

The costing of COVID-19 Intensive Care Units at a tertiary hospital in Cape Town, South Africa

Retrospective Cost Analysis:
A quantitative observational study

Period: April 2020 – March 2022



Thesis submitted in fulfilment of the requirements for the degree of
Master of Medicine (MMed) in Anaesthesia
April 2023

Candidate:
Dr Kirsten Hood
HDXKIR001

Supervisors:
Prof Ivan Joubert
Dr Lucy Cunnama
Dr Shrikant Peters

Department of Anaesthesia and Perioperative Medicine
Faculty of Health Sciences



UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA - UNIVERSITEIT VAN KAAPSTAD

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

Declaration



I, Kirsten Hood, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor part thereof has been, is being, or is to be submitted for another degree at the University of Cape Town or any other university. This work has not been reported or published prior to registration for the abovementioned degree.

This thesis is presented in fulfilment of the requirements for the degree of MMed (Anaesthesia). All data was collected from sources within the hospital by the researcher herself. The candidate has completed the dissertation under supervision, after registration for the degree. This work has been prepared for submission to the South African Medical Journal (SAMJ). The Vancouver convention has been used for citation and referencing. Each contribution to, and quotation in this thesis from the work(s) of other people has been attributed and has been cited and referenced.

This dissertation has been submitted to the Turnitin module (or equivalent similarity and originality checking software), and I confirm that my supervisor has seen my report and any concerns revealed have been resolved with my supervisor.

I empower the University of Cape Town to reproduce, for the purposes of research, either the whole or any portion of the contents in any manner whatsoever.

Name: Kirsten Hood
Signature: *Kirsten Hood*
Student number: HDXKIR001
Date: 20 March 2023

Supervisor declaration

The journal publishing the paper is accredited by the department of higher education and training or it has been approved by the UCT Health Sciences Specialist Training Committee and:

- The candidate is the first author on the paper
- The candidate contributed the most to the paper
- The candidate developed the protocol and wrote the paper under supervision
- The candidate was involved in the analysis, presentation, and interpretation of results
- The other authors and their contributions to the paper are stated

Signed by candidate

Supervisor: Ivan Joubert

Date: 17 April 2023

Acknowledgements, format, and contributions

This work has been prepared for submission to the South African Medical Journal (SAMJ). The SAMJ formatting and referencing styles have thus been used throughout the dissertation. The manuscript is written in UK English and presented in Microsoft Word format. As per SAMJ requirements, text is single-spaced, in 12-point Times New Roman font, and contains no unnecessary formatting. The Vancouver referencing convention has been used. All data was collected from sources within the hospital by the researcher herself. These sources included finance and statistics departments as well as multiple clinical and managerial sources. The candidate has completed the dissertation under supervision, after registration for the degree.

I would like to express my sincere thanks and gratitude to the following people, without whom this research would not have been possible: Ivan Joubert for the research idea and supervising. Lucy Cunnama for supervising, and whose guidance and health economic costing expertise were integral to this costing study. Shrikant Peters, whose help and guidance were essential for planning, data collection, and execution of this research. Zainap Ganief for providing essential ICU costing FBU data and patient number information. Christel Arnold-Day for providing integral COVID-ICU in-patient day numbers. Multiple people in managerial positions at GSH mentioned in the acknowledgements at the end of the publication-ready document, who provided specific cost component information for different departments.

Publication-ready manuscript

The costing of COVID-19 Intensive Care Services at a tertiary hospital in Cape Town, South Africa

Kirsten Hood, Lucy Cunnama, Shrikant Peters, Christel Arnold-Day, Ivan Joubert

Author Affiliations and Institutional Addresses:

K A Hood	Department of Anaesthesia and Perioperative Medicine, University of Cape Town and Groote Schuur Hospital, South Africa
L Cunnama	Health Economics, School of Public Health, University of Cape Town, South Africa
S M Peters	Groote Schuur Hospital, Western Cape Government: Health, and School of Public Health and Family Medicine, University of Cape Town
C Arnold-Day	Division of Critical Care, Department of Anaesthesia and Perioperative Medicine, University of Cape Town and Groote Schuur Hospital, Cape Town, South Africa
I A Joubert	Division of Critical Care, Department of Anaesthesia and Perioperative Medicine, University of Cape Town and Groote Schuur Hospital, Cape Town, South Africa

Author Email Addresses:

Kirsten Hood	kahood89@gmail.com
Lucy Cunnama	lucy.cunnama@uct.ac.za
Shrikant Peters	shrikant.peters@westerncape.gov.za
Christel Arnold-Day	christelday@gmail.com
Ivan Joubert	ivan.joubert@uct.ac.za

Address for correspondence:

Kirsten Hood
D23, Groote Schuur Hospital
Main Road, Observatory
Cape Town, 7935
Tel: +27 724345225
Email: kahood89@gmail.com

Date: April 2023

Key words: COVID, COVID-19, ICU, COVID-ICU cost analysis, cost per in-patient day, South Africa

Table of Contents

Publication-ready manuscript	5
List of Abbreviations	7
List of Figures	8
List of Tables	9
List of Appendices	10
Abstract	11
Main Article	12
Background	12
Methods	14
Results	19
Discussion	22
Conclusions	26
References	28
Appendix Material	30
Appendix A: UCT Human Research Ethics (HREC) Approval Letter	30
Appendix B: Groote Schuur Hospital Management Approval Letter	31
Appendix C: Instructions to Authors	32

List of Abbreviations

ARDS - Acute respiratory distress syndrome
COVID – Clinical COVID-19 illness caused by the SARS-CoV-2 coronavirus
CPI - Consumer Price Index
CSSD – Central Sterilising and Supply Department
EN – Enrolled Nurse
ENA – Enrolled Nurse Auxiliary
FBU – Functional Business Unit
GSH – Groote Schuur Hospital
HR – Human Resources
HREC - Human Research Ethics Committee
ICU – Intensive Care Unit
IMV - Invasive mechanical ventilation
LMICS - Low- and middle-income countries
LoS - Length of stay
MPI - Medical Price Index
NHI – National Health Insurance
NHLS – National Health Laboratory Service
NTSG – National tertiary services grant
OT – Overtime
PES – Provincial equitable share
PN – Professional Nurse
PPE - Personal protective equipment
TPN - Total parenteral nutrition
UCT – University of Cape Town
UPFS – Uniform Patient Fee Schedule
USD – US Dollars
WC – Western Cape
WHO - World Health Organisation
ZAR - South African Rands (R)

List of Figures

Figure 1: Dates of COVID waves that affected GSH

Figure 2: Bar graph showing monthly COVID in-patient days over the two-year study period

Figure 3: Pie chart showing the leading cost drivers for COVID-ICU over the two-year period

Figure 4: Pie chart showing the breakdown of contributions to the human resources cost component for COVID-ICU

List of Tables

Table 1: Cost components included in the COVID-ICU service analysis

Table 2: Summary of total costs, in-patient day costs and percentage contribution of cost components over the two-year study period

Table 3: Breakdown of component contributions to the human resources cost driver for COVID-ICU

List of Appendices

Appendix A: UCT Human Research Ethics Committee (HREC) Approval Letter

Appendix B: Groote Schuur Hospital Management Approval Letter

Appendix C: Instructions to authors (South African Medical Journal)

Abstract

Background: The expansion of Groote Schuur Hospital's (GSH) Intensive Care Unit (ICU) capacity to accommodate an unprecedented number of patients during the COVID-19 pandemic was an expensive undertaking. There are currently no published formal retrospective analyses of the financial costs of running and expanding COVID-ICUs in South Africa.

Objectives: To conduct a cost analysis of the COVID-ICU service at a tertiary state hospital in Cape Town, South Africa. This analysis included the cost of COVID-ICU admissions relating to the first four COVID waves. Aims were to estimate total costs, in-patient day costs, and cost drivers for COVID-ICU.

Methods: A retrospective cost analysis (quantitative observational study) using a mixed-methods costing approach, was conducted across the COVID-ICUs at GSH. The data used included two consecutive hospital financial years, between April 2020 and March 2022. Costs were calculated monthly and then combined to achieve a total cost over the two-year period. COVID-ICU in-patient days were used as the primary allocation factor. Cost inputs included recurrent costs such as human resources, diagnostics, pharmaceuticals, oxygen, enteral feeds, blood products, consumables, and overheads, as well as capital costs including equipment, and building space.

Results: The study period covered the four COVID waves that affected GSH ICU units between April 2020 and March 2022. This period included 10 497 COVID-ICU in-patient days resulting from a total of 776 COVID-ICU admissions. The total calculated spending across the two financial years was R262 482 904, resulting in a cost per in-patient day of R25 006, and a utilisation of 4,4% of the total hospital budget during the same period. The median length of stay was nine days, resulting in a median cost per admission of R225 050. The top five cost drivers were human resources (60%), consumables (9%), pharmaceuticals (8%), oxygen (5%), and overheads (5%).

Conclusion:

This is a retrospective costing study of the COVID-ICUs at a tertiary hospital in Cape Town, throughout the entire portion of the pandemic that required ICU admissions in South Africa. This analysis provides useful financial insights, a potential economic model for ICU budgeting, and creates a platform for future economic analyses and policy planning regarding level-of-care decisions for general ICU admissions or for similar future pandemics within the South African and LMIC hospital setting.

Main Article

Background

The emergence and spread of the novel coronavirus, SARS-CoV-2 was declared a pandemic by the World Health Organization (WHO) on the 11th of March 2020.^{[1][2]} Its consequent clinical illness (hereafter written as COVID), brought significant challenges to the delivery of adequate healthcare worldwide. The response to the surge of Groote Schuur Hospital (GSH) in-patient numbers during the COVID pandemic included expansion of both wards and Intensive Care Units (ICUs), alongside major de-escalations of other services within the hospital. The first COVID patient who required invasive mechanical ventilation (IMV), was admitted to the GSH ICU on the 5th of April 2020.^{[3][4]} The subsequent expansion of GSH ICU capacity to accommodate an unprecedented number of patients during the COVID waves, came at an unknown financial cost.

The Division of Critical Care at GSH, usually manages 25 ICU beds in units covering surgical, medical, cardiothoracic and source isolation ICU patients,^[4] but during COVID wave peaks, Critical Care services expanded to six COVID-ICU units comprising 36 beds, and two non-COVID-ICU units comprising 12 beds to cover other critical medical and surgical patients. COVID-ICU beds were utilised exclusively for COVID patients who needed IMV. Patients who required admission for supplementary oxygen but either did not yet require IMV or were not suitable candidates for ICU as per the standardised triage system, were cared for in general wards where they received oxygen via high flow, face mask, or nasal cannulae depending on their changing requirements. ICU expansion was dynamic with changes determined by patient demand and resource availability throughout the respective waves within the hospital.^[4] At the peaks of waves, the ICU medical staff were divided into teams, each responsible for 12 beds. The number of doctors was increased from the normal baseline as the bed numbers expanded, primarily through re-distribution of registrars (trainee specialists) from various departments throughout the hospital to help full-time in ICU during busy periods. The major limiting factor for creating new COVID-ICU units, when needed, was the availability of ICU-trained nursing staff. This was due to the rapid expansion of beds throughout the province, decreasing the availability of staff. The usual ICU ratio of professional nurse (PN) to patient, is 1:2, but in COVID-ICU this was reduced to 1:3 with the remainder of nursing support provided by enrolled nurses (ENs) and enrolled nursing auxiliaries (ENAs).^[4]

There is currently no literature providing retrospective cost analyses of establishing and operating COVID-ICUs at hospitals in South Africa or other low- and middle-income countries (LMICs). There is also a paucity of baseline data describing the above-mentioned costs for non-COVID public-sector ICUs in the country, with only one national study by Mahomed et al, being published on the subject in 2019.^[7] A COVID-ICU-related economic costing model was developed by Cleary et al.,^[5] early in the pandemic to aid ICU bed acquisition decision-making, and there was a study published after the first national wave of COVID admissions by Edoaka et al.,^[6] that estimated daily COVID in-patient costing in South Africa at varying levels of clinical care within a public hospital setting. The study by Edoaka et al., calculates economic costs by totalling consumables, capital equipment and human resources, and they provide estimates (both including and excluding facility fees), that are

based on resource inputs derived from local clinical guidelines, literature, and expert opinions.^[6]

It is important to estimate COVID-ICU costs to understand the costs and cost drivers of running and expanding the COVID-ICU service within hospitals from policy, economic, and service provision perspectives amongst others. This costing provides some of the information required to further perform an assessment of the economic impact of COVID-ICUs at GSH, which can inform current and future public health policy, hospital management planning and resource allocation decisions.

Objectives

The purpose of this research was to do a cost analysis of the GSH COVID-ICU service. The primary aim was to determine the total costs of patient admissions to COVID-ICU units at GSH throughout the two-year period. Secondary aims were to describe the associated unit costs, reflected as cost per in-patient day, and to identify the major cost drivers.

Methods

This study took place at GSH, which is a 991-bed, state sector, tertiary-level academic hospital affiliated with the University of Cape Town (UCT). It was approved by the UCT Human Research Ethics Committee of the Faculty of Health Sciences (ref. no. 685/2021), and permission to collect data and conduct the study was granted by GSH management.

This is a descriptive, retrospective cost analysis (quantitative, observational), from a healthcare provider perspective, of the GSH COVID-ICU spending for two complete institutional financial years, from April 2020 to March 2022. Costs and in-patient days for all admissions to the COVID-ICU during this period were included in the study. The study covered the four COVID waves that the GSH ICU was involved in managing (see Figure 1).

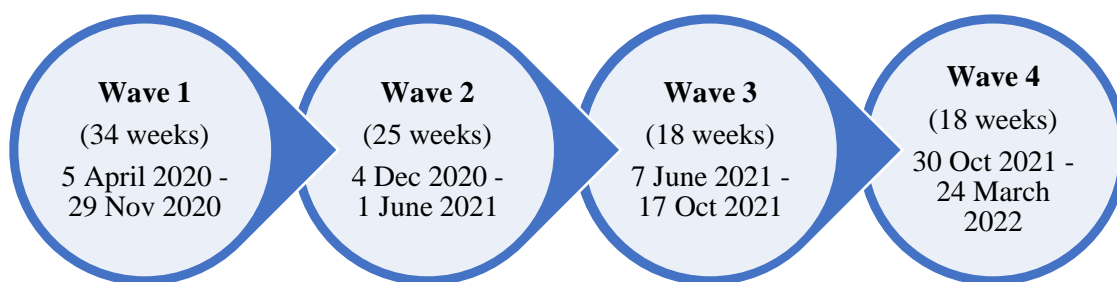


Figure 1: Timeline illustrating the COVID waves that affected GSH

In-patient days were used as the main allocation factor throughout this costing study. COVID-ICU in-patient days at GSH have previously been published.^[8] Figure 2 illustrates the trend of GSH COVID-ICU in-patient days, over the two-year study period. Eight patients required admission to COVID-ICU after March 2022. These patients and costs fell outside the study period and were excluded from the costing analysis. Total ICU (including non-COVID-ICU) and total hospital in-patient day information was obtained from Hospital Information Management.

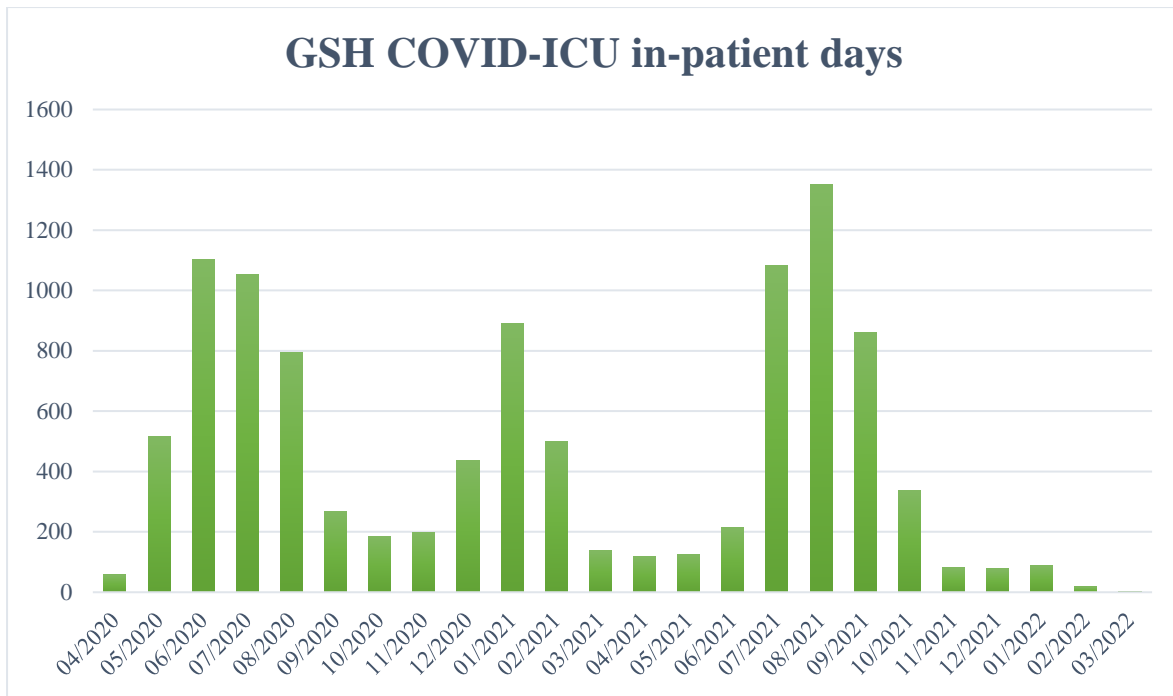


Figure 2: Bar graph showing monthly COVID-ICU in-patient days over the two-year study period

A mixed-methods (both top-down and bottom-up) costing approach was used due to the varying formats of the costing data available from multiple sources within the hospital information management system. Actual costs throughout the two-year period were recorded and calculated in the local currency of spending - South African Rands (ZAR or R).

Table 1 outlines COVID-ICU cost components and their constituents. A bottom-up approach was used to calculate costs of human resources, diagnostics (laboratory and radiology tests), consumables, pharmaceuticals, enteral feeds, blood products, maintenance, and building space (metres squared multiplied by cost per metre, and inflation accounted for to estimate 2021 prices). A top-down approach was used to allocate costs of oxygen, overheads, equipment, and burial services.

Table 1: Cost components included in the COVID-ICU service analysis

Human Resources	Diagnostics	Pharmaceuticals	Oxygen	Consumables	Overheads
<ul style="list-style-type: none"> - Doctors - Nurses - Operational unit managers - Administrative staff - Clinical Technologists - Radiographers (allied) - Physiotherapists (allied) - Dietitians (allied) 	<ul style="list-style-type: none"> - National Health Laboratory Service (NHLS) - Laboratory Radiography 	<ul style="list-style-type: none"> - Pharmacy costs 	<ul style="list-style-type: none"> - Oxygen usage 	<ul style="list-style-type: none"> - Medical and surgical supplies - Other supplies e.g., stationery 	<ul style="list-style-type: none"> - Utilities (water, electricity) - Cleaning - Security - Waste management - Laundry services
Nutrition	Equipment	Blood Products	Burial services	Land and building	Maintenance
<ul style="list-style-type: none"> - Enteral Feeds - Feeding sets 	<ul style="list-style-type: none"> - Medical equipment - General equipment 	<ul style="list-style-type: none"> - Blood and Blood products 	<ul style="list-style-type: none"> - Overall cost to COVID-ICU 	<ul style="list-style-type: none"> - Building space cost 	<ul style="list-style-type: none"> - Engineering maintenance costs

Human resources

The doctors running COVID-ICUs at GSH included five permanent intensivists, a specialist pulmonologist who worked permanently in ICU during waves and busy periods, a critical care fellow, registrars and other specialists in varying numbers depending on the number of patients in ICU. Final rosters were analysed, and salaries of all doctors involved in COVID-ICU in any given month, including those seconded from other areas, were extrapolated from the hospital functional business unit (FBU) which included accurate monthly salaries including commuted overtime pay.

The most common nursing staffing allocation per six COVID-ICU beds per 12-hour shift was two PNs, two ENs and one ENA. These ratios were converted into staff required per ICU bed, per 24 hours. Based on monthly nursing shift patterns, the average number of shifts per nurse per month was estimated and used to calculate the number of nursing salaries that were required to fulfil all shifts per bed per month (i.e., full-time equivalent nurses per in-patient day). To determine how many COVID-ICU nursing shifts were required per individual month, accurate daily COVID-ICU in-patient numbers were used to convert the staff number required per bed into the total staff required for each month. To calculate accurate average salaries, daily and nightly rosters from the month of January 2021 which included a wave peak were used to identify exactly which permanently employed nursing staff worked across one COVID-ICU unit. Their actual individual monthly salaries were then taken from the hospital FBU which included overtime, and an average salary for each grade of nurse (PN, EN, ENA) was derived. This was more accurate than using published Western Cape salary level tables as those do not include accurate overtime. Based on the total number of fully paid nurses in each category required to cover the fluctuating shifts in each month of the study, and using the average salary calculated for each group, total nursing salaries for each month

were calculated. A minority of the shifts were filled by agency staff who had varying pay rates, but this was excluded from the costing and permanent average salaries were applied to those agency shifts instead.

Unit managers are all senior nurses who are permanently employed to run the nursing element of the ICU units. They all continued working full-time throughout the study period, and their individual salaries were taken from the FBU. The same process was followed for administrative staff which included the ICU secretaries and a public health specialist who is the full-time medical manager for critical care.

Allied health professionals who played a large role in the COVID-ICUs included radiographers, physiotherapists, and dietitians. Their cost allocation per month was calculated using the published Western Cape 2021 salary scale tables, the number of staff from each pay category working in COVID-ICUs each month, and the percentage of their workday spent in the COVID-ICUs. Information regarding the above staff allocation was provided by respective heads of the clinical departments.

Clinical technologists who are responsible for medical equipment and patient transfers within the hospital were allocated to specific COVID wards and ICUs throughout the pandemic. The actual salaries of those allocated to COVID-ICUs were drawn from the FBU.

Consumables, pharmaceuticals, NHLS, blood, engineering maintenance

The hospital consistently maintains an accurate digitised FBU, from which costing information for COVID-ICU units for the above-headed components were directly drawn for each month. The FBUs keep per unit costs for each item ordered from each area in the hospital during each month. Costs therefore include ongoing operating costs and for engineering maintenance, include replacements of items and purchase of new items when required, however set up costs pertaining to all equipment and assets are incorporated in cost of capital.

Oxygen

Liquid oxygen costs during the COVID period were R11 000 per tonne. The usual oxygen consumption for GSH of one tonne per day, increased during the peaks of waves to between 11 and 15 tonnes per day.^[4] At peak, this oxygen was being used by 53 high-flow machines and around 40 ventilators. For costing purposes, the consumption of oxygen was converted into ventilator equivalents. As high-flow machines utilise higher flow than ventilators, the 53 high-flow machines' consumption was converted into an equivalent of 80 ventilators so that at peak, 14 tonnes of COVID-related excess oxygen were used by 120 ventilator equivalents. This was then used to calculate oxygen costs per ventilator per day and applied to the monthly costing calculations for oxygen use for the 40 ventilated beds in COVID ICU depending on respective in-patient day numbers per month.

X-ray diagnostics

Radiography salaries were included in human resources, whilst the cost of x-rays themselves were included in diagnostics. The cost per x-ray was obtained from the GSH Case Management Department, and an average assumption of one mobile chest x-ray per patient day was applied based on scrutiny of radiographic records.

Nutrition

Most patients in COVID-ICU were receiving nutrition via nasogastric tubes. The cost of nutrition included enteral feeds and feeding sets that were changed for each patient daily. In-patient day costs for nutrition, were obtained from the Dietetics Department, and COVID-ICU in-patient numbers were used to calculate monthly feeding costs. There were a few patients who received total parenteral nutrition (TPN), which was included in the FBU costs for pharmaceuticals.

Cost of capital

Medical equipment replacement costs were obtained from both the director of finance for GSH and the head clinical technician who is responsible for procurement of the equipment in the GSH ICUs. An equivalent annual cost for medical equipment was calculated using an annuity factor at a rate of 3%,^[9] and a useful lifespan of 10 years.^[10] This lifespan decision was based on literature^[11] and experiential accounts by the same lead clinical technician. COVID-ICU building space cost was estimated by measuring the square metreage of the space used and then utilising an excel-based order of magnitude estimator, created by the Department of Health and Centre for Scientific and Industrial Research (CSIR), to calculate the cost to build new hospitals. Inflation was considered when converting to a 2021 cost estimate. An annual cost was then calculated for the building space by annuitizing at a rate of 3% over 30 years. This annual amount was doubled to allocate a building cost to the two-year study period.

Overheads

Overheads included electricity, water, cleaning costs, security costs, waste management, and laundry services. Most of these costs came from the hospital's assistant-director of finance, in the form of annual costs for GSH. A top-down approach was used to apportion these costs to the COVID-ICUs. This was done by calculating which percentage of the total hospital in-patient days, were COVID-ICU in-patient days, and applying that percentage to the annual overhead costs.

Burial costs and COVID waste disposal

A different allocation factor was applied to burial costs and specific COVID waste disposal. A daily record was kept throughout the pandemic, of the wards and ICUs allocated to COVID patients. This was converted to monthly allocations, and then the percentage of COVID rooms in the hospital belonging to COVID-ICU per month was calculated. This percentage was then used to allocate burial costs and COVID waste disposal costs more accurately than using only an ICU percentage of whole hospital in-patient numbers. After calculation, COVID waste disposal costs were added to overheads totals. To note, was the assumption that almost all deaths in the hospital during the pandemic were COVID-related due to major de-escalation of most other services.

All costing data collected over the two-year study period, was collated, and analysed in Microsoft Excel. Monthly costs were calculated and converted to an overall COVID-ICU cost by totalling them over the full period. In-patient day costs were calculated by dividing the total amount spent by the total number of COVID-ICU in-patient days recorded throughout the same period. Cost drivers were ranked by analysing the percentage of the total spending accounted for by each component group.

Results

The study period, covering two financial years from April 2020 to March 2022, included 10 497 COVID-ICU in-patient days resulting from 776 COVID-ICU admissions. Table 2 summarises total costs, in-patient day costs, and cost component percentage contributions.

Table 2: Summary of total costs, in-patient day costs and percentage contribution of cost components over the two-year study period in ZAR

	Cost over two-year period	Cost per in-patient day
Human Resources	R156 510 179	R14 910
Consumables	R22 853 646	R2 177
Pharmaceuticals	R21 268 018	R2 026
Oxygen	R13 527 515	R1 289
Overheads	R12 830 771	R1 222
Diagnostics	R10 912 802	R1 040
Assets and Equipment	R8 610 925	R820
Land and Building	R5 267 524	R502
Maintenance	R4 689 172	R447
Blood Bank	R3 393 248	R323
Nutrition	R1 945 448	R185
Burial services	R673 657	R64
Totals	R262 482 904	R25 006

Total cost over 2 years

The total cost to GSH to run COVID-ICU over the study period, which covered four waves of COVID admissions, was R262 482 904. This utilised 4,4% of the total hospital budget of R5 977 175 000 for the same period. This budget included an additional COVID budget allocated to the hospital.

Cost per in-patient day

The cost per in-patient day in COVID-ICU was R25 006. The median length of stay (LoS) in COVID-ICU was 9 days which resulted in an overall median cost per admission of R225 050 regardless of outcome. For survivors, the median LoS was 11 days resulting in a median cost per admission of R275 061 for those who did not demise in ICU.

Cost drivers

Refer to Table 2 for the full breakdown including all cost drivers. A graphical representation of the leading cost drivers can be seen in Figure 3.

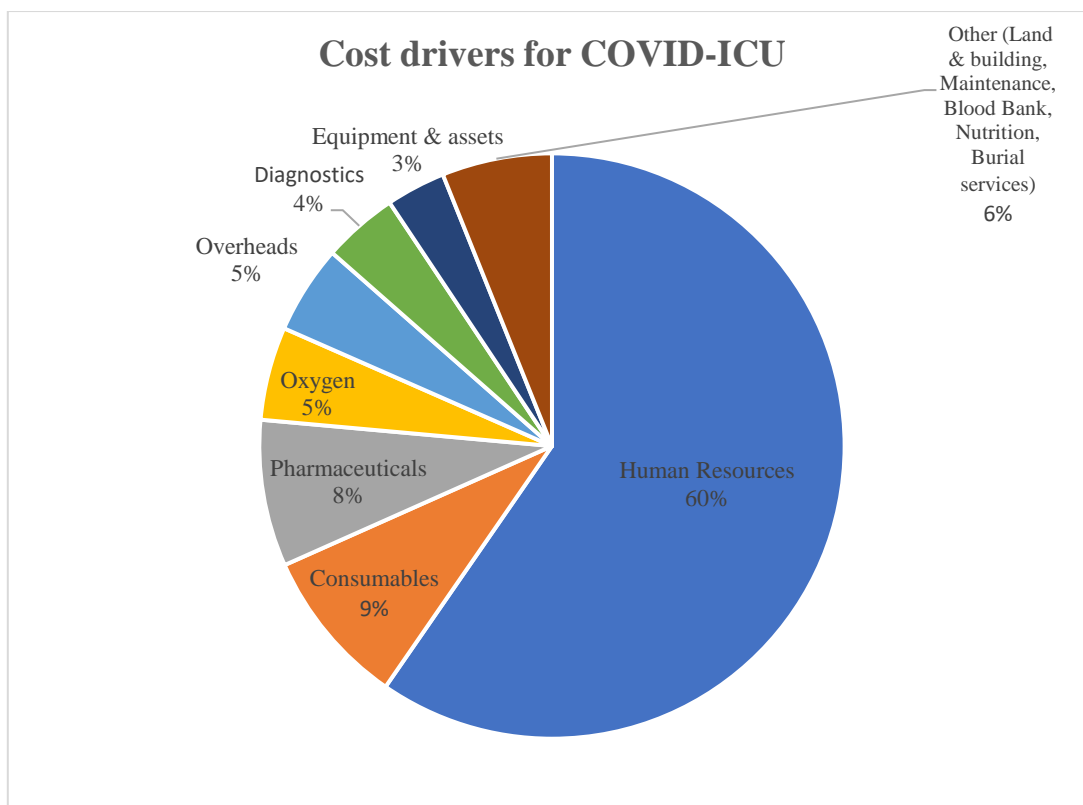


Figure 3: Pie chart showing the leading cost drivers for COVID-ICU over the two-year period

Human resources were the leading cost driver, accounting for 59,6% of total costs. The next biggest cost drivers included consumables (8,7%), pharmaceuticals (8,1%), oxygen (5,2%) and overheads (4,9%). Within human resources, 46% was spent on nursing and unit managers, 40% on doctors, and the remainder on allied health (dietitians, radiographers, and physiotherapists), administrative, and clinical technology staff. See Table 3 and Figure 4.

Table 3: Breakdown of component contributions to the human resources cost driver for COVID-ICU

HUMAN RESOURCES (HR)	Total cost over two-year period	Cost per in-patient day
Nurses and unit managers	R72 673 342	R6 923
Doctors	R62 443 858	R5 949
Allied Health Professionals	R10 971 036	R1 045
Administration staff	R5 449 427	R519
Clinical Technologists	R4 972 516	R474
Totals	R156 510 179	R14 910

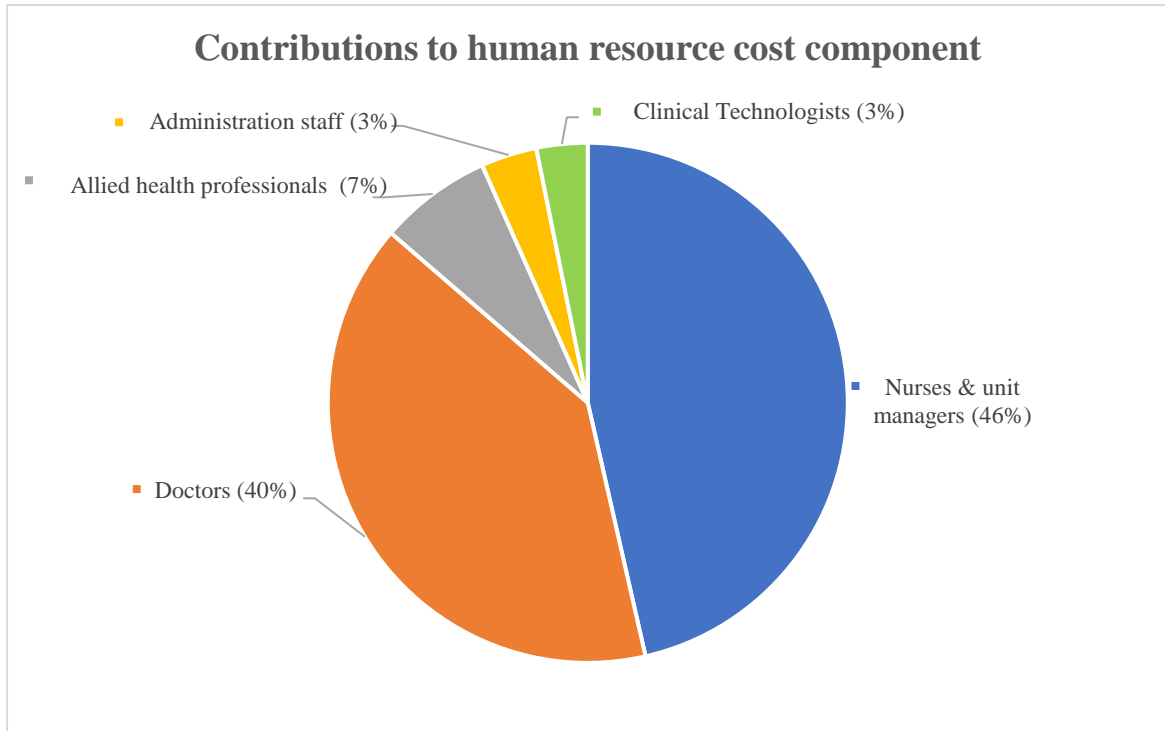


Figure 4: Pie chart showing the breakdown of contributions to the human resources cost component for COVID-ICU

Discussion

Costing of critical care patient services in public and private hospitals in South Africa is important for many reasons. The costs of individual patient management are not often considered or updated in the public sector, as no individual billing for services is done. Despite the small percentage of healthcare facility beds that ICUs normally occupy, the costs of admissions into ICUs are significant. There is a paucity of data on both COVID-ICU and baseline general ICU costing in LMICs.

Beginning in 2020, COVID-ICU treatment was a novel experience for healthcare institutions globally. Within our setting, logistical and clinical protocols were developed by GSH hospital management and the critical care team as the pandemic progressed. Despite a mortality rate of nearly 70% for ventilated COVID patients over the first two GSH COVID waves,^[8] efforts continued throughout all four waves, to provide maximal ventilatory support and ICU treatment to as many patients who fitted the standardised triage criteria as possible. With dynamic decision-making required at great pace, and no previous universal experience to guide the process, little was known throughout most of the pandemic, about the financial implications or economic efficiencies of the resulting healthcare-level decisions. Beyond early assessments and assumption-based economic modelling estimates, there is no formally published retrospective data on the actual financial or economic costs of running and expanding COVID-ICUs in South Africa. By providing a complete retrospective cost estimate over the two-year admission period, this research starts to fill the gap in ICU costing knowledge regarding COVID treatment in LMIC tertiary public hospital ICU settings. This will form the basis of future economic assessments to analyse cost effectiveness of level-of-care decisions for COVID and similar medical situations within this, and other settings.^{[7][13]}

The findings from our study estimated that the cost of running and expanding the GSH COVID-ICU over two financial years was R262 482 904. This two-year period covered most of the COVID-ICU admissions, with only the last eight COVID-ICU admissions, that occurred after March 2022, being omitted as they fell outside of the study period. An interesting aspect to note is that, as can be seen from the discrepancy in wave numbers in figures 1 and 2, GSH was affected by 4 clinical waves of infection, however wave 4 resulted in negligible numbers of critical care admissions as most patients admitted required only ward care. There is currently no similar published literature over the complete two-year period in a public LMIC setting for direct comparison. One of the only private sector COVID-ICU cost estimates, was shared via web articles written in May 2020 by South Africa's largest private medical scheme, Discovery Health. They reported that the average cost of all COVID hospital admissions across their members at that point was R84 708 per-person, the average cost of a COVID-ICU admission was R169 525, and the average cost of stay in ICU for patients on ventilators was R340 737.^{[14][15]} Patients being admitted to private ICU facilities did not all require IMV like they did at GSH. This was due to more bed availability allowing different triage criteria, which is why Discovery had different overall ICU costs for ventilated versus non-ventilated patients. There is no publicly available breakdown or substantiation of these costs in the report.

GSH's annual budget is comprised of a provincial equitable share (PES) and a national tertiary services grant (NTSG). For the 2020/21 hospital financial year it was R2 872 881 000 and for 2021/22 it was R2 993 270 000. This gives a combined total hospital budget over the two-year study period of R5 866 151 000. The total COVID ICU spending during this time of R262 482 904 accounted for 4,5% of that total hospital budget. During the

pandemic, GSH also received an additional COVID budget, which came to a total of R111 024 000 over the two-year study period. The amount spent on COVID ICU alone surpassed this additional budget (236,4%). Overall, the COVID ICU spending accounted for 4,4% of the total budget including the additional COVID allocation.

The only local paper addressing general ICU costing in a LMIC which assessed a tertiary hospital in Durban, South Africa, was published in 2019 by Mahomed et al. ^[7] It looked at 544 admissions and 4 987 in-patient days throughout the April 2015 – March 2016 financial year and estimated a general ICU cost per in-patient day of R22 870. ^[7] This study excluded land and building costs, as well as registrar salaries due to absence of data. The researchers reported that these daily costs in South Africa were comparable to the mean direct costs for an ICU-day, determined by standardised costing methodology, across four European countries. ^[17] According to the Western Cape (WC) Government's new (April 2022) uniform patient fees schedule (UPFS) tariffs, externally funded patients admitted to public institutions, will be charged a facility fee of R7 417 plus a professional fee of R630 per 12 hours of a general ICU stay, which equates to R16 094 per in-patient day. ^[16] There is no breakdown of these charges, nor any available information about how they have been calculated.

The estimated cost per in-patient day in GSH COVID-ICU was R25 006, and the median length of stay in COVID-ICU was nine days which resulted in a median, outcome independent, cost per admission of R225 050. This daily cost falls near the upper margin of the assumption-based predictive economic model costs produced by Cleary et al., which estimated a daily cost range between R8 922 and R26 767. ^[5] A study by Edoaka et al. found an ICU in-patient day cost estimate for patients requiring IMV (including facility fees) to be USD 1314,24 (R21 829,53), which is only R 3 177 less than our study showed. As an indirect comparison to our study, the abovementioned general ICU in-patient day costing of R22 870 in South Africa using 2015-2016 data, ^[7] is R2 136 less than our daily cost estimate. This small discrepancy can likely be accounted for by inflation, the omission of land and building costs and registrar salaries from the Mahomed paper, and extra daily oxygen costs for COVID-ICU. Oxygen consumption was higher overall for COVID-ICU than general ICU because every COVID-ICU patient required ventilation with high oxygen percentages and flows due to the clinical presentation of ARDS, whereas in general ICUs, oxygen and ventilation requirements are far less. COVID-ICU treatment was relatively standardised, and except for oxygen, required no further additional costly inputs when compared with regular ICU patients, hence the abovementioned WC UPFS tariffs may represent an underestimation of the amount needed to recoup general daily ICU costs.

The length of stay (LoS) estimated from the Cleary et al. model was between 4.3 and 13.3 days with a base value of 8.8 ^[5] which correlated well with the overall median GSH COVID-ICU stay of 9 days. The median was used in our study instead of the mean due to a small cohort of patients with very extended stays skewing the mean LoS to 13.5 days. The median LoS was longer for COVID-ICU survivors, at 11 days, resulting in a median cost per admission of R275 061 for those who did not demise in ICU. The Edoaka study used an average length of stay for ICU admissions with IMV of 16 (10-31) days, which they obtained from the South African COVID-19 Hospital Sentinel Surveillance database. ^[6] ^[18]

In our study 59,6% of COVID-ICU costs were attributable to human resources; slightly more than the recent South African paper showing human resource contributions of 55%. ^[7]

In their study however, the authors do acknowledge that their human resource contribution was under-represented due to the omission of unobtainable salaries of rotational registrars. In international ICU costing studies, human resources were also the leading cost driver. ^[17] ^[19] In our study medical and surgical consumable products were the next biggest cost driver at 8,7%, followed by pharmaceuticals at 8,1%. Oxygen contributed 5,2%, then overheads at 4,9%, and diagnostics (NHLS specimen pathology testing and x-ray radiology costs) at 4,2%. The remaining cost components contributed even smaller amounts as can be seen in results Table 2.

Due to the nature of the pandemic, its waves, and the resulting shortage of available nursing staff, the nurse-to-patient ratio in COVID-ICU was less than that in the general ICU which decreased nursing costs per patient. This should be noted for policy-making purposes, as nursing costs in an ideal ICU set up would have been higher had there been less staff shortages and HR constraints. Despite this, in keeping with an older South African costing study from 1995, nurses accounted for the highest proportion of human resource costs. ^[20] In our study, nurses and unit managers (nurses occupying a managerial capacity within the units), accounted for 46% of the costs, followed by doctors at 40% who were made up of intensivists, other specialists, registrars, and medical officers. Allied health professionals including radiographers, physiotherapists and dietitians accounted for 7%, with administration staff and clinical technicians accounting for 3% each.

The strengths of this study include a high level of accuracy of costing data kept by GSH, that is analysed monthly by all departments in the hospital. Access to well-kept financial information in the form of FBUs, and documented staffing rosters and salaries were integral to ensuring costs were accurate. Two full financial years were covered to ensure precision, and account for clinical and logistical changes in practice as the pandemic progressed and efficiencies within the hospital improved. Fortuitously, the months included, correlated exactly with the four COVID waves that affected ICU admissions. Although well-justified assumptions were necessary for some of the costing components and allocations, there were no costs left out of this study completely. Fluctuations in COVID-ICU costs were minimal when compared to general ICU costs because COVID-ICU treatment protocols followed a more standardised approach, so averaging costs per in-patient day over the whole period is likely to be more accurate than the same approach for a general ICU where a large variety of pathologies being treated require different ICU treatment. Follow-up and complementary studies are planned that will further enhance the findings of this research, which include costing of the non-COVID ICU as a comparison and conducting an economically focussed study to explore the opportunity costs associated with expanding COVID-ICU services.

There were limitations in this study. Not all cost inputs for ICU admissions at GSH are electronically based, nor are they all kept in a centralised, accessible source. Due to availability of data in different forms, including some only in aggregated forms, a mixed-methods approach had to be employed instead of a complete and ideal bottom-up approach. The scope of this study was limited to the COVID-ICU at GSH. This single-hospital scope will have an impact on generalisability of the costing to other LMIC healthcare settings, however the quantitative nature of the study and the quality of the data makes it an accurate indication of the spending on COVID-ICU at this tertiary hospital and allows generalisability to other government healthcare settings in South Africa. Although costs of services will differ in other LMICs, the model is generalisable as the requirements for an ICU will be similar. Direct full-time critical care staff management costs were included in the study, however human resource costs pertaining to external departments such as engineering, supply chain

management, human resource departments and overall organisational hospital management teams i.e., head office and senior management costs were not included due to insufficient information regarding to COVID-ICU specific time allocation during the study period. As such, the total cost, and the cost per PDE is a minimum cost, as it does not include the full hospital support costs, or the costs of running a bed within a larger organization, whether state or private sector. This therefore represents a “within facility” costing. This makes it slightly more difficult to compare to the private sector costs referenced, that will include not only the transversal support costs, but also an unknown profit margin at many levels from consumables through to provider, and funders. Regarding nursing costs, an underestimation should be noted, as an average working month per nurse was used to calculate average nursing salaries for each nursing group without factoring in periods of annual leave or sick leave. During the pandemic, annual leave was not generally taken, however for the purposes of model generalisability, this should be factored in. For medical staffing we would use a factor of 13% to cover annual leave, 4 days sickness and 5 days CPD/CME leave to fill a roster through a 365-day period. Overheads may also have been underestimated as they were calculated using a top-down approach to apportion costs by using the respectful percentage of COVID-ICU to total hospital in-patient days, which does not account for the increased intensity of care for COVID-ICU beds compared with standard hospital beds. Medical air was not included in the costing study.

Conclusions

This study provides a retrospective analysis of COVID-ICU costing at a tertiary hospital in Cape Town throughout the entire portion of the pandemic that required ICU admissions in South Africa. The cost of R262 482 904 to run the COVID-ICU at GSH over two financial years, inclusive of almost all patient admissions throughout the pandemic, revealed a cost per in-patient day of R25 006. Costing per in-patient day in COVID-ICU at GSH was relatively standardised due to the disease treatment following a routine package of care. This analysis provides useful financial insights and evidence for ICU budgeting, and creates a platform for future economic analyses, and policy planning regarding level-of-care decisions for general ICU admissions or for similar future pandemics within LMIC hospital settings. Further research within the GSH setting regarding non COVID-ICU costing, as well as opportunity costing of the COVID-ICU expansion are planned.

Declaration. None.

Acknowledgements. Authors thank Zainap Ganief for providing the FBU financial data, inpatient day information, and salary data; Ebrahim Samsodien for providing the aggregated financial data relating to overheads for GSH; Mr Peters and Abalene Lesalaise from ICU nursing administration for providing all nursing rosters and advising on nursing and agency staffing; Grant Strathie for information regarding clinical technicians and medical equipment costs, Annelise Bezuidenhout for GSH budget and ICU equipment cost information; Ms Vanishree Naicker for advice regarding pharmacy costs, Ronald de Jager for providing financial information and rostering for COVID waste disposal and cleaning services; Annalena du Toit and Nathaniel van Wyk for providing information about dietitian allocations, salary graded, and feeding costs; Carolyn Davids regarding physiotherapy allocations and grades; Nazlea Behardien-Peters regarding radiography staffing, Mr Michael Pass regarding hospital security staffing; Charlene Daniels from Case Management for information regarding x-ray costs; Lynn Kester from HR regarding salary breakdown details and WC salary adjustment tables; Dr David Thomson, Dr Dave Fredericks and Ingrid Wilson for medical doctor rosters and allocations.

Author contributions. KH compiled the protocol and completed all aspects of data collection, results, analysis, and write up of the study. IJ contributed to study conception and supervised. LC provided technical advice, supervision and GSH building cost information. SP provided all contacts for data collection as well as COVID ward allocation information. CAD provided COVID-ICU inpatient day numbers and wave information. All authors approved the final manuscript for submission.

Funding. None.

Conflicts of interest. None.

References

- (1) World Health Organisation. WHO Coronavirus (COVID-19) Dashboard. 2022; Available at: <http://covid19.who.int>.
- (2) World Health Organization, (WHO). WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. 2020; Available at: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020>.
- (3) South African Department of Health. Health updates on Coronavirus on 9 March 2020. 2020; Available at: <https://www.gov.za/>.
- (4) Michell W, Joubert I, Peters S, Fredericks D, Miller M, Piercy J, et al. The organisational response of a hospital critical care service to the COVID-19 pandemic: The Groote Schuur Hospital experience. *South Afr J Crit Care* 2021 -08;37(2).
- (5) Cleary SM, Wilkinson T, Tamandjou Tchuem CR, Docrat S, Solanki GC. Cost-effectiveness of intensive care for hospitalized COVID-19 patients: experience from South Africa. *BMC Health Serv Res* 2021 -01-22;21(1).
- (6) Edoke I, Fraser H, Jamieson L, Meyer-Rath G, Mdewa W. Inpatient Care Costs of COVID-19 in South Africa's Public Healthcare System. *Int J Health Policy Manag* 2022;11(8):1354.
- (7) Mahomed S, Mohamed OH. Cost of intensive care services at a central hospital in South Africa. *SAMJ: South African Medical Journal* 2019 Jan 01;109(1):35-39.
- (8) Arnold-Day C, van Zyl-smit RN, Joubert IA, Thomson DA, Fredericks DL, Miller MGA, et al. Outcomes of patients with COVID-19 acute respiratory distress syndrome requiring invasive mechanical ventilation admitted to an intensive care unit in South Africa. *SAMJ: South African Medical Journal* 2022 Jan 01;112(1):34-39.
- (9) Vassall A, Sweeney S, Kahn JG, Gomez G, Bollinger L, Marseille E, Herzel B, DeCormier Plosky W, Cunnama L, Sinanovic E, Bautista-Arredondo S, GHCC Technical Advisory Group, GHCC Stakeholder Group, Harris K, Levin C. Reference Case for Estimating the Costs of Global Health Services and Interventions. *Global Health Cost Consortium*; 2017.
- (10) Kenton W. Equivalent Annual Cost (EAC): What It Is, How It Works, Examples. 2020; Available at: <https://www.investopedia.com/terms/e/eac.asp>.
- (11) Aridi M, Hussein B, Hajj-Hassan M, Khachfe HM. A novel approach for healthcare equipments lifespan assessment Cancer Incidence In Lebanon View project Prevalence and Risk Factors of Symptomatic Dry Eye Disease in the Middle East View project.

- (12) Dasta JF, McLaughlin TP, Mody SH, Piech CT. Daily cost of an intensive care unit day: The contribution of mechanical ventilation. *Crit Care Med* 2005;33(6):1266-1271.
- (13) Elliott D. Costing intensive care services: a review of study methods, results and limitations. *Aust Crit Care* 1997;10(2):55-63.
- (14) Tarrant H. Covid-19 hospital admissions cost Discovery R85 000 on average. 2020; Available at: <https://www.moneyweb.co.za/news/companies-and-deals/covid-19-hospital-admissions-cost-discovery-r85-000-on-average/>. Accessed 20 November, 2021.
- (15) de Wet P. Discovery is paying R340,737 per patient on ventilation for Covid-19 in schemes it runs. 2020; Available at: <https://www.businessinsider.co.za/discovery-estimates-the-cost-of-treating-covid-19-up-to-r3-561-per-medical-scheme-member-2020-5>. Accessed 28 November, 2022.
- (16) Western Cape Government. Western Cape Government Hospital Tariffs: An Overview - Full-Paying Patients - UPFS Fee Schedule: Implementation date: APRIL 2022. 2022; Available at: https://www.westerncape.gov.za/general-publication/western-cape-government-hospital-tariffs-overview?toc_page=2. Accessed 28 November, 2022.
- (17) Tan SS, PhD., Bakker, Jan, PhD., M.D., Hoogendoorn ME, M.Sc, Kapila, Atul, PhD., M.D., Martin, Joerg, PhD., M.D., Pezzi, Angelo, PhD., M.D., et al. Direct Cost Analysis of Intensive Care Unit Stay in Four European Countries: Applying a Standardized Costing Methodology. *Value in health; Value Health* 2012;15(1):81-86.
- (18) MASHA H, and SACEMA. Estimating cases for COVID-19 in South Africa: Assessment of alternative scenarios FOR PUBLIC RELEASE.
- (19) Negrini D, Sheppard L, Mills GH, Jacobs P, Rapoport J, Bourne RS, et al. International Programme for Resource Use in Critical Care (IPOC) a methodology and initial results of cost and provision in four European countries. *Acta Anaesthesiol Scand* 2006;50(1):72-79.
- (20) Potgieter PD, Hammill L, Gough A, Hammond JMJ. South Africa. The Blue Economy in Sub-Saharan Africa 2021 -05-19:115.

Appendix Material

Appendix A: UCT Human Research Ethics (HREC) Approval Letter



UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee



Room 45-E52- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-appoint@uct.ac.za

Website: www.health.uct.ac.za/fhs/research/humanethics/forms

28 October 2021

HREC REF: 685/2021

Prof I Joubert

Division of Critical Care Medicine
Unit 4, Area C 27, NGSB
Email: ivan.joubert@uct.ac.za
Student: hdxkir001@myuct.ac.za

Dear Prof Joubert

PROJECT TITLE: THE COST OF COVID-19 ICU AT A TERTIARY HOSPITAL IN CAPE TOWN, SOUTH AFRICA-MASTERS CANDIDATE-DR KIRSTEN HOOD

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020; 06 July 2020 & 01 July 2021.

Approval is granted for one year until the 30 October 2022.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledges that the student: Dr Kirsten Hood will also be involved in this study.

Please quote the HREC REF 685/2021 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

HREC/REF 685/2021sa

Appendix B: Groote Schuur Hospital Management Approval Letter



GROOTE SCHUUR HOSPITAL
Enquiries: Dr Bernadette Eick
e-mail: GSHResearch.Request@westerncape.gov.za

PROFESSOR IVAN JOUBERT
DIVISION OF CRITICAL CARE MEDICINE

E-mail: Ivan.joubert@uct.ac.za

Dear Professor Joubert

RESEARCH PROJECT: The Cost of COVID-19 ICU at a Tertiary Hospital in Cape Town, South Africa.
Masters Candidate: Dr Kirsten Hood

Your recent letter to the hospital refers.

You are granted permission to proceed with your research, which is valid until **30 October 2022**.

Please note the following:

- a) Your research may not interfere with normal patient care.
- b) Hospital staff may not be asked to assist with the research.
- c) **Confidentiality must always be maintained.**
- d) No additional costs to the hospital should be incurred as indicated in your Annexure 2 i.e. Lab, consumables or stationery. **If access to TRACK Care/NHLS is required, kindly attach our letter of approval to the application form and approach Information Management to assist with data.**
- e) **No patient folders may be removed from the premises or be inaccessible.**
- f) Please provide the research assistant/field worker with a copy of this letter as verification of approval.
- g) **Should you at any time require photographs of your subjects, please obtain the necessary indemnity forms from our Public Relations Office (E45 OMB or ext. 2187/2188).**
- h) Should you require additional research time beyond the stipulated expiry date, please apply for an extension.
- i) Please discuss the study with the HOD before commencing.
- j) Please introduce yourself to the person in charge of an area before commencing.
- k) On completion of your research, please forward any recommendations/findings that can be beneficial to use to take further action that may inform redevelopment of future policy / review guidelines.
- l) Please contact Michelle Riley (Patient Fees) at ext. 2276 to ascertain if there will be charges for conducting the Research and to obtain a quote or to discuss charges
- m) **Kindly submit a copy of the publication or report to this office on completion of the research.**
- n) **At no time should any posters encouraging patients to partake in research, be displayed within a clinical area.**
- o) **Please adhere to ALL COVID-19 regulations and Groote Schuur Hospital policies.**

I would like to wish you every success with the project.

Yours sincerely

DR BERNADETTE EICK
CHIEF OPERATIONAL OFFICER
Date: 09 December 2021

C.C. Mr L. Naidoo, Dr. S Peters, Mr. A Mohamed

G46 Management Suite, Old Main Building,
Observatory 7925
Tel: +27 21 4046288 Fax: +27 21 404 6125

Private Bag X,
Observatory, 7935
www.westerncape.gov.za/health

Appendix C: Instructions to Authors

South African Medical Journal Author guidelines

General article format/layout

Accepted manuscripts that are not in the correct format specified in these guidelines will be returned to the author(s) for correction, which will delay publication.

General:

- Manuscripts must be written in UK English.
- The manuscript must be in Microsoft Word format. Text must be single-spaced, in 12-point Times New Roman font, and contain no unnecessary formatting (such as text in boxes).
- Please make your article concise, even if it is below the word limit.
- Qualifications, **full** affiliation (department, school/faculty, institution, city, country) and contact details of ALL authors must be provided in the manuscript and in the online submission process.
- Abbreviations should be spelt out when first used and thereafter used consistently, e.g. 'intravenous (IV)' or 'Department of Health (DoH)'.
- Include sections on Acknowledgements, Conflict of Interest, Author Contributions and Funding sources. If none is applicable, please state 'none'.
- Scientific measurements must be expressed in SI units except: blood pressure (mmHg) and haemoglobin (g/dL).
- Litres is denoted with an uppercase L e.g. 'mL' for millilitres).
- Units should be preceded by a space (except for % and °C), e.g. '40 kg' and '20 cm' but '50%' and '19°C'.
- Please be sure to insert proper symbols e.g. μ not u for micro, α not a for alpha, β not B for beta, etc.
- Numbers should be written as grouped per thousand-units, i.e. 4 000, 22 160.
- Quotes should be placed in single quotation marks: i.e. The respondent stated: '...'
- Round brackets (parentheses) should be used, as opposed to square brackets, which are reserved for denoting concentrations or insertions in direct quotes.
- If you wish material to be in a box, simply indicate this in the text. You may use the table format –this is the *only* exception. Please DO NOT use fill, format lines and so on.

Research

Guideline word limit: 4 000 words

Research articles describe the background, methods, results and conclusions of an original research study. The article should contain the following sections: introduction, methods, results, discussion and conclusion, and should include a structured abstract (see below). The introduction should be concise – no more than three paragraphs – on the background to the research question, and must include references to other relevant published studies that clearly lay out the rationale for conducting the study. Some common reasons for conducting a study are: to fill a gap in the literature, a logical extension of previous work, or to answer an important clinical question. If other papers related to the same study have been published

previously, please make sure to refer to them specifically. Describe the study methods in as much detail as possible so that others would be able to replicate the study should they need to. Results should describe the study sample as well as the findings from the study itself, but all interpretation of findings must be kept in the discussion section, which should consider primary outcomes first before any secondary or tertiary findings or post-hoc analyses. The conclusion should briefly summarise the main message of the paper and provide recommendations for further study.

Select figures and tables for your paper carefully and sparingly. Use only those figures that provided added value to the paper, over and above what is written in the text.

Do not replicate data in tables and in text .

Structured abstract

- This should be 250-400 words, with the following recommended headings:
 - o **Background:** why the study is being done and how it relates to other published work.
 - o **Objectives:** what the study intends to find out
 - o **Methods:** must include study design, number of participants, description of the intervention, primary and secondary outcomes, any specific analyses that were done on the data.
 - o **Results:** first sentence must be brief population and sample description; outline the results according to the methods described. Primary outcomes must be described first, even if they are not the most significant findings of the study.
 - o **Conclusion:** must be supported by the data, include recommendations for further study/actions.
- Please ensure that the structured abstract is complete, accurate and clear and has been approved by all authors.
- Do not include any references in the abstracts.

Here is an example of a good abstract.

Main article

All articles are to include the following main sections: Introduction/Background, Methods, Results, Discussion, Conclusions.

The following are additional heading or section options that may appear within these:

- Objectives (within Introduction/Background): a clear statement of the main aim of the study and the major hypothesis tested or research question posed
- Design (within Methods): including factors such as prospective, randomisation, blinding, placebo control, case control, crossover, criterion standards for diagnostic tests, etc.
- Setting (within Methods): level of care, e.g. primary, secondary, number of participating centres.

- Participants (instead of patients or subjects; within Methods): numbers entering and completing the study, sex, age and any other biological, behavioural, social or cultural factors (e.g., smoking status, socioeconomic group, educational attainment, co-existing disease indicators, etc) that may have an impact on the study results. Clearly define how participants were enrolled, and describe selection and exclusion criteria.
- Interventions (within Methods): what, how, when and for how long. Typically for randomised controlled trials, crossover trials, and before and after studies.
- Main outcome measures (within Methods): those as planned in the protocol, and those ultimately measured. Explain differences, if any.

Results

- Start with description of the population and sample. Include key characteristics of comparison groups.
- Main results with (for quantitative studies) 95% confidence intervals and, where appropriate, the exact level of statistical significance and the number need to treat/harm. Whenever possible, state absolute rather than relative risks.
- Do not replicate data in tables and in text.
- If presenting mean and standard deviations, specify this clearly. Our house style is to present this as follows:
- E.g.: The mean (SD) birth weight was 2 500 (1 210) g. Do not use the \pm symbol for mean (SD).
- Leave interpretation to the Discussion section. The Results section should just report the findings as per the Methods section.

Discussion

Please ensure that the discussion is concise and follows this overall structure – sub-headings are not needed:

- Statement of principal findings
- Strengths and weaknesses of the study
- Contribution to the body of knowledge
- Strengths and weaknesses in relation to other studies
- The meaning of the study – e.g. what this study means to clinicians and policymakers
- Unanswered questions and recommendations for future research

Conclusions

This may be the only section readers look at, therefore write it carefully. Include primary conclusions and their implications, suggesting areas for further research if appropriate. Do not go beyond the data in the article.

Illustrations/photos/scans

- If illustrations submitted have been published elsewhere, the author(s) should provide consent to republication obtained from the copyright holder.

- Figures must be numbered in Arabic numerals and referred to in the text e.g. '(Fig. 1)'. Each figure must have a caption/legend: Fig. 1. Description (any abbreviations in full).
- All images must be of high enough resolution/quality for print.
- All illustrations (graphs, diagrams, charts, etc.) must be in PDF or jpeg form.
- Ensure all graph axes are labelled appropriately, with a heading/description and units (as necessary) indicated. Do not include decimal places if not necessary e.g. 0; 1.0; 2.0; 3.0; 4.0 etc.
- Scans/photos showing a specific feature e.g. *Intermediate magnification micrograph of a low malignant potential (LMP) mucinous ovarian tumour. (H&E stain).* –include an arrow to show the tumour.
- Each image must be attached individually as a 'supplementary file' upon submission (not solely embedded in the accompanying manuscript) and named Fig. 1, Fig. 2, etc.

Tables

- Tables should be constructed carefully and simply for intelligible data representation. Unnecessarily complicated tables are strongly discouraged.
- Large tables will generally not be accepted for publication in their entirety. Please consider shortening and using the text to highlight specific important sections, or offer a large table as an addendum to the publication, but available in full on request from the author
- Embed/include each table in the manuscript Word file - do not provide separately as supplementary files.
- Number each table in Arabic numerals (Table 1, Table 2, etc.) and refer to consecutively in the text.
- Tables must be cell-based (i.e. not constructed with text boxes or tabs) and editable.
- Ensure each table has a concise title and column headings, and include units where necessary.
- Footnotes must be indicated with consecutive use of the following symbols: * † ‡ § ¶ || then ** †† ‡‡ etc.

Do not: Use [Enter] within a row to make 'new rows':

Rather:

Each row of data must have its own proper row:

Do not: use separate columns for *n* and %:

Rather:

Combine into one column, *n* (%):

Do not: have overlapping categories, e.g.:

Rather:

Use \diamond symbols or numbers that don't overlap:

References

NB: Only complete, correctly formatted reference lists in Vancouver style will be accepted. Reference lists must be generated manually and not with the use of reference manager software. Endnotes must **not** be used.

- Authors must verify references from original sources.
- Citations should be inserted in the text as superscript numbers between square brackets, e.g. These regulations are endorsed by the World Health Organization,^[2] and others.^[3,4-6]
- All references should be listed at the end of the article in numerical order of appearance in the Vancouver style (not alphabetical order).
- Approved abbreviations of journal titles must be used; see the List of Journals in Index Medicus.
- Names and initials of all authors should be given; if there are more than six authors, the first three names should be given followed by et al.
- Volume and issue numbers should be given.
- First and last page, in full, should be given e.g.: 1215-1217 **not** 1215-17.
- Wherever possible, references must be accompanied by a digital object identifier (DOI) link). Authors are encouraged to use the DOI lookup service offered by CrossRef:
 - o On the Crossref homepage, paste the article title into the 'Metadata search' box.
 - o Look for the correct, matching article in the list of results.
 - o Click Actions > Cite
 - o Alongside 'url =' copy the URL between { }.
 - o Provide as follows, e.g.: <https://doi.org/10.7196/07294.937.98x>

Some examples:

- *Journal references:* Price NC, Jacobs NN, Roberts DA, et al. Importance of asking about glaucoma. *Stat Med* 1998;289(1):350-355. <http://dx.doi.org/10.1000/hgjr.182>
- *Book references:* Jeffcoate N. Principles of Gynaecology. 4th ed. London: Butterworth, 1975:96-101.
- *Chapter/section in a book:* Weinstein L, Swartz MN. Pathogenic Properties of Invading Microorganisms. In: Sodeman WA, Sodeman WA, eds. Pathologic Physiology: Mechanisms of Disease. Philadelphia: WB Saunders, 1974:457-472.
- *Internet references:* World Health Organization. The World Health Report 2002 - Reducing Risks, Promoting Healthy Life. Geneva: WHO, 2002. <http://www.who.int/whr/2002> (accessed 16 January 2010).
- Legal references

- Government Gazettes:

National Department of Health, South Africa. National Policy for Health Act, 1990 (Act No. 116 of 1990). Free primary health care services. Government Gazette No. 17507:1514. 1996.

In this example, 17507 is the Gazette Number. This is followed by :1514 - this is the notice number in this Gazette.

- Provincial Gazettes:

Gauteng Province, South Africa; Department of Agriculture, Conservation, Environment and Land Affairs. Publication of the Gauteng health care waste management draft regulations. Gauteng Provincial Gazette No. 373:3003, 2003.

- Acts:

South Africa. National Health Act No. 61 of 2003.

- Regulations to an Act:

South Africa. National Health Act of 2003. Regulations: Rendering of clinical forensic medicine services. Government Gazette No. 35099, 2012. (Published under Government Notice R176).

- Bills:

South Africa. Traditional Health Practitioners Bill, No. B66B-2003, 2006.

- Green/white papers:

South Africa. Department of Health Green Paper: National Health Insurance in South Africa. 2011.

- Case law:

Rex v Jopp and Another 1949 (4) SA 11 (N)

Rex v Jopp and Another: Name of the parties concerned

1949: Date of decision (or when the case was heard)

(4): Volume number

SA: SA Law Reports

11: Page or section number

(N): In this case Natal - where the case was heard. Similarly, (C) would indicate Cape, (G) Gauteng, and so on.

NOTE: no . after the v

- *Other references (e.g. reports) should follow the same format: Author(s). Title. Publisher place: Publisher name, year; pages.*
- Cited manuscripts that have been accepted but not yet published can be included as references followed by '(in press)'.
- Unpublished observations and personal communications in the text must **not** appear in the reference list. The full name of the source person must be provided for personal communications e.g. '...(Prof. Michael Jones, personal communication)'.