot go back and retrieve or see what you have captured. What you have captured, you have passed. I don't know if it will ever only be visible to .....of whoever is seeing the reports. But you as a person, you cannot, you are unable to go back and check as to whatever that today, whoever you captured today, it was not easy to do that. And then the connection was always a problem."* **(IG7)**

(Excel)"So, but the challenge with the consolidation, you have to make sure that your numbers, your case numbers, your district case numbers, align, because once they move out of alignment, the whole data is distorted. That's one of the challenges. So, every day when they bring back the... Before you start consolidating, you should check if the cases, the way the line list is, it's the same as the way you issued it out. And then also, you have to make sure that you correct the fractions to full, whole numbers. Because if they've updated the contacts, let's say, yesterday, they only got one, but when they complete isolation, they've got five." **(IG16)**

Managers reported that there was poor data timeliness, which they perceived to be due to non-automation of information, and which sometimes led to duplication of tracing efforts, and delayed tracing of cases and contacts in health facilities.

""that everything that is reported is real time. You are not lagging (behind), because that is when now sometimes when you call, they are saying, "Why are you calling me after so many days?" They are sort of feeling like they do not need the service, but when we are on point, as you receive the list, we call the list. We follow up them on time. We have the gadgets. We report again on time." **(IG3)**

"...And the person would say no, but then another clinic came, or other people came to service us, and we already have been traced…….if we would have a system where, as the patient is

captured, ….they would immediately generate that the person in this address, …… then it will make things efficient and it will not take time. So, it will maybe have assisted. But yes, someone had to populate the information, which takes a bit of time." **IG11**

Managers were asked to tell us their perception about data completeness, accuracy and timeliness out of five, and mean scores were 3.2 (SD:1.21), 3.7 (SD:0.77 and 3.4 (SD: 0.96) respectively. When managers were asked what they used data for, 68.2% (15/22) said they used data for reporting while 63.6% (14/22) said they used the data for decision making such as determining where "hot spot" areas and determine where to conduct more COVID-19 testing. Some (13/22, 59.1%) managers also said they used their data for planning, most notably for human resource planning. Most managers reported that they analyzed their tracing data at least once a month (16/22, 72.73%)

Contact tracing managers perceptions on contact tracing outcomes

Contact tracing managers were asked to score out of 10, how they perceived their area to have performed in contact tracing. (See table 11 for managers responses) Contact tracing was defined as the ability to identify COVID-19 contacts, trace or find them, follow them up over the quarantine period and timely referral for COVID-19 testing in instances where contacts develop symptoms. The mean overall manager's score for perceived performance was 6.8 (SD:1.6), with a median of 7.5 (IQR:5-8). When managers' scores were stratified by area of work, we found that the district mean score was 7.8 (SD: 0.35), East sub-district mean score was 6.4 (SD:1.7), North was 6.8 (SD:1.3) and South was 7.1(SD:2.1). A Fischer's exact test showed that there was no significant difference in perception of contact tracing performance between the three sub-districts areas (p=0.733).

Table 3: CT managers perceptions of overall contact tracing performance, EHD, 2021

Item	**n**	**Min**	**Max**	**Mean (SD)**	**Fischer's test of difference: p value**
Overall contact tracing outcome score	17	4	8.5	6.8 (1.56)	
North sub-district score	4	5	8	6.8 (1.25)	0.733
East sub-district score	7	4	8	6.4 (1.72)	
South sub-district score	4	4	8.5	7.1 (2.10)	

Some managers felt that contact tracing performance was not uniform with poorer contact tracing

quality during peak and better-quality contact tracing in between peaks when case numbers where lower, furthermore managers felt that there was better tracking and tracing of COVID-19 cases that contacts. Managers reported that tracing backlogs commonplace, especially during COVID-19 outbreak peaks.

Managers perceived Barriers and facilitators to contact tracing

Tracing managers' perceived barriers and facilitators to contact tracing implementation were categorized into programmatic, workforce, tracing processes, data processes and client related factors and are shown in the diagram below and discussed in the following paragraphs. The greatest perceived facilitator to contact tracing was teamwork as shown in Figure 7, below.

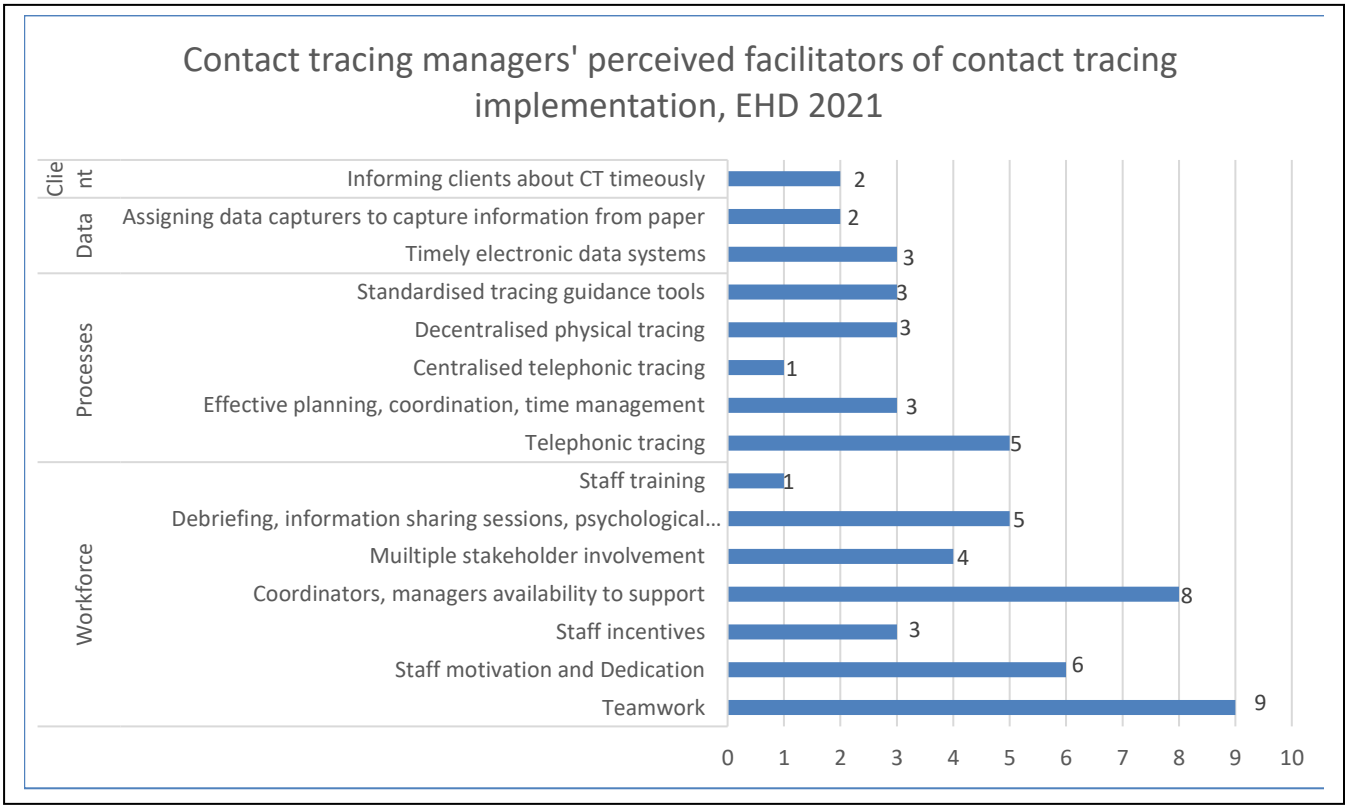


Figure 7: Contact tracing managers perceived facilitators to contact tracing implementation, EHD, 2021

Tracing managers perceived poor data quality and staff shortages to be the greatest barriers to contact tracing implementation as shown in the Figure 8 below.

Figure 8: Contact tracing managers perceived barriers to contact tracing implementation, EHD, 2021

Managers perceived programmatic barriers and facilitators to contact tracing implementation

There was a concern by one manager that was no policy on how contact tracing is supposed to be implemented, and this corroborated by managers that explained that they learnt what to do as the pandemic progressed. Managers cited instances where there was poor communication between the district and sub-district, and among different stakeholders which impeded contact tracing implementation and once resolved contact tracing was able to move forward. Some managers also perceived the fact that contact tracing was an "unfunded mandate" and also the fact that DOH and COE are not administratively integrated to be barriers to contact tracing implementation.

"…. she taught me what she knew. It was not sort of there were policies and standards and say this is how things are supposed to be. I was just grasping from what she was saying…." **(IG3)**

"….we would think on how to do the reports and things like that and then district would come with their own plan on how to report and things like that. And then, it was like not communicated properly how to do the thing. It was sort of like a trial and error and then they

would come, we have a meeting and then discuss so that we can have a uniformity of the reporting" **(IG14)**

Managers perceived workforce related facilitators and barriers to contact tracing implementation

More than three quarters (18/22, 81.82%) of managers cited staff shortages as a barrier to contact tracing, firstly staff with chronic diseases were initially not included in COVID-19 related activities, then later staff would be absent from work because they were sick or had burnt out. Conversely, teamwork, staff dedication, and the participation of other district programmes with multidisciplinary approach and involvement of other departmental and external stakeholders was cited to facilitate effective contact tracing. There were issues with motivating some staff members in the North sub-district, with issues, notably in the COE around being compensated for overtime work.

"They were committed. They never complained,..... they never complain that it is Sunday, I am not working. They were always available." **(IG12)**

""Everyone was just, you know, giving their best that they could, and with that I think made it easier that, in as much as they have their own other programmes that they are employed for, with this additional one that was not even part of their job description that that was not even part of their scope. When I sat down with them and explained that we are now expected to do 1, 2, 3, you know, they supported, and everyone just, you know, was willing to participate" **(IG15)**

*"Sometimes it was some hassle to get, although at the end, we used to get people to help that, you had first to brief people and to make them aware the importance of being part of the team and to be available even after hours, although it was difficult sometimes to some people to be available after hours. It was a momentous task to get one to say I am available afterwards or even on weekends. It has been a challenge. People have been demanding to be paid overtime, to work beyond their normal hours. "***(IG21)**

The provision staff incentives such as being paid overtime or getting water and or snacks when working in the field, were perceived to be facilitators of contact tracing, while staff safety in the field and the fear of contracting COVID-19 which happened especially in the beginning were cited as barriers to contact tracing.

""It is staff, when most especially during the first, the first wave, there was a lot of fear amongst staff members. They did not want to get exposed to COVID-19.....people had all those fears, with or without PPE." **(IG12)**

There was a high tracing workload and competing work priorities firstly for tracers, but also for

supporting programmes and tracing facilities. Staff training, the availability of managers and/or coordinators to support staff, facilitating debriefing and information sharing sessions and the psychological wellness of tracing staff were perceived to be facilitators of contact tracing, as was effective planning, coordination, and time management.

"You know, Monday to Monday, anytime of the day, at night times or in the morning on a Sunday or whenever, you get maybe a message ……"There is a household that have got a positive case. Go and..." So, you will just have to be available at any time. So, there were days where we were working nonstop. You know, going to the households for tracings and telephone tracing…. It was difficult" **(IG15)**

Managers' perceived tracing processes related barriers and facilitators to contact tracing implementation

The lack of access to tracing equipment, most notably telephones, laptops and/or gadgets and PPE was cited as a barrier to contact tracing by half of the managers (11, 55.00%). Lack of transport, with tracing teams sometimes using other programmes' cars or mobile vans and having to trace cases or contacts in hard-to-reach places including informal settlements were viewed to be barriers to contact tracing. Other resource related barriers to contact tracing were lack of airtime, workspaces for tracing, laboratory specimen collection process gaps and the shortage of isolation and/or hospital beds when needed.

"At first, we were using the (programme) funds to communicate, and there was a problem with the bills were high….., the District gave us cell phones, to assist, and the airtime will run out, then you'll get a message that it was overused, ……. so, you end up using your own at times, ... you can see that this person is struggling to breath. I'm heading for a disaster. You'll use your phone to phone an ambulance." **(IG22)**

"We were sharing transport with the school health nurses. So, it was easier when the schools were closed, but once they are open, we have a challenge with transport. We have to wait for them to finish their programme and then that is when they will give us a car. It is only this year that…. At least we had the car that was allocated to the clinic". **(IG12)**

There was a perception among managers, as with tracers, that physical contact tracing was the more effective system of tracing and yet telephonic tracing was the more efficient way of contact tracing. Managers' perception was that centralised telephonic tracing and decentralised physical tracing facilitated a better tracing system and physical tracing, especially during peaks,

was a barrier to tracing. While implementing physical tracing alone was cited as a barrier to reaching more cases and contacts. Daily contact tracing was also perceived to be a barrier to

implementing contact tracing once cases were very high, following up a patient three or four times over the quarantine or isolation period enabled tracers to be able to trace more cases. Standardised tracing tools that guided contact tracers was perceived to make contact tracing work easier.

"I think it was better when we were doing the physical contact tracing, because when we get there, you are at home. And you are able to find out who are you staying with, they are there at home and everything. But since we're also doing the telephone tracing, then you're speaking to this one and can just tell you whatever they want to tell you. So the physical contact tracing, it's much better than the telephone contact tracing. And I prefer the physical, it really did the work, but then the time." **(IG20)**

"*In the beginning when the cases were fewer, we were doing quite well, because we, with the templates that we were using, we knew when to follow. But as the cases became too much, we needed to now re-adjust and change the template to phone every third day, or fourth day, to cover, you know, at least three to four calls per patient during the time. So, we had a lot of adjustments to do because the cases were becoming too much, and realistically, we couldn't..."*

(IG16)

Managers perceived data related facilitators and barriers of contacts tracing implementation

Most managers' perception of the district paper-based tools was that they were useful, simple to use, and facilitated effective contact tracing. The district paper tools guided tracers on which questions they had to ask, however, they noted that there were inefficiencies in that you had to constantly be printing copies for use daily, and managers would still have to collate the information and capture onto Excel spreadsheets for reporting which became barriers to contact tracing. In some facilities, the use of data capturers to collate and capture of information for reporting improved data quality and timeliness of reporting.

"Paperwork took a lot of time and some facilities made sure they had many administrative support staff to capture lab forms, tracing tools and tracing tally sheets. After working facility teams would have to sit together and tally the work that has been done for the day in order to send the daily report to the district and to their managers. The collating of tracing work was time consuming as multiple papers had to be consolidated and then captured into the excel or word document for reporting." **(IG9)**

"I feel paper-based, uhm, it still needs, you do double work, for instance. So, whereby you have to fill in the papers, but then you will have to report an Excel document to the DOH website. So, if we would have one system, electronic system, that will be, it would have been better for me."

(IG11)

"*Excel is never easy, because then it gets corrupted. And now you will find your numbers are not as what you have reported, and some are missing."* **(IG11)**

Most managers (21/22, 95.45%) perceived that poor data quality was a barrier to implementing contact tracing. Missing, duplicate, incorrect and delayed information affected the ability of the tracing team to trace cases and contacts in a timely manner and duplicate efforts. Another barrier was that information was collected on paper-based tools and having to collated into electronic database was time consuming. Though electronic Apps were available for use, they were not found to be useful for various reasons including the inability to interact with the app or to use the data for reporting.

(Mpilo App)" I think it used a lot of network data….and sometimes, the tablets would lose the network in hard-to-reach places. And then, secondly, was that once the teams had gone out, and as a district we're trying to retrieve the work that was done for the day, we couldn't retrieve that data. We had to wait for the Mpilo people to create a dashboard of what was done for the previous day. And then, when we looked at the dashboard, then we look at the paper tools, the information was not tying. The dashboard was always behind, so it shows us that it is not really providing information, true reflection of what is happening on the ground.

." **(IG16)**

"But I think failure for the national or province to have software specific for outbreaks has made, created a lot of work for us, because we had to move from paper to finding a better solution. And the software(s) that were created, they didn't create the software with the districts. They don't involve the districts when they do whatever that they do, and at the end of the day, you find that the districts can't work with that. There's no point of having the best idea if you don't involve the people at the ground level that knows the challenges. And they didn't even pre-trial it. They didn't try it out to say, let's see if maybe in the first month, if it will work, and then improve on it. They just introduce it without pre-trialing it, and it becomes a problem." **(IG18)**

Managers perceived client related facilitators and barriers of contact tracing implementation

Managers cited various client related factors to be barriers to contact tracing including clients that were uncooperative, misinformed and unwilling to engage with contact tracing teams. The issue of COVID-19 related stigma as a possible cause for lack of engagement was mentioned by some managers, and unrealistic community expectation and language barriers were also perceived to be barriers to contact tracing. Some managers suggested that informing clients about contact tracing at the point of testing may facilitate tracing by improving client cooperation as would allocating one tracer to each contact for continuity of care and building of rapport.

"….. most of the people are like, would say they are vaccinated, or they are getting vaccinated. And some of them, the people do not understand the reason why we are still calling. Yes. And they would even want to find out, and what do you do with it? And then you explain and say but

it is useless because we are all going there to be vaccinated……Some of them do not even want to talk to you. You call and then say, "Why are you calling here?" I am calling in connection with this as a support. "No. I am not interested." Phone down" (**IG1)**

"*What made it difficult on the other hand was that once the person then has tested positive and you visit the family, then the family members from that specific house would start experiencing from the other community members in the street, a different kind of treatment, because .....once they see these people wearing blue gowns or white gowns, then they know, there is a COVID case there."* **(IG9)**

"We also give them an option to say should anything happen to you between this period, don't hesitate to phone. So, that's why we allocate specific cases to a specific person. So that person will then communicate with this person, then we know that they're being handled by one team member" **(IG16)**

Discussion

Contact tracing preparedness and outcomes

It was reported that in many affluent countries there were few contact tracers that were available to do COVID-19 contact tracing and this may be because infectious outbreaks are less common in these regions.(23) There was a multi-stakeholder, multidisciplinary, inter-departmental approach to implementing contact tracing in EHD, and this enabled leveraging on external stakeholder strengths. This was also done in Nigeria where the DOH leveraged on partner support in order to expand of human resources.(14) The majority of staff were from the provincial DOH and COE , however there were contact tracers that were employed by district support partners. Many of these tracers had already been trained and already had contact tracing experience. These experienced staff members were paired with new contact tracing staff or acted as tracing team leaders. Teamwork also enabled in new contact tracers to learn from more experienced CTs and facilitated more effective contact tracing. There was therefore "on the job" training that took place. In a Sierra Leonne outbreak it results showed that training and supervision of contact tracers impacted contact tracing implementation.(26) COVID-19 and contact tracing training for CTs was also rolled out in the EHD district and sub-districts. In line with Sierra Leonne findings, our results showed that tracers that were formally trained in tracing and who had tracing experience appeared to have better tracing outcomes. When CTs perceptions of their skills was compared to performance in an objective test, we found that EHD CTs had an accurate perception of their skillsets.

Contact tracers scored the clarity or roles and responsibilities and the availability of good work support

highest in terms of CT preparedness. Managers had lower scores for work support, but they perceived themselves to be well equipped to perform their contact tracing management duties. The availability of equipment was perceived by both tracers and manages to be an important facilitator of contact tracing, as has been shown in other studies.(18,20,26) Some COE managers perceived that they were disadvantaged in terms of access to equipment and other resources, as the COE was perceived to have less funding for providing tracing services than the DOH. When we statistically compared perceptions of COE managers and tracers about access to equipment, work guidelines and work support to DOH perception we found that they had similar scores. Coe and DOH managers and CTs, similarly, had similar perceptions about the clarity of their roles and responsibilities, time availability to do their work and the extent to which they felt they had been rewarded for the tracing work that they did. Managers scored time availability for fulfilling their tracing work requirements lowest, and tracers had the lowest score for perceptions of how well rewarded that had been for their tracing work. Some tracers commented that there was a need for tracers to get more incentives for the work they were doing. There was therefore no evidence to suggest that COE staff members were significantly disadvantaged when compared to their DOH counterparts in terms of tracing preparedness.

Our study showed that Coe staff members were more likely to report lower proportions of contacts that were followed up over the quarantine period. Conversely, contact tracers that were employed by district support partners were more likely to have used electronic contact tracing tools than both COE and DOH staff. These results suggest that the COE and DOH were able to work together to ensure that contact tracing was implemented in a largely uniform manner.

Contact tracing fidelity

Our findings show that EHD largely implemented COVID-19 tracing according to the SA national guidelines. (15,16) In the district, once contact tracing information was received by tracers, cases were contacted to source contact information, and where contacts were already known, tracing was able to commence immediately. Studies have shown that the ability to find contacts and the speed at which symptomatic contacts are found and quarantined, affects the success of the contact tracing system in averting the COVID- 19 outbreak. (22,23) In a USA study, it was reported that the median interval from case investigation to notifying the contact was three days, while findings were that less than 50% of contacts were linked to cases. (26,28) Similarly, our study showed that contact tracers perceived the biggest bottleneck to contact tracing to be the issue of finding contacts. Once contacts were found, most CTs perceptions were that contacts would be found in three days, and more than 50% of contacts would be followed up.

Cases and contacts that were found were given health information and advised to isolate or quarantine over the mandated time. As seen in in the United Kingdom, where 61% of people who were self-isolating reported that they'd left their houses in the prior 24 hours, contact tracers reported that some contacts continued to work or left their homes for various reasons during their quarantine time. (23) This may have impeded contact tracing effectiveness, as there was no system in place for managing clients that did not adhere to quarantine requirements. The WHO recommends that contacts must be quarantined in appropriate settings with access to health , infection prevention and other provisions.(21) Contact tracers reported that there were situations where people could not quarantine as they lived in one roomed dwellings with their families, furthermore, managers reported the issue of bed shortages in quarantine sites.

The district implemented both physical and telephonic contact tracing, however, telephonic contact tracing became the dominant form of contact tracing. A North Carolina study found that telephonic tracing impeded on the ability of health workers to establish a rapport with contacts and in our study, most tracers and managers, similarly, perceived that physical tracing was superior to telephonic tracing as one on one interaction enabled the building of rapport with clients and also allowed the tracers to assess patients situations more accurately.(28) Though telephonic tracing was reported to be inferior, staff members felt that it was more feasible when there were high COVID-19 contacts. As was done in the Senegal Ebola virus outbreak, the loss of rapport in telephonic tracing was mitigated by ensuring that contacts were followed up by the same tracer over their quarantine period, in order to establish relationships and build trust with clients.(19)

Tracers reported that patients did not find daily follow up, as prescribed by national guidelines, to be acceptable, and this resulted in an amendment of follow up timelines to every three to four days, unless otherwise indicated. Though the Mpilo App had the function that allowed for contacts to self-monitor, the district did not implement passive contact tracing as it was reported that the App was not user friendly, was a challenge to use because of internet connectivity challenges and staff members were unable to retrieve information from the App to monitor tracing performance or inform decision making.(16,17) In accordance with SA guidelines, physical tracing was implemented in all districts and contacts that were not found or who developed COVID-19 symptoms were visited in their homes and tested for COVID where necessary. (16,17).

Contact tracing feasibility

As was found in a modelling study, we found that that the quality of case and contact information that was received from the province to district, sub-district and then facilities, had a significant impact on the ability of tracers to find, follow-up and quarantine symptomatic contacts in a timely

manner.(27) There was a challenge, firstly, of identifying contacts such as work colleagues as cases were sometimes reluctant to share information of other close contacts that were not family members and this has been observed in other settings.(23,28) Similar to France, there was also a gap in tracing close contacts that would have been strangers, such as those that came into contact with cases on public transport.(27) Contact tracing was more feasible where cases and contacts were clustered around the same geographical location and ease of tracing was further enhanced where tracers were tracing in the areas that they were already familiar with. The use of community health workers, was therefore an effective strategy for ensuring contact tracing efficiency, as was observed in the implementation of contact tracing in Cape town.(14) We also found that the more decentralized East and South sub-districts were more likely to find and follow-up COVID-19 contacts.

Hellewell et al found that contact tracing effectiveness was affected by the initial case numbers, delay in isolating contacts that developed symptoms and the COVID-19 R_0. A COVID-19 R_0 of 2.5 or more required at least 70% of contacts to be traced for timely aversion of the outbreak.(22) In South Africa the COVID-19 R_0 varied over time with the lowest having occurred after the initial hard lockdown.(25) Our study found that the district response was initially challenged due to the initial lack of human and other resources, lack of access to information and user friendly guiding documents. Physical contact tracing was initiated initially, however the district realized that this type of tracing was time consuming and reached much lower numbers of contacts. This initial implementation time lag may have led to higher initial case numbers, and an initial delay in isolating symptomatic COVID-19 contacts. Faced rapidly increasing case numbers, the district had to escalate their COVID-19 response by, among other things, improved contact tracing structures and channeling human and other resources to prevent rapid community transmission. Barriers to tracing, once systems were established included lack of case and contact information, delays in data movement and logistic issues, including the lack of transport, lack of telephones, staff shortages and the difficulty of tracing contacts that were in hard-to-reach areas. This was similar to findings in the Sierra Leonne Ebola outbreak. (24,26)

Contact Tracing implementation adaptation

As there was initially limited guidance on the contact tracing strategy, managers, at all levels, and contact tracers approached COVID-19 tracing implementation with an “it must be done” attitude and were willing to learn continually. Most managers stated that it was a new pathogen where there was limited information, but they knew that contact tracing had to be done to avert the pandemic. The district and staff members had to be flexible enough to respond and adapt to changing contexts. Staff members had high workloads, most still had to fulfill other work priorities

besides contact tracing, and they had to learn how to balance their activities. As was shown in a systematic review, staff members had to be resilient, capitalize on supervisor and team support structures and build coping skills in order to continue to be functional.(29) Some of the changes the district had to implement include changing from physical tracing to telephonic tracing when COVID-19 cases increased, contact follow-up timelines were amended as caseloads and client preferences were observed, decentralization of tracing from district to subdistrict and then to facilities was implemented to improve the tracing system effectiveness, and paper-based tracing tools were amended and improved over time to ensure they became user friendly and useful for district tracing, monitoring and reporting. As observed in other settings, the ability of the district to implement new COVID-19 and contact tracing training, engage internal and external stakeholders to support the novel pandemic, the willingness of managers to take on additional contact tracing roles and provide supervision and support to the newly established tracing teams and the willingness of community health workers and staff members from all district levels to be involved in contact tracing, were enablers to implementing contact tracing. (10,18,19,26,53) As seen in the Sierra Leonne Ebola outbreak, there was no community engagement prior to district contact tracing implementation which may have resulted in low community participation, non-cooperation of cases and contacts due, in part, to the community stigma that was reported. (19,26)

Contact tracing Acceptability

Various factors facilitated and impeded the acceptability of contact tracing both within among tracing staff and in communities that received tracing services. As seen in the Western Cape, there was initial anxiety amongst contact tracers about the risk of getting COVID-19. As case numbers increased, staff were faced with an overwhelming contact tracing workload, which was also observed in the Western Cape and in the Rwanda COVID-19 contact tracing system. (14) Though there were some cases where staff was not willing to participate in contact tracing, most staff and managers reported that staff members recognized the need for contact tracing to be implemented and were motivated and dedicated to performing contact tracing activities. We found that some issues that may have impeded tracing activities included the safety concerns associated with visiting households, the lack of staff incentives, competing work priorities and staff shortages. Client related factors that may have impeded tracing efforts included poor community trust, language barriers and instances where there was severe illness and/or death at the time when contacts were traced. The challenge of mistrust was observed in the Nigerian COVID-19 contact tracing system and has been found in other populations such as in the African American populations, and also where contacts are undocumented immigrants.(14,23) These client related factors could have been mitigated by early community engagement and public health messaging about the importance of contact tracing.(23)

Contact tracing tools, data management and reporting

WHO recommends that countries develop integrated information collection platforms, to ensure efficient data collection, collation and reporting.(10,18) Previous studies have found that data incompleteness and inaccuracy are challenges of using of paper-based data collection tools. (24,31,32) In the EHD, data challenges were experienced along the data process stream, from the missing data received from the province to inaccuracies in the data that flowed to and from the district, sub-districts, and health facilities. Data that was received from the province had to be cleaned and then allocated to sub-districts, and then facilities. Managers and tracers described challenges such as the lack of case and contact information and the difficulty of having to contact health facilities and testing sites for information. National contact tracing tools that were recommended were not user friendly or context specific There were also challenges with loss of paper records and Excel databases getting corrupted. This resulted in delays in data movement from the point of receipt in the district to the point of service delivery, and led to tracing backlogs, duplication of tracing efforts and the inability to follow up contacts in a timely manner. These challenges have been observed previously in a Guinea Ebola outbreak with the implementation of paper-based contact tracing systems.(30) One of the South African contact tracing best practices was reported to be the upgrading of central provincial electronic databases to cater for contact tracing data collection needs in the Western Cape.(14)

Managers felt that the implementation of electronic tracing tools may have facilitated tracing efficiency. Electronic tracing may improve tracing capacity in large outbreaks, but there is limited evidence that patient level or health care level digital tracing is superior to manual tracing. User engagement and equitable access of tracing tools are important for tools to be used effectively in a contract tracing system, furthermore, tools should be tested and proven to be effective before being used for tracing.(32–34) Contact tracing data collection tools were initially developed centrally without the involvement of district implementation staff, and were not tested in the district. There was a top-down approach to introducing both the national paper based and provincial Mpilo Apps for district use. Due to the inequity of access to data and internet and difficulties experienced in using these tools, tools were not acceptable to many users and access to electronic tools was inequitable. Paper-based tools became the more accessible and equitable tool that could be used in the district. Low uptake and unknown tool effectiveness have been cited in previous studies to be challenges to use of digital tools, and this was the case in EHD. (31–33)

In our study we found that staff members that were employed by district support partners and external stakeholders, staff that were doing telephonic contact tracing, and staff that worked in the

North sub-district were more likely to have used electronic apps. The results suggest that partner staff members may have had better access to training, gadgets, airtime and other resources that facilitated the use of electronic tools. The more centralized nature of the North sub-district tracing system and their highly telephonic based contact tracing may have necessitated the use of other apps in order to improve tracing outcomes. WHO recommends that contact tracing data should be accessible, accurate and must inform public health decision-making. (18,27,30) Though there were no clear data feedback loops in the tracing system, managers used the data that they reported to identify hot spots and for human resource planning.

Study Strengths and Limitations

1.The strength of this study is that it is one of the first contact tracing observational studies that has engaged with program implementers in South Africa, where previous studies have often been modelling or perspective pieces. We were able to investigate the experiences of coal face workers and evaluate the barriers and facilitators to implementation. Interviews allowed us to explore the various implementation factors. This study's findings will inform policy and enable evidence-based decision making and contact tracing implementation in future epidemics. The study has generated new knowledge in the South African context and, with novel pathogens being identified because of urbanization and climate change, the study will inform surveillance and disease control initiatives in the future.

2. Our study was a cross sectional study and as a result we are not able to accurately assess the temporality of contact tracing events, however the use of descriptive and analytical methods in the study and inclusion of both the contact tracers and managers enabled us to corroborate findings, thus strengthening our study.

3. Interviewer bias could have occurred in the collection and analysis of qualitative information; however, the use of a standard semi-structured interview guide will have minimized this bias.

4. This study is restricted to Ekurhuleni Health district; therefore, study findings may not be generalizable to all districts in SA.

5. Social desirability bias is when interviewees provide answers that may be viewed as favorable to the interviewer. This bias may have occurred in our study as some interviewees may have been aware that the interviewer has previously worked in the district and was an employee of the provincial department of health. The fact that interviews were conducted a year after the interviewer stopped working in the district may have mitigated for this risk.

Conclusion

Our findings show that both the provincial and local spheres of government were involved in providing contact tracing services, there was standardisation in terms of resources, skills, structures and both actors rapidly reprioritised, restructured, and reallocated resources in response to the pandemic. The EHD tracing system was able to leverage on health care workers' skills that were already available in the district. Over time contact tracing roles became clearer, tracing processes became more efficient, and equipment was made more available, which was because of the learning and improvement approach to implementation that managers and tracers deferred to in implementing contact tracing. There was support for workers, most notably at the tracing implementation coalface level, however, at all levels implementers were faced with the challenge of managing competing activities and time limitations.

Physical tracing was perceived to have superior tracing outcomes, as tracers could build a rapport with patients and personally observe the contacts' context, telephonic tracing became the mainstay of tracing as it was less time consuming and therefore more efficient for reaching larger numbers of cases and contacts. Contact tracers' perceptions was that the initial finding of contacts was the most challenging aspect of contact tracing. There were similar tracing outcome perceptions in both COE and PDOH staff.

Though the district was able to involve multiple stakeholders in contact tracing implementation and our study showed that the district was able to set up a largely standardised, and effective contact tracing systems, there were weaknesses in the implementation process including poor community engagement efforts which led to poor engagement and negative perceptions about contact tracing in the community. Teamwork, and integration with health practitioners were perceived by both managers and tracers facilitate tracing implementation. There was however notably poor communication with health practitioners that collected COVID-19 contact details, which led to poor quality contact tracing data. Our study brings to light the gaps in availability of legislation and guidelines that are context specific or that can be readily adjusted to guide how contact tracing is implemented, roles and responsibility of all stakeholders, how data is collected and managed, and how the community is expected to conduct themselves in a pandemic.

Resilience, flexibility, and determination to continually improve was required for the implementation of an effective tracing system in EHD. The lack of workspace, transport, telephones and other equipment were key barriers to contact tracing implementation but did not deter tracing implementation efforts. Workforce related facilitators of contact tracing included teamwork, training, and supervision of CTs. Barriers include staff shortages, high workload and

competing work priorities. Our study also found that linkage of tracers with clinicians and /or health facilities and placement of tracing staff in areas they are familiar with fosters effective contact tracing. Community education and engagement, engagement with COVID-19 testing facilities and early client engagement could facilitate client cooperation and minimize COVID-19 related stigma.

The availability of accurate client information was perceived to facilitate contact tracing by enabling timely identification and finding of cases and contacts, as well as easier follow up of clients, and effective management of symptomatic contacts. Our study found that effective communication, planning and coordination between the different stakeholders are important facilitators of effective contact tracing implementation. Our study also highlights the need for an inclusive approach to developing integrated, efficient and timely tools for use in districts. Tools must be tested for effectiveness and acceptability, and structures that facilitate equitable access must be put in place before tools are rolled out.

Recommendations

Community Engagement

We recommend

- the continual building of relationships between communities and healthcare providers to build community trust in the healthcare system
- early, effective community education and engagement about contact tracing in the event of an outbreak
- the use of community health workers that are accustomed to community settings and households for contact tracing

This will enable community buy in and improve participation in future contact tracing implementation. This will also facilitate communication and community adherence to outbreak guidelines, as well as enable the sharing of information between health providers and the communities for contact tracing improvement.

Contact tracing planning and implementation

We recommend that standardised but flexible contact tracing guidelines and/or standard operating procedures are developed to inform future contact tracing activities, these should include guidance on roles and responsibilities of staff members, up-scaling and downscaling of tracing activities, physical and telephonic tracing, centralisation and decentralisation of contact tracing, when and how routine health services can be downscaled, and how resources can be accessed rapidly in the

event of high outbreak caseloads.

Human Resources

1. Our study showed superior contact tracing outcomes when contact tracers had been providing contact tracing services for longer, formally trained in contact tracing or had previous contact tracing experience. It is therefore important for health care workers to be continually trained and equipped in contact tracing implementation.
2. The availability of support structures and initiatives such as team debriefing sessions is recommended for contact tracing staff to allay anxieties and enable staff to cope with workloads and other challenges
3. Re-allocation of staff that may already be skilled in outbreak control, but may not be employed as contact tracing staff, as well as leveraging on district support partners will enable districts to increase staff numbers to support outbreak efforts.
4. We also recommend that staff workloads are reviewed and rationalised to allow staff to be more effectively manage their work outputs, furthermore, incentives should be considered for staff that work overtime.

Outbreak management and surveillance

1. We recommend that there is timely access to equipment, transport, reliable internet and telephonic services in the district, sub-districts and in health facilities.
2. We also recommend that there is an inclusive, consensus orientated and responsive approach to the development and implementation of contact tracing tools, in order to ensure that user friendly tools are developed and can be used to collect complete, good quality data to inform outbreak decision making.
3. The identification and development of easily accessible, effective, and efficient data collection and management electronic platforms which can be readily activated when needed. These tools can leverage on already existing centralized provincial or notifiable medical conditions health information platforms.
4. Finally, we recommend that there is a need to implement the National Public Health Institution of South Africa (NAPHISA) bill and the WHO integrated disease surveillance and response (IDSR) strategy, which facilitates an integrated national approach to country-specific epidemic-prone diseases, diseases targeted for elimination and eradication and endemic diseases. These strategies will build a trained surveillance and response workforce that is informed and ready, improve human resource gaps that were highlighted in our study and strengthen country surveillance and response capacity.(54, 55)

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Appendices

Appendix 1: Plagiarism declaration

SCHOOL OF PUBLIC HEALTH

STUDENT DECLARATION

PLAGIARISM

I Mazvita Naome Mberi nee Muropa (student number: 9901201f) am a post-graduate student registered for the degree / programme MMmed Public Health in the Wits School of Public Health.

I am submitting my Research report for partial fulfillment of the requirements for the degree of Master of Medicine (Public Health Medicine).

I hereby declare the following:

- I am aware that plagiarism is the use of someone else's work without their permission and/or without acknowledging the original source.
- I am aware that plagiarism is wrong
- I confirm that the work submitted for the above course and module, is my own work, except where I have stated otherwise
- I have followed the required conventions in referencing the thoughts and ideas of others
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or if I have failed to acknowledge the ideas or writing.

Signature:  Date: 31/03/2022

Appendix 2: Human Research Ethics Committee (medical) Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Dr MNM Mberi

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M2011100

NAME: (Principal Investigator)	Dr MNM Mberi
DEPARTMENT:	School of Public Health Department of Community Health Medical School University
PROJECT TITLE:	*Staff perceptions of the COVID-19 contact tracing system in the Ekurhuleni Health District, 2020*
DATE CONSIDERED:	2020/11/27
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Professor LS Thomas
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2021/05/17

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **November** and therefore reports and re-certification will be due in the month of **November** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator

Date 11/06/2021