Knowledge, attitudes and practices of COVID-19 infection prevention and control among nurses in the intensive care unit at Groote Schuur Hospital, Cape Town.

A Dissertation presented by

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1

Declaration

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3

Abbreviations

IPC   Infection Prevention and Control

KAP   Knowledge, Attitudes, and Practices

ICU   Intensive Care Unit

PPE   Personal Protective Equipment

GSH   Groote Schuur Hospital

LMIC   Low-and Middle-income Countries

PN   Professional Nurse

EN   Enrolled Nurse

ENA   Enrolled Nurse Assistant

ARDS   Acute Respiratory Distress Syndrome

HCWs   Healthcare Workers

PCR   Polymerase Chain Reaction

Table of contents

Table and figures

Study aim and objectives

Aim:

- To describe the knowledge, attitudes and practices of intensive care nurses regarding COVID-19 infection prevention and control at Groote Schuur Hospital.

 Primary objectives:

- To determine intensive care nurse's knowledge, attitudes, and practices regarding COVID-19 infection.

Second objective:

- To describe intensive care nurses' experiences and perceptions of COVID-19 infection prevention control and practice at Groote Schuur Hospital.

Knowledge, attitudes and practices of COVID-19 infection prevention and control among nurses in the intensive care unit at Groote Schuur Hospital, Cape Town

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Abstract

Introduction: Critical care environments rapidly adapted infection prevention and control (IPC) practices in response to the COVID-19 pandemic. Critical care nurse's knowledge, attitudes, and practices (KAP) regarding COVID-19 IPC may impact the risk of healthcare-associated COVID-19 transmission.

Methods: A mixed-methods study was conducted among intensive care unit (ICU) nurses at Groote Schuur Hospital, Cape Town, South Africa between 20 April and 30 May 2021. Participants completed anonymous, self-administered, 33-item KAP questionnaires and individual interviews regarding their lived experiences and perceptions of COVID-19 IPC in critical care.

Results: One hundred and sixteen ICU nurses participated (93.5% response rate) including 57 professional nurses (49.0%), 34 enrolled nurses (29.0%) and 25 enrolled nursing assistants (22.0%) with young females (31-49 years) predominating (99; 85.3%). Nurses' overall COVID-19 IPC knowledge scores were moderate-good (78%), with professional nurses having significantly better knowledge regarding the route of SARS-CoV-2 transmission (p<0.001). ICU nurses' attitude scores to COVID-19 IPC were low (55%), influenced by limited IPC training, insufficient time to implement IPC precautions and shortages of personal protective equipment (PPE). Respondents' scores for self-reported COVID-19 IPC practices were moderate (65%); the highest compliance was reported for performing hand hygiene after touching patient surroundings (68%). Only half of the respondents (47%) had undergone N95 respirator fit-testing, despite working in a high-risk environment for COVID-19 transmission.

Conclusion: Regular and intensive training on COVID-19 IPC precautions should be provided to equip ICU nurses with the requisite knowledge and skills to prevent healthcare-associated COVID-19 transmission. Enhanced IPC training and consistent PPE availability may contribute to more favourable attitudes and better IPC practices among ICU nurses.

Comprehensive support such as IPC, occupational health and safety should be offered to preserve the well-being of ICU nurses during the COVID-19 pandemic.

Keywords: COVID-19; infection prevention control; intensive care unit; knowledge; attitudes; practices.

Introduction

Coronavirus disease (COVID-19) is a severe respiratory illness caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), a novel β-coronavirus that emerged in Wuhan, China in late 2019 and rapidly spread worldwide[1]. COVID-19 is a highly infectious disease spread primarily through respiratory aerosols from human to human[1]. Although most COVID-19 infections are mild or even asymptomatic, up to 5% of patients will require hospital care[2] . Severe COVID-19-associated pneumonia is the leading indication for admission to the intensive care unit (ICU) [2].

As a result of the COVID-19 pandemic, the working conditions for ICU staff globally became increasingly difficult. The pandemic resulted in surges in ICU bed demand, higher patient-to-nurse ratios, and increased staff absenteeism due to COVID-19 infection-related sick leave. Furthermore, ICU nurses were particularly at risk of developing mental health problems, including depression, anxiety, and burnout during the pandemic[3].

South African healthcare facilities follow the national Infection Prevention and Control (IPC) guidelines and policies, including those specifically developed for COVID-19 IPC which outline the recommended IPC measures for different clinical areas, clinical activities, and staff [4]. These guidelines are intended to provide direction for healthcare workers to ensure both occupational and patient safety in the care of patients with infectious diseases. Specific recommendations in the ICU setting include the use of the closed endotracheal tube and patient suctioning, bed spacing of three meters and dedicated patient care equipment[4].

ICU nurses' understanding, acceptance and implementation of national and local COVID-19 IPC practice guidelines is key to ensuring safe ICU working environments, as they carry the primary responsibility for IPC policy implementation and practices[5]. Acknowledging the key role of ICU nurses in attaining COVID-19 IPC compliance, several studies from low-and middle-income countries (LMIC) have surveyed healthcare workers' knowledge, attitudes, practices (KAP) during the COVID-19 pandemic[1,6-8]. Most studies concluded that healthcare

9

workers in LMIC settings have adequate knowledge and a positive attitude to IPC during the COVID-19 pandemic[7-10], but to our knowledge, at the time of our study, none had included interviews with ICU nurses. We aimed to describe ICU nurses' KAP and lived experiences of COVID-19 IPC at a tertiary hospital's dedicated COVID-19 ICU in Cape Town, South Africa.

Methods

Study Setting and population

This study was conducted in the COVID-19 dedicated ICUs at Groote Schuur Hospital (GSH), Cape Town, South Africa. GSH is a 991-bed academic hospital situated in the City of Cape Town Metropolitan health district, which was the epicentre of COVID-19 infection in the Western Cape Province during the first, second and third infection waves[25]. Groote Schuur Hospital has ten ICUs (with six beds each and one isolation unit with seven beds), of which seven were designated for COVID-19 patients (total bed capacity 43) since April 5, 2020.

The seven COVID-19 ICUs are staffed by 120 permanent nurses and four sessional nurses. Every nurse is responsible for implementing IPC in the ICU. The nursing categories consist of Professional nurse (PN), Enrolled nurse (EN) and Enrolled nurse assistant (ENA) [26]. A PN possesses a four-year nursing degree, occupies a senior nursing position that includes supervision to EN and ENA, administrative duties and the performance of skilled nursing procedures. Each PN was responsible for the care of two ventilated patients, executing doctors' orders and administering intravenous infusion medication. An EN with a two-year nursing diploma programme, took care of non-ventilated patients and administered oral medication only. ENAs have a one-year diploma, thus their key duties are to assist the PN and ENA, clean patients and clean the unit.

GSH has an on-site IPC Unit employing three IPC nurse specialists and one nursing clinical facilitator. Pre- COVID-19, the ICU clinical facilitator conducts in-service training every two weeks for ICU nurses. Since the onset of COVID-19, only one face-to-face IPC in-service training session was held and nurses were encouraged to watch a COVID-19 IPC video on the hospital computers. The limited training time for COVID-19 IPC was a result of the huge pressure of COVID-19 patient admissions to the ICU, which precluded ICU nurses from attending more in-service training sessions.

All patients admitted to the COVID-19 ICUs have nasopharyngeal swabs done to test for SARS-CoV-2 (using polymerase chain reaction (RT-PCR) tests), and additional laboratory testing as required, including microbiology and virology for specified bacterial and other respiratory viral pathogens. The Occupational Health Service at GSH offers free annual

10

influenza vaccination to all healthcare workers and has monitored healthcare workers' COVID-19 infection rates at the facility since April 2020.

Study design

This research was designed as a mixed-methods study [10], with simultaneous data collection for both study components between 20 April and 30 May 2021 to explore ICU nurses' knowledge, attitudes and practices related to COVID-19 IPC. Quantitative data were collected using an anonymously self-administered 33-item questionnaire to assess participants' knowledge, attitudes, and practice (KAP) regarding COVID-19 IPC, as well as participants' demographics (nursing category, work experience and risk factors for severe COVID-19 disease). We developed an individually-administered semi-structured interview questionnaire comprising six open-ended questions to further explore and provide insights into the three quantitative constructs covered in the quantitative assessment (see appendix 1).

Sample

A convenience sampling strategy was employed, enrolling PN, EN and ENA categories from the COVID-19 ICUs. The principal investigator visited all seven COVID-19 dedicated ICUs five times during the study period (including day and night shifts) to explain the purpose of the study and to invite all the nurses working in the COVID-19 ICU to participate. Nurses completed the questionnaires manually, in English, providing written informed consent and the questionnaires were collected after each twelve-hour shift by the study PI.

Random purposive sampling was used to select participants to interview for the qualitative arm of this study[12]. The sample included all the nursing categories (PN, EN and ENA) working in COVID-19 ICUs with varying years of work experience, gender (female and male), and education level (diploma and degree). Each participant was approached and invited to participate in the interview part of the study and the purpose of the study was explained.

Measurement instruments

Self-administered questionnaire

A survey instrument was designed based on previous KAP studies on healthcare-associated infections[10]. The instrument was designed to understand the KAP of COVID-19 IPC among nursing staff in the ICU. The questionnaire consisted of four parts: participant demographics

11

(10 questions); knowledge (nine questions); attitudes (15 questions) and practices (eight questions). Knowledge questions assessed the understanding of COVID-19 IPC measures, attitude questions sought to determine the ICU nurse's attitudes level towards COVID-19 IPC measures, while practices questions collected the data on methods of prevention of COVID-19 infection (see appendix 2).

Semi-structured qualitative question guide

The semi-structured qualitative guide was designed to complement the quantitative questionnaire and focused on exploring the lived experiences of COVID-19 IPC at the Groote Schuur Hospital dedicated COVID-19 ICUs. The semi-structured guide comprised of six open-ended questions centred on experience in ICU, application of IPC measures during the COVID-19 pandemic, adaptation to new COVID-19 IPC guidelines, COVID-19 IPC training, COVID-19 precautions, and how ICU nurses were coping in their daily practice and personal lives.

Data management and Statistical analysis

Quantitative data from the manually completed questionnaires were entered into a RedCAP database by the PI and analyses were performed using Stata Statistical software version 15.0 (Stata Corp, College Station, TX). Participants' demographic characteristics were described using frequencies (n) and percentages (%). The categorical data were summarised using the frequency and percentages. The proportions for knowledge (K), attitude (A) and practice (P) were compared by nursing job category (EN vs ENA vs PN). The Chi-square or Fisher's exact test was used for comparing categorical data.

The Spearman's rho correlation test was used to find the relationship between knowledge, attitude and practices, following the conversion of individual items in the questionnaire to overall percentages of the correct answers. The statistically significant level was set in all tests at $p<0.05$.

Qualitative Analysis

Qualitative data was obtained by posing six pre-specified open-ended questions to participants. Participants' responses were audio-recorded, transcribed verbatim and a six-step thematic analysis approach was employed[13]: familiarisation with data, generating initial codes, searching for themes, reviewing themes, defining, naming themes and producing a report.

12

Emerging themes developed from respondents' lived experiences while working with COVID-19 IPC precautions in the ICU, and direct participants' quotes that best reflected these emerging themes were selected.

Mixed Methods integration

The interconnected themes from the qualitative data were integrated and aligned with the results of the quantitative data[14]. Themes that represented the knowledge, attitudes and practices of ICU nurses regarding COVID-19 IPC were identified and conclusions were drawn in conjunction with the quantitative data.

Ethics approval

Ethics approval was obtained from the Human Health Research Ethics Committee of the University of Cape Town (774/2020). All participants provided written informed consent.

Results

Demographics

Out of one hundred and twenty-four (124) eligible COVID-19 ICU nurses, one hundred and sixteen (116) nurses participated in the study (response rate of 93.5%). Respondents were predominantly young females (n=99; 85.3% female; 59.5% aged 31-49 years) (Table 1). Respondents comprised the following nursing categories: PN (n=57; 50.0%), EN (34; 29.3%) and ENA (n=25;22.0%). Almost half of the respondents had substantial (>10 years) ICU nursing experience (n=51, 45.9%). Approximately one-quarter of all nurses had one or more underlying medical conditions which placed them at increased risk for severe COVID-19 disease (n=32, 28%). Fifty-two nurses (44.8%) reported previously having undergone one or more COVID-19 RT-PCR test(s), and 21 (18.1%) had previously been diagnosed with COVID-19 infection at the time of the study.

ICU Nurses' knowledge of COVID-19 IPC

Respondents' overall knowledge scores pertaining to COVID-19 transmission mechanisms and prevention measures in the ICU were moderate-to-good (78%). Professional nurses had significantly higher scores than other nursing categories regarding the role of aerosol transmission of the SARS-CoV-2 virus (p<0.001, Table 2). ICU nurses had good knowledge (82%) regarding the importance of hand hygiene to remove COVID-19 viral particles from the skin; 78% of the respondents believed that alcohol hand rub is as effective for decontaminating hands possibly contaminated with COVID-19, as handwashing with soap and water. ICU nurses had good knowledge (91%) of the indications for terminal cleaning and disinfection of hospital rooms. Most (84%) respondents were aware that all patients admitted to ICU were tested for COVID-19 infection.

ICU Nurses' attitudes to COVID-19 IPC

ICU nurses' attitudinal scores with regards to COVID-19 IPC were marginally positive (55%), (Table 3). Half of the respondents (51%) reported having a positive attitude towards COVID-19 infection prevention and control (IPC). However, half of the respondents (50%) believed that they had received insufficient training in COVID-19 IPC measures before admitting infected patients to the ICU. Many respondents (72%) , especially PNs (88%), (p<0.005) believed that the high workload during the COVID-19 pandemic had resulted in decreased time to adhere to standard IPC practices in the ICU. Attitudes were also influenced (especially among PNs [63%]), p<0.005) by inadequate availability of PPE in ICU during the COVID-19 pandemic.

ICU Nurses' practices for COVID-19 IPC

Respondents' overall self-reported practice scores were moderate (65%). The highest reported compliance was for the performance of hand hygiene after touching the patient's surroundings (68%), as well as the performance of hand hygiene before and after touching COVID-19 infected patients (67%). Less than half of respondents (47%) , especially ENAs (40%), p=0.039, (Table 4) had undergone N95 respirator fit-testing, despite working in a high-risk environment for COVID-19 transmission. One-third of staff (30%) reported for duty despite having symptoms of possible COVID-19 infection. Self-reported adherence to protective measures was low-to-moderate with only 66% wearing all recommended PPE when nursing

14

COVID-19 infected patients. Only 56% reported adhering to transmission-based precaution signs in the ICU. ICU nurses reported low uptake rates for the annual influenza vaccination in 2019/20 (46%).

Correlation relationship between COVID-19 IPC knowledge, attitudes, and practices

Table 5 shows the correlation relationship between COVID-19 IPC KAP. There was a significant positive correlation (r=0.484, p=0.047) between higher knowledge scores and desired practices. There was also a significant positive correlation between positive attitudes and desired practices (r=0.511, p<0.001). However, the knowledge and attitudes scores were not significantly correlated (r = 0.207, p = 0.407). Thus knowledge appears not to influence attitudes but does influence practices. Attitudes appear to influence practices.

Qualitative themes

In the qualitative arm of the study, 11 participants were recruited and were predominantly females (n=7, 64%) aged 31-49 years (60%), including five PNs, three ENs, and three ENAs. Half (50%) of the participants had over 10 years of experience in ICU nursing. Three interconnected themes comprising coping mechanisms and interventions to limit the occupational risk of COVID-19 infection emerged: Inadequate IPC training during the COVID-19 pandemic; Limited adherence to COVID-19 IPC practices; and Emergence of coping methods, resilience, and teamwork among ICU nurses during the COVID-19 pandemic.

Theme 1. Inadequate IPC training during the COVID-19 pandemic

A key theme that emerged from the qualitative data was that IPC training during the COVID-19 pandemic was considered to be inadequate for ICU nurses' needs. Many expressed frustration at the lack of training on COVID-19 IPC and the intermittent availability of PPE. Respondents also highlighted that rapid changes to protocols and procedures were needed and rapidly communicated to them during the pandemic as new knowledge emerged, to keep abreast of current COVID-19 IPC best practices. Respondents demanded regular training on COVID-19 IPC to ensure compliance.

Responder. 09 *"COVID-19 is a new disease and has changed the critical environment completely. New information continues to surface regarding preventative measures. We need regular in-services training on COVID-19 IPC, please".*

Responder.11 *" I need a continuous update on new evidence regarding COVID-19 IPC ... on how to conduct infection prevention controls in the ICU environment and most importantly how to prevent ourselves from contracting this disease."*

Theme 2. Limited adherence to COVID-19 IPC practices

Respondents understood that the COVID-19 IPC guidelines were intended to combat virus transmission to healthcare workers and patients. Respondents commonly described how they applied COVID-19 IPC precautions to protect themselves from infection but had limited time to implement these IPC measures despite their intent to comply. The increased workload due to increased responsibilities, the volume of patients and the complexity of caring for COVID-19 patients were further factors that negatively influenced their compliance.

Responder.05 "*We tried [to] comply with COVID-19 IPC all the time, but it is difficult and sometimes you forget because we found ourselves looking after more than three intensive patients, ventilated on inotropic support, and besides that, you have guided our colleague from other departments, who have no ICU experience*".

Responder.09 *"The workload is too much, and we have minimal time to follow the COVID-19 IPC due to the severe illness of our patients, but we try all the time, but COVID patients are complicated"*.

Responder.06 *"It is very strenuous working with COVID patients because patients are critically ill all the time. It is impossible to adhere to the IPC protocol to the latter because we are trying to save lives. We acknowledge the importance of the COVID-19 IPC, we have limited time"*.

Theme 3. Emergence of coping methods, resilience, and teamwork among ICU nurses during the COVID-19 pandemic

During the pandemic, ICU nurses had to balance the need to protect themselves and their families, while doing their best to ensure optimal patient outcomes under difficult circumstances at work and in their personal lives. Nurses expressed the strongest emotions regarding their care of patients with COVID-19 pneumonia or acute respiratory distress syndrome (ARDS), and expressed that they felt the weight of the responsibility of caring for these patients.

Responder. 7 . "*COVID-19 patients are very infectious. I feel vulnerable to contract COVID-19 infection and spread to my family". "It also feels like everything is weighing heavy on us during this COVID-19 pandemic*".

Respondents appeared to have changed their behaviours within the workplace and home, and adopted a range of coping strategies such as leaving their work clothes in the garage, not hugging their families, praying, exercising and other self-care measures.

Responder. 08 "*When working in the COVID ICU, we changed our clothes before and after the shift. We put on PPE, aprons and N95 masks. After the shift ,we changed back to nursing uniforms. When arriving at home, I leave my working clothes, shoes, and bag in the garage, take a full shower and do hand hygiene. We are trying to protect my children and the rest of my family from COVID-19 infection*".

The high workload during the pandemic and the low patient survival rate diminished the morale of ICU nurses, and at times they became pessimistic about the care they provided to COVID-19 patients. The respondents were overwhelmed by the shortage of PPE and constantly changing IPC protocols and procedures. This negatively impacted their attitudes to and compliance with IPC measures. Yet, the ICU nurses shared sentiments like '*we will survive*' and '*we are determined to serve our patients.*' ICU nurses displayed resilience and coping mechanisms with the high workload of COVID-19 patients. Despite all the uncertainty, they remain committed to their frontline duties, returning to work each day to provide nursing care during the public health pandemic, and displaying a high level of altruism and dedication, often at the expense of their own health.

Responder.03 "*It's very stressful to work with COVID patients and the first precaution is to counsel yourself and be calm within, because if by any chance you are stressing, then you will miss out on a lot of things. So, as long as you are calm, I think that's the first thing to protect yourself because you know what to do. Try by all means to adhere to IPC protocols*"

Responder.10 "*Yoh, it was so draining, draining...You feel exhausted. You feel like you must go off sick. Then you think if you go off sick, who is going to look after the patients. You must force yourself to go to work. Although you get exhausted, tired, you must force yourself because you pledged.*"

They also highlighted the importance of teamwork in caring for COVID-19 patients.

Responder. 7 "*The workload has increased significantly in the ICU since COVID19 came. We need each other, teamwork was the key to navigating away through COVID-19 waves.*

17

COVID-19 patients are very heavy and you will need help from your colleague, that is why teamwork is very crucial".

Responder.10 *"Generally, ICU work needs teamwork among nurses. COVID-19   patients are difficult to nurse because of their infectious status. Teamwork is required throughout the day. We are helping each other in these difficult circumstances."*

Discussion

A mixed-methods design was used to assess the COVID-19 IPC KAP of ICU nurses working at an academic hospital in a middle-income setting. Most respondents had moderate to good knowledge levels related to COVID-19 IPC, similar to recent reports from Nigeria[15] and South Africa[16]. Knowledge scores were generally lowest among nurses with the least training (Enrolled Nurse (EN) and Enrolled Nurse Assistant (ENA). These scores demonstrated that COVID-19 IPC in-service training and messaging has most likely been effective in increasing ICU nurses' IPC knowledge. Wide media coverage of COVID-19 and public preventive measures implemented by the South African government may also have played an important role in the high knowledge level of our respondents.

Qualitative responses, however, did not support this interpretation. The respondents commonly identified the lack of regular IPC training during the COVID-19 pandemic as a major setback. They expressed their concerns more broadly about a "new" and "highly" infectious disease," which in their opinion required IPC training for adequate patient management and safety. Furthermore, guidance and regular in-service training for COVID-19 IPC is needed to correct some misconceptions and empower all nursing categories with accurate scientific information.

Knowledge levels on the key concepts of COVID-19 IPC measures such as hand hygiene, routes of infection transmission and environmental cleaning was good. Most respondents correctly understood that alcohol hand rub is an adequate measure to limit the direct and indirect contact spread of COVID-19 infection, with many describing hand hygiene as a "key" mitigation measure. This is reassuring because a good knowledge of COVID-19 transmission

18

patterns and prevention measures will improve ICU nurse's practices and thereby limit occupational risk.

The respondents expressed concern about their working environment, especially the rapid changes in protocols and the severity of illness among their patients. These results are in keeping with sentiments expressed in previous reports of COVID-19 IPC in ICUs[9,11,13]. The attitude of ICU nurses may affect their practice of COVID-19 infection prevention and control measures. In this study, we assessed the acceptance and experience of the COVID-19 IPC by ICU nurses. Most respondents demonstrated a marginally positive attitude towards COVID-19 IPC adherence and practice in the ICU. Our qualitative data suggest that attitudes are influenced by fear of infection, high workload, and perceived negative impacts of COVID-19 on healthcare workers' (HCWs) health and that of their families. Similar findings were observed in Uganda[7]and Nigeria[15]. The marginally positive attitude could possibly be attributed to the limited training in IPC, insufficient time to implement IPC protocols and PPE shortages. Respondents also reflected on the ICU environment and the complexity of patient management brought on by COVID-19 ARDS patients, as well as that introduced by new or frequently updated IPC measures.

Half of the respondents believed they had received inadequate training in procedures for safely donning and doffing PPE for COVID-19. Most respondents however felt that the high workload during the COVID-19 pandemic resulted in decreased time to adhere to standard IPC practices in the ICU. Respondents expressed similar concerns about the inconsistent availability of PPE and fears of contracting COVID-19 themselves. The availability of PPE in ICUs in protecting staff from COVID-19 infection, and an adequate supply of PPE may therefore improve ICU nurses' attitudes to work. The major demand caused limited availability of PPE, but the situation was corrected over time and may no longer be a major problem within this hospital[21].

We found a positive relationship between positive attitudes and practices suggesting that attitude influences the respondents' COVID-19 IPC practice. The self-reported compliance of ICU nurses with recommended COVID-19 IPC practice was moderate. Similar findings were reported from China[6] regarding moderate to good compliance with COVID-19 IPC. Less than half of the respondents had performed N95 respirator fit testing despite their high-risk work environment. Similar results were reported in a recent study from Nigeria[17]. During

19

the COVID-19 pandemic, qualitative fit-testing was discontinued in Western Cape facilities (owing to the risk of cross-infection) and this may have contributed to the low numbers of staff who had been fit-tested.

Most respondents did not adhere to transmission-based precaution signs in the COVID-19 ICU. Factors for this low adherence did not emerge during the qualitative inquiry. The practice of effective preventative measures such as handwashing and donning of appropriate Personal Protective Equipment will ensure the safety of healthcare workers (HCWs) by reducing healthcare-associated COVID-19 transmission.

Qualitative data suggest that respondents were willing to adapt to rapid changes in COVID-19 IPC guidelines, despite some having indicated that this added to their workload which in turn had likely adversely affected their compliance with COVID-19 IPC recommendations. There was generally a positive attitude among the respondents towards COVID-19 IPC, and the respondents expressed a desire for more regular in-service training on new evidence-based COVID-19 IPC precautions. The infrastructure and shortage of nursing staff are long-standing issues, and the COVID-19 pandemic has compounded them and resolution thereof requires interventions at an institutional level.

We found low attitudes and some non-compliant IPC practices among ICU nurses regarding highly infectious diseases. To boost staff attitudes, the institution's management should ensure the provision of an uninterrupted and sustainable supply of PPE, while addressing the concerns of the nursing staff and also continue with IPC education. With the looming threat of multiple COVID-19 waves and potentially more infectious and virulent variants, the institution's managers need to update relevant information timeously and responsibly and ensure that this is rapidly communicated to nurses along with ongoing in-service training. Policy-makers should inspire confidence in nursing staff by taking responsibility for long-term health and safety, as the data suggests that nurses remain committed to their roles and tasks of caring for ICU patients. Given the risk of staff burnout, employee wellness and support should remain a priority for healthcare employers.

The study's major limitation is the use of self-reported rather than directly observed COVID-19 IPC practices. Reporting bias may have been introduced by the subjective nature of the survey. This study was a single centre study with limited generalisability. The rapidly changing knowledge stream of COVID-19 may also affect the generalisability of our findings. This study was performed before the COVID-19 vaccination was readily available in South Africa.

20

COVID-19 vaccination is the single most effective IPC measure and provides 72% protection against severe disease and death from COVID-19[24]. Future studies should evaluate COVID-19 vaccine uptake among ICU nurses, given their reported low uptake of the annual influenza vaccine.

This study has several strengths. To the authors' knowledge, this is the first mixed-methods assessment study performed in a resource-limited setting. The qualitative data gives meaning and explanation to the quantitative results. Data for this study was collected immediately after the second peak of the COVID-19 pandemic, the timing of which allowed for study participants to share fresh experiences with explicit examples. One of the strengths of this study is that there is unlikely to be selection bias, as the survey studied ICU nursing staff, and the majority responded.

Conclusion

Regular and intensive training in COVID-19 IPC precautions should be provided to equip ICU nurses with the requisite knowledge and skills to prevent healthcare-associated COVID-19 transmission. Enhanced training and consistent PPE availability may contribute to better attitudes and IPC practices among ICU nurses. It is important to monitor for burnout among ICU nurses and implement targeted interventions at an individual and organizational level. Regular debriefing sessions would empower individuals to share their own experiences, learn from each other, and thereby strengthen both the ICU team and provide support for individual ICU nurses[22-23].

Recommendations

This was a single centre study and therefore a bigger multicentre study would provide more data for external validation.

Authors contribution

All the authors contributed to the study design and reviewed the manuscript. The principal investigator carried out data collection, data cleaning and statistical analysis. All authors read and approved the final manuscript.

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Competing interests

No conflict of interests declared

22

Table 1. Participant demographic characteristics

Variable	N (116)	%
Gender		
Female	99	85.3
Male	17	14.7
Age range (in years)		
18-30	17	15.0
31-49	69	60.0
50+	30	25.0
Work Experience (years)		
<1	8	7.0
1-5	28	24.5
5-10	27	23.7
>10	51	44.8
Nursing job category		
Professional Nurse	57	49.0
Enrolled Nurse	34	29.0
Enrolled Nursing Assistant	25	22.0
Nurses with underlying medical conditions	32	28.0
Risk factors for severe COVID-19 infection:		
Diabetes	9	7.8
Hypertension	16	13.8
Heart disease	1	2.6
Chronic lung disease	3	0.9
Previous pulmonary Tuberculosis	3	2.6
Living in a household with people vulnerable to severe COVID-19 disease	27	23.3
Previously underwent a COVID RT-PCR testing	52	44.8
Previously diagnosed with COVID-19 infection	21	18.1
Required ≥1 quarantine periods after high-risk COVID-19 exposure in the ICU	27	23.3

Table 2. ICU nurses' knowledge regarding infection prevention and control precautions for COVID-19

Knowledge questions (correct response)	Total n=116 (%)	Professional Nurse (PN) n=57(%)	Enrolled Nurse (EN) n=34(%)	Enrolled Assistant (ENA) n=25(%)	P-value
The hospital environment (surfaces and water) is the main source of COVID-19 transmission to staff (**false**)	65 (56.0)	35 (61.4)	19 (56.0)	11 (44.0)	<0.001
Handwashing with soap and water is sufficient to remove COVID-19 viral particles from the skin (**true**)	97 (81.8)	47 (82.4)	28 (82.3)	20 (80.0)	0.654
Alcohol hand rub is as good as handwashing with soap and water for decontaminating hands that are possibly contaminated with COVID-19 (**true**)	91 (78.4)	45 (78.9)	28 (82.3)	18 (72.0)	0.520
Hand hygiene should be done before putting on a mask or N95 respirator (**true**)	110 (94.8)	55 (96.4)	32 (94.1)	23 (92.0)	0.839
Patients with COVID-19 infection require the same infection control precautions as patients infected with antibiotic-resistant bacteria (**false**)	78 (67.2)	40 (70.2)	22 (64.7)	16 (64.0)	0.864
Terminal cleaning and disinfection of the hospital room is required following the discharge of patients with COVID-19 (**true**)	106 (91.2)	52 (91.2)	31 (91.1)	23 (92.0)	0.305
COVID-19 infection is spread mainly by the respiratory route (**true**)	102 (87.9)	50 (87.7)	28 (82.3)	20 (80.0)	0.664
Open suctioning and intubations are aerosol-generating procedures (**true**)	105 (90.5)	54 (94.7)	28 (82.3)	23 (92.0)	0.999
The Groote Schuur hospital Unit for Infection Prevention and Control performs active surveillance by testing every patient admitted to ICU for COVID-19 (**true**)	98 (84.4)	49 (85.9)	27 (79.4)	22 (88.0)	0.999

Table 3. ICU nurses' attitudes regarding infection prevention and control precautions for COVID-19

Attitude questions (desired response)	Total n=116 (%)	Professional Nurse (PN) n=57(%)	Enrolled Nurse (EN) n=34(%)	Enrolled Assistant (ENA) n=25(%)	P-value
I received adequate teaching about IPC during undergraduate and in-service training **(agree)**	57 (49.1)	30 (53.3)	16 (47.1)	11 (44.0)	0.489
I received sufficient training in IPC for COVID-19 before we began admitting infected patients to the ICU **(agree)**	70(60.3)	39(68.3)	20(59.1)	11 (44.0)	0.008
I received sufficient training in the procedures for safely donning and doffing PPE for COVID-19 **(agree)**	58 (50.0)	31 (54.4)	16 (47.0)	11 (44.0)	0.520
Groote Schuur Hospital ICU have adequate isolation facilities to reduce potential infection transmission of COVID-19 **(agree)**	57 (49.1)	28 (49.1)	16 (47.0)	13 (52.0)	0.361
Prevention of in-hospital COVID-19 staff, and patient infections is the responsibility of the infection prevention and control (IPC) staff **(disagree)**	52 (44.8)	24 (42.1)	18 (52.9)	10 (40.0)	0.875
Staff members who do not perform hand hygiene or ignore infection control recommendations should be reprimanded **(agree)**	58 (50.0)	29 (50.9)	17 (50.0)	12 (48.0)	0.240
The ICU nursing staff have a positive attitude towards COVID-19 infection prevention and control (IPC) **(agree)**	59 (51.1)	30 (53.0)	16 (47.0)	13 (52.0)	0.217
Transmission of COVID-19 infection can be prevented by taking antibiotics (disagree)	67(58.1)	37(65.1)	19(56.0)	11 (44.0)	0.218

The information and training about IPC for COVID-19 provided to ICU nursing staff was adequate to empower staff to protect themselves **(agree)**	58 (50.0)	29 (51.0)	17 (50.0)	12(48.0)	0.228
The high workload during the COVID-19 pandemic resulted in decreased time to adhere to standard IPC practices in the ICU **(agree)**	84 (72.4)	50(88.1)	20 (59.0)	14(56.0)	0.048
I am familiar with the COVID-19 IPC guidelines for the ICU **(agree)**	61 (62.9)	31(54.3)	17(50.0)	13(52.0)	0.322
During the COVID-19 pandemic, there has been adequate availability of PPE in ICU **(agree)**	72 (66.4)	40 (70.2)	19 (56.1)	13 (52.0)	0.048
During the COVID-19 pandemic, there has been adequate availability of cleaning supplies and disinfectants in the ICU **(agree)**	66 (52.6)	34 (59.6)	19 (52.9)	13 (52.0)	0.195
The correct PPE to care for COVID-19 patients is always available in the ICU **(agree)**	68 (59.0)	36 (63.1)	18 (53.1)	14 (56.0)	0.474

Table 4. ICU nurses' practices regarding infection prevention and control precautions for COVID-19

Practice questions (desired response)	Total n = 116 (%)	Professional Nurse (PN) n =57(%)	Enrolled Nurse (EN) n =34(%)	Enrolled Assistant Nurse (ENA) n = 25(%)	P-value
I always wear the correct personal protective equipment (PPE) when dealing with COVID-19 infected patients **(agree)**	77 (66.4)	39 (68.4)	20 (59.2)	18 (52.0)	0.662
I always recognize and adhere to the transmission-based precaution signs in ICU **(agree)**	69 (59.4)	37 (65.1)	21 (62.0)	15 (60.0)	0.698
I have performed fit-testing for use of N95 respirators **(agree)**	55 (47.4)	30(53.0)	15 (44.1)	10(40.0)	0.039
When I am sick, I feel obliged to come to work because we are short-staffed **(disagree)**	61 (53.1)	33 (58.1)	18 (53.0)	10(40.0)	0.687
All staff in the ICU should receive an annual influenza vaccine **(agree)**	64 (55.2)	34 (60.0)	18 (53.0)	12 (48.0)	0.979
Staff who develop possible symptoms of COVID-19 should not report for duty **(agree)**	71 (61.0)	39 (65.1)	20 (59.0)	14 (56.0)	0.772
I perform hand hygiene before and after touching patients with Covid-19 infection **(agree)**	78 (67.2)	41 (71.2)	22 (63.1)	15 (60.0)	0.772
I perform hand hygiene after touching the patient's surroundings like beds, tables, doors, etc **(agree)**	79 (68.1)	40 (70.1)	23 (68.1)	16(64.0)	0.858

Table 5. Correlation between knowledge, attitudes, and practices scores

Variables	Correlation Coefficient	p-value
Knowledge - Attitudes	0.207	0.407
Knowledge – Practices	0.484	0.047
Attitudes – Practices	0.511	<0.001

*Correlation is significant at p<0.05

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Appendix 1

Semi-structured qualitative question guid

1. Tell me about your experience of working in the (ICU)?

2. How do you apply infection prevention protocols in the COVID-19 ICU?

3. How have you adapted IPC practices COVID-19?

4. Have you received training on COVID-19 IPC?

5. What precautions are you taking to prevent yourself and patients from contracting COVID-19 infection in the ICU?

6. How are you coping during this COVID-19 pandemic?

7. Is there anything else that you would like to share regarding COVID-19 IPC?

Appendix 2

Please answer the following questions with a cross in the appropriate box (X)

Demographics of Intensive care nurses	
1. **Gender**	
Male	
Female	
2. **Age, (in years)**	
18-29	
31-49	
50+	
3. **Nursing category**	
Professional Nurse (RN)	
Enrolled Nurses (EN)	
Enrolled Nursing Assistants (ENA)	
4. **Work Experience, (in years)**	
<1	
1-5	
5-10	
>10	
5. **Do you have any underlying health conditions?** **Put a cross in the box of all that apply**	
Diabetes	
Hypertension	
Heart disease	

Chronic lung disease			
Previous pulmonary tuberculosis			
Autoimmune disease			
HIV/AIDS			
None of the above			
Prefer not to say			
6. Are you living in a household with people vulnerable to COVID-19 infection?	Yes	No	
7. Did you need to go into quarantine after high-risk COVID-19 exposures in the ICU?	Yes	No	
8. Did you go for COVID RT-PCR tests?	Yes	No	
9. If yes, how many COVID RT-PCR tests did you have? (Write the number of tests in the box opposite)			
10. Were you ever diagnosed with a COVID-19 infection?	Yes	No	

Please answer True or False to the following questions with a cross in the appropriate box (X)

Knowledge regarding IPC for COVID-19	Place a cross over your chosen response	
1. The hospital environment (surfaces and water) is the main source of COVID-19 transmission to staff	True	False
2. Handwashing with soap and water is sufficient to remove COVID-19 viral particles from the skin	True	False
3. Alcohol hand rub is as good as handwashing with soap and water for decontaminating hands that are possibly contaminated with COVID-19	True	False
4. Hand hygiene should be done before putting on a mask or N95 respirator	True	False
5. Patients with COVID-19 infection require the same infection control precautions as patients infected with antibiotic-resistant bacteria	True	False
6. Terminal cleaning and disinfection of the hospital room is required following the discharge of patients with COVID-19	True	False
7. COVID-19 infection is spread mainly by respiratory droplets	True	False
8. Open suctioning and intubations are aerosol-generating procedures	True	False
9. The Groote Schuur hospital Unit for Infection Prevention and Control performs active surveillance by testing every patient admitted to ICU for COVID-19	True	False

The attitude and perception of nurses on COVID-19 infection

Please answer the following questions with a cross in the appropriate box (X)

Attitudes regarding IPC for COVID-19	Agree strongly 1	Agree 2	Neutral 3	Disagree 4	Disagree strongly 5
1. I received adequate teaching about IPC during undergraduate and in-service training					
2. I received sufficient training in IPC for COVID-19 before we began admitting infected patients to the ICU					
3. I received sufficient training in the procedures for safely donning and doffing PPE for COVID-19					
4. Groote Schuur Hospital ICU have adequate isolation facilities to reduce potential infection transmission of COVID-19					
5. Prevention of in-hospital COVID-19 staff and patient infections is the responsibility of the infection prevention and control (IPC) staff					
6. Staff members who do not perform hand hygiene or ignore infection control recommendations should be reprimanded					
7. The ICU nursing staff have a positive attitude towards COVID-19 infection prevention and control (IPC)					
8. Transmission of COVID-19 infection can be prevented by taking antibiotics					
9. The information and training about IPC for COVID-19 provided to ICU nursing staff was adequate to empower staff to protect themselves					
10. The high workload during the COVID-19 pandemic resulted in decreased time to adhere to standard IPC practices in the ICU					
11. I am familiar with the COVID-19 IPC guidelines for the ICU					
12. During the COVID-19 pandemic, there has been adequate availability of PPE in ICU					

13. During the COVID-19 pandemic, there has been adequate availability of cleaning supplies and disinfectants in the ICU					
14. I consider working in the ICU to be high-risk for contracting COVID-19 infection					
15. The correct PPE to care for COVID-19 patients is always available in the ICU					
Practices regarding IPC for COVID-19	**Agree strongly 1**	**Agree 2**	**Neutral 3**	**Disagree 4**	**Disagree strongly 5**
1. I always wear the correct personal protective equipment (PPE) when dealing with COVID-19 infected patients					
2. I always recognize and adhere to the transmission-based precaution signs in ICU					
3. I have performed fit-testing for use of N95 respirators					
4. When I am sick, I feel obliged to come to work because we are short-staffed					
5. All staff in the ICU should receive an annual influenza vaccine					
6. Staff who develop possible symptoms of COVID-19 should not report for duty					
7. I perform hand hygiene before and after touching patients with Covid-19 patients					
8. I perform hand hygiene after touching the patient's surroundings like beds, tables, doors, etc					