

An audit of difficult airway trolleys at central and tertiary hospitals affiliated with the University of the Witwatersrand. A cross-sectional study.

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Abstract

Background:

Airway management equipment is essential for mitigating morbidity and mortality associated with difficult airway complications in anaesthesia (Apfelbaum et al., 2013). This study audited the availability, physical structure, contents, and maintenance of difficult airway trolleys (DATs) and grab bags across four South African central and tertiary hospitals against United Kingdom Difficult Airway Society (DAS) guidelines.

Methods:

A prospective, contextual, descriptive cross-sectional audit was conducted across four university-affiliated academic hospitals in Gauteng, South Africa. DATs and grab bags were evaluated against DAS criteria using a validated REDCap® checklist assessing location, physical structure, drawer labelling, equipment completeness, algorithm display, routine checking systems, and grab bag availability. Data were analysed using descriptive statistics.

Results:

Fifteen DATs were audited across 21 theatre complexes comprising 72 operating theatres. Eleven trolleys (73.3%) were concentrated at a single hospital, while two hospitals possessed only one trolley each. While 14 trolleys (93.3%) were fully mobile, only seven (46.7%) were logically stocked, and two (13.3%) lacked drawer labelling entirely. None of the DATs (0.0%) met complete DAS guidelines for top, side, or drawer contents. Video laryngoscopes and flexible fiberoptic scopes were universally absent on DATs. Cognitive airway algorithms were displayed on six trolleys (40.0%), and only one hospital utilised locally agreed guidelines. Difficult airway grab bags were available at two hospitals (50.0%) but lacked surgical cricothyroidotomy equipment.

Conclusions:

A substantial deficiency exists in the quantity, stocking logic, labelling, and content standardisation of DATs across public academic hospitals relative to surgical volume.

Recommendations:

Institutional management must prioritise standardising DAT contents according to validated algorithms, establishing mandatory daily checking logs, procuring video-assisted airway equipment, and deploying localised cognitive decision aids across all clinical areas where anaesthesia is administered.

Keywords: Airway Trolleys, Central and Tertiary Hospitals, Witwatersrand.

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Introduction

Airway management is a core competency in anaesthesiology, where failures in securing a definitive airway or maintaining adequate oxygenation remain leading causes of perioperative morbidity and mortality (Apfelbaum et al., 2013; Cook, Woodall and Frerk, 2011). The United Kingdom Royal College of Anaesthetists and Difficult Airway Society (DAS) Fourth National Audit Project (NAP4) identified serious complications

(including hypoxic brain damage, emergency surgical airway access, unanticipated intensive care unit admission, and death) arising from adverse airway events (Cook, Woodall and Frerk, 2011; Cook et al., 2011). Similarly, the American Society of Anesthesiologists (ASA) Closed Claims analysis and the Australian Incident Monitoring Study (AIMS) established that inadequate ventilation, unrecognised oesophageal intubation, and difficult tracheal intubation account for over 75% of

adverse respiratory events (Caplan et al., 1990; Williamson et al., 1993). International bodies advocate for immediate access to dedicated, logically organised difficult airway trolleys (DATs) stocked with essential rescue equipment within a reachable distance of under two minutes from any location where anaesthesia is administered (Bjurström, Bodelsson and Stureson, 2019; Difficult Airway Society, 2018; Janssens and Hartstein, 2001).

In low- and middle-income countries (LMICs) like South Africa, the delivery of safe anaesthesia operates under health system constraints, high surgical workloads, and complex disease burdens (Armstrong et al., 2020; Hodgson et al., 2008). Although recommendations for South African airway management resources have largely been adapted from DAS and ASA frameworks (Hodgson et al., 2008), local public sector facilities frequently face procurement bottlenecks, inconsistent equipment maintenance, and non-standardised trolley layouts across different surgical suites within the same hospital network. While audits in high-income countries demonstrate varying compliance with DAT guidelines, often showing high availability of basic equipment alongside shortages of advanced devices (Adams and Piper, 2019; Baker et al., 2007), there is a lack of empirical data regarding the physical readiness and equipment quality of DATs in South African public sector hospitals.

As unpreparedness during an unanticipated difficult airway event may pose immediate adverse perioperative risks, formal multisite audits are needed to evaluate whether public academic centres maintain adequate DAT availability, physical structure, logical stocking, and cognitive decision aids.

This study aimed to audit the availability, physical structure, contents, labelling, checking systems, and cognitive algorithm displays of DATs and grab bags across four central and tertiary academic hospitals affiliated with the University of the Witwatersrand against standard DAS guidelines (Difficult Airway Society, 2018).

Methods

Study design and study setting

A prospective, contextual, descriptive cross-sectional audit design was employed to evaluate difficult airway equipment readiness and structural functionality across four academic hospital complexes affiliated with the University of the Witwatersrand in Johannesburg, Gauteng, South Africa. The audit was conducted at Chris Hani Baragwanath Academic Hospital (CHBAH), Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), Helen Joseph Hospital (HJH), and Rahima Moosa Mother and Child Hospital (RMMCH). Data collection was carried out across all study sites between July and August 2021.

Sample population

The study audited a total sample size of 15 DATs ($N = 15$)

distributed across 21 operating theatre complexes comprising 72 active operating theatres across the four participating academic hospital facilities.

Sampling technique

A non-probability complete census sampling approach (purposive sampling) was utilised. All resuscitation trolleys explicitly identified as adult DATs within the operating theatre complexes during the audit period were targeted and evaluated to achieve a 100% audit of available eligible equipment.

Inclusion and exclusion criteria

Included in the study were all resuscitation trolleys explicitly designated and configured as adult DATs located within the operating theatre complexes of the participating hospitals. Excluded from the study were standard resuscitation crash carts, dedicated paediatric airway trolleys, and general surgical equipment carts not specifically assigned for difficult airway management.

Data measurement

Data were gathered using a standardised data collection tool developed in Microsoft Excel® and hosted on the REDCap® electronic data capture platform. The data collection tool was constructed following an extensive literature review based on the United Kingdom DAS guidelines for DAT setup to establish content validity (Difficult Airway Society, 2018).

Content and face validity were formally verified by three senior anaesthesiologists with specialised expertise in difficult airway management. To eliminate data contamination and prevent unregistered movement of equipment between suites, a single researcher conducted the audit at each hospital facility on a single dedicated day.

Variables

The primary audited variables encompassed trolley existence, exact physical location, and physical distance in metres to the nearest active operating suite. Structural and functional variables included wheel mobility, drawer count configuration, logical stocking sequence, and external drawer labelling (Supplementary Information S1). Content variables were assessed for completeness across the top surface, side attachments, and Drawers 1 through 5 against DAS standards (Supplementary Information S1). Additional operational variables included the presence and visibility of cognitive difficult airway algorithms, attached routine checking logs, specific extension aids, and the availability and itemised contents of emergency difficult airway grab bags (Supplementary Information S1).

Statistical methods

Data were exported from REDCap® into Microsoft Excel® and STATA version 15 software for descriptive statistical analysis. Categorical variables were summarised using

absolute frequencies and percentages (N , %). Continuous variables were expressed as means with standard deviations or medians with interquartile ranges (IQR), as appropriate to the underlying data distribution.

Ethical consideration

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Ethical approval was granted by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (Clearance Certificate No. W-CBP-210727-01; Supplementary Information S2). Institutional permission was formally obtained from the Chief Executive Officers and Heads of Departments of Anaesthesiology at CHBAH, CMJAH, HJH, and RMMCH (Supplementary Information S3–S4). To preserve institutional and staff confidentiality, no individual personnel or identifying hospital markers were recorded on data collection sheets. Equipment deficits identified during data collection were reported immediately to the respective operating theatre nursing managers.

Informed consent was not applicable as the research design evaluated physical equipment infrastructure without involving human participants.

Results

Availability, Location, and Physical Proximity of DATs

A total of 15 DATs were identified across 21 theatre complexes comprising 72 operating theatres in the four audited central and tertiary hospitals (Table I). Trolley availability was disproportionately concentrated at

CHBAH, which possessed 11 DATs (73.3%) across 11 theatre complexes serving 30 operating theatres (Table I). CMJAH maintained two DATs (13.3%) across eight theatre complexes serving 25 operating theatres (Table I). HJH (12 operating theatres) and RMMCH (5 operating theatres) each possessed one DAT (6.7% each; Table I).

The physical location and proximity of DATs relative to operating suites varied by institution (Table I). While the majority were located in passages outside operating rooms (46.7%) or within recovery rooms (40.0%), critical outliers in proximity were identified (Table I). The distance between DATs and the nearest theatre complex ranged from 5 to 2,000 m at CHBAH and from 5 to 60 m at CMJAH. The single DATs at RMMCH and HJH were located 10 m and 20 m from their respective theatre complexes. Overall, the distance ranged from 5 to 2,000 m. Regarding physical structure, 93.3% ($n=14$) of the audited DATs were fully mobile on four functional wheels; however, half of the CMJAH inventory ($n=1$) possessed fixed wheels that hindered manoeuvrability (Table I). Drawer configurations varied across all sites, ranging from four to seven drawers.

Adherence to standardised stocking and labelling protocols was inconsistent. A logical stocking sequence, defined as ordering contents according to DAS algorithmic steps, was observed in less than half of the audited trolleys (46.7%, $n=7$) (Table I). External drawer labelling consistent with DAS specifications was present on 86.7% ($n=13$) of the overall inventory. However, standardisation was completely absent at CMJAH, where the facility's inventory ($n=2$) lacked both logical stocking sequences and external drawer labelling (Table I).

Table I: Availability, physical characteristics, stocking, and drawer labelling of DATs across audited hospitals ($N = 15$)

Parameter / Variable	CHBAH ($n=11$)	CMJAH ($n=2$)	RMMCH ($n=1$)	HJH ($n=1$)	Combined Total ($N=15$)
Institutional Characteristics					
Total theatre complexes, N	11	8	1	1	21
Total operating theatres, N	30	25	5	12	72
Total DATs present, n (%)	11 (73.3)	2 (13.3)	1 (6.7)	1 (6.7)	15 (100.0)
Physical Location & Distance, n (%)					
Passage outside theatres	6 (54.5)	1 (50.0)	0 (0.0)	0 (0.0)	7 (46.7)
In or adjacent to the recovery room	4 (36.4)	0 (0.0)	1 (100.0)	1 (100.0)	6 (40.0)
Department of Anaesthetics	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)	1 (6.7)
External equipment stocking room	1 (9.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (6.7)
Distance to nearest theatre (metres)	5–2,000	5–60	10	20	5–2,000
Trolley Functionality & Structure					
Fully mobile on four wheels, n (%)	11 (100.0)	1 (50.0)	1 (100.0)	1 (100.0)	14 (93.3)
Drawer count configuration, n	5	5; 7	4	4	4–7
Logical stocking sequence present, n (%)	5 (45.5)	0 (0.0)	1 (100.0)	1 (100.0)	7 (46.7)
External drawer labelling present, n (%)	11 (100.0)	0 (0.0)	1 (100.0)	1 (100.0)	13 (86.7)

CHBAH, Chris Hani Baragwanath Academic Hospital; CMJAH, Charlotte Maxeke Johannesburg Academic Hospital; DAT, Difficult Airway Trolley; HJH, Helen Joseph Hospital; RMMCH, Rahima Moosa Mother and Child Hospital.

Equipment Contents of DATs

Zero DATs (0.0%, $N = 15$) met full DAS content requirements across the top, side, and Drawers 1 through 5 combined (Figure 1). For top surface equipment, portable stack systems and portable scopes with battery light sources were absent across all 15 DATs (0.0%) (Figure 1A). RMMCH maintained two recommended items on top of its DAT: a flexible intubating fiberoptic

scope and a single-use fiberoptic scope (6.7% of total DATs) (Figure 1). All 15 DATs (100.0%) contained unrecommended or non-essential equipment stored on top, including Ring-Adair-Elwyn (RAE) nasal endotracheal tubes, reinforced endotracheal tubes, Raytec gauze swabs, and plastic normal saline irrigation bottles (Figure 1B). Zero DATs (0.0%) met DAS standards for side-mounted equipment (Figure 1B)

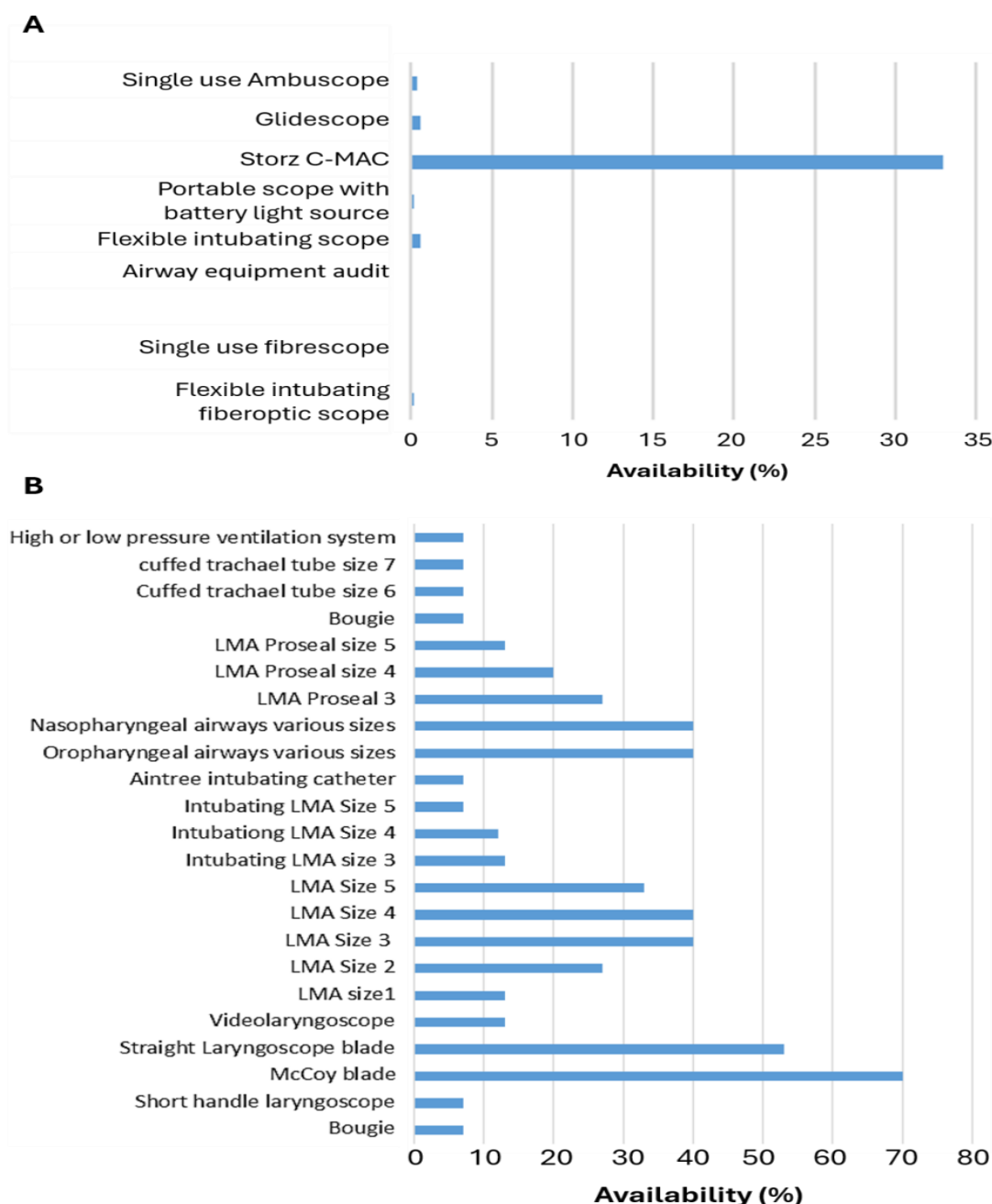


Figure 1: Summary of equipment stocking compliance across (A) top surface and side attachments; and (B) Drawers 1 through 5 of audited difficult airway trolleys (N = 15) relative to DAS guidelines

DAT, Difficult Airway Trolley; LMA, Laryngeal Mask Airway.

Cognitive Algorithms, Routine Checking Systems, and Emergency Grab Bags

Cognitive difficult airway algorithms were displayed on six of the 15 audited DATs (40.0%; Figure 2). At CHBAH, nine DATs (81.8%) lacked cognitive algorithms entirely (Figure 2). At CMJAH, one DAT (50.0%)

displayed three cognitive algorithm charts while the second displayed zero (Figure 2). The DAT at HJH displayed five of the six recommended algorithm charts, representing the only trolley in the study that displayed locally agreed-upon institutional guidelines alongside standard DAS flowcharts (Figure 2). Zero DATs (0.0%, N = 15) possessed attached routine maintenance checking documentation or specific extension aids (Figure 2). Dedicated emergency difficult airway grab bags were

present at two of the four audited hospitals (HJH and RMMCH; Figure 2). The grab bag at RMMCH contained 14 of 16 recommended items (87.5%), lacking laryngoscopy blades and surgical cricothyroidotomy sets

(Figure 2). The grab bag at HJH contained 14 of 16 recommended items (87.5%), lacking nasopharyngeal airways and surgical cricothyroidotomy sets (Figure 2).

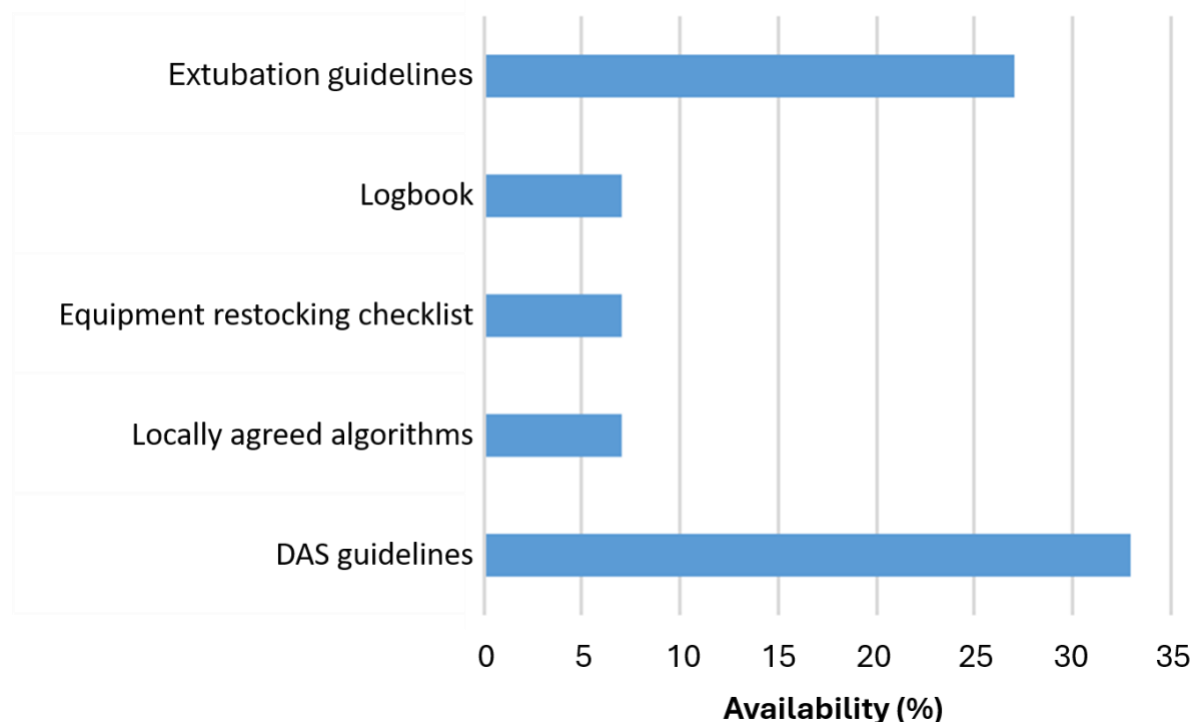


Figure 2: Distribution of cognitive algorithm displays, routine maintenance checking systems, and emergency grab bag availability across audited academic hospitals.

Discussion

This prospective cross-sectional audit demonstrates substantial deficits in the provision, physical location, structural organisation, equipment stocking, and routine maintenance of DATs across public sector central and tertiary academic hospitals in Johannesburg. The findings highlight a disparity between local clinical infrastructure and international recommendations established by the DAS, ASA, and Australian and New Zealand College of Anaesthetists (ANZCA).

A fundamental concern identified by the audit is the marked numerical imbalance and inequitable distribution of DATs relative to surgical volume and complex physical layout. While CHBAH maintained 11 DATs across 30 operating theatres (1 trolley per 2.7 theatres), CMJAH operated with only two DATs for 25 operating theatres spread across eight physically discrete complexes (1 trolley per 12.5 theatres). Mathematical resource modelling for operating suites indicates that any surgical centre with more than 16 adjoining active locations requires a minimum of two dedicated airway trolleys to ensure rapid deployment during overlapping emergencies without compromising patient safety (Udeh, Udeh and Dalton, 2016). Although the physical distance of DATs to

operating rooms averaged seven metres at CHBAH and 5–10 metres at RMMCH and HJH, storing a DAT 2,000 metres away in a central equipment room (CHBAH) or 60 metres away near administrative offices (CMJAH) breaches the core safety standard requiring immediate accessibility within two minutes (Bjurström, Bodelsson and Stureson, 2019; Difficult Airway Society, 2018).

Physical organisation and logical stocking of DATs are pivotal to reducing cognitive overload and preventing delays during acute airway crises. In the present audit, less than half of all DATs (46.7%) were logically stocked according to the DAS step-wise algorithm (Plan A to Plan D), and two DATs (13.3%) lacked drawer labelling entirely. Unlabelled or illogically organised drawers force clinicians to search through non-sequential compartments during hypoxia, escalating stress and procedural delay (Fuchs et al., 2021).

None of the audited DATs (0.0%) met full DAS guidelines for top, side, or drawer contents. Advanced video-assisted and flexible optical equipment was absent on DAT tops across three of the four institutions. Instead, clinicians stored these instruments in locked storerooms to protect against theft or damage, creating an operational barrier during an unexpected "cannot intubate, cannot

oxygenate" (CICO) emergency. Furthermore, 100% of DAT tops were cluttered with non-essential items such as saline bottles and unrecommended endotracheal tubes. Audits in high-income countries (HICs) such as Australia and the United Kingdom report high availability of essential airway equipment (median scores of 88.9% to 100%), with deficits largely confined to advanced devices (Adams and Piper, 2019; Baker et al., 2007). Conversely, the present audit identified missing basic rescue equipment, including supraglottic airways and primary intubation blades, within Drawers 1 to 3. This reflects the systemic impact of procurement bottlenecks, financial constraints, and supply chain disruptions typical of low- and middle-income country (LMIC) public healthcare sectors (Armstrong et al., 2020; Hodgson et al., 2008).

Cognitive decision aids were absent on 60.0% of audited DATs. Displaying clear, standardised airway algorithms on equipment trolleys aids rapid decision-making, streamlines team communication, and mitigates fixation errors during life-threatening crises (Edelman, Perkins and Brewster, 2019; Fuchs et al., 2021). The documented lack of locally adapted cognitive algorithms (present in only one hospital) highlights a lack of institutional standardisation. Furthermore, zero DATs (0.0%) possessed attached routine maintenance checking documentation. Data from the Australian Incident Monitoring Study (AIMS) revealed that one-third of reported difficult intubation incidents were directly attributable to a failure to check the safety and readiness of equipment prior to anaesthesia (Williamson et al., 1993).

Emergency difficult airway grab bags were available in only two hospitals (50.0%). Although these grab bags contained most recommended items (87.5%), both lacked surgical cricothyroidotomy equipment. Portable grab bags are essential for managing airway emergencies in remote locations, during intra-hospital transit, or in satellite areas where dedicated DATs are absent (ANZCA, 2021; Bjurström, Bodelsson and Stureson, 2019).

Generalizability

The findings of this audit are representative of major public sector tertiary academic complexes affiliated with university training circuits in South Africa. Because the participating central and tertiary facilities handle high-volume surgical caseloads and complex referral pathologies in Gauteng, the identified equipment deficits, stocking inconsistencies, and procedural gaps likely reflect systemic challenges throughout South African public sector surgical complexes. However, the results may not be generalisable to private healthcare facilities or smaller regional and district hospitals operating under different governance and resource frameworks.

Conclusion

DATs across the audited central and tertiary academic hospitals fall notably short of international standards defined by the DAS. Inadequate trolley numbers relative

to theatre suites, inequitable distribution, illogical stocking, absent drawer labels, lack of displayed cognitive algorithms, and non-existence of routine checking logs pose risks to perioperative patient safety during unanticipated difficult airway emergencies.

Limitations

Several limitations must be acknowledged when interpreting the findings of this audit. First, the study evaluated a limited sample size of 15 DATs across four central and tertiary academic hospitals within a single university circuit in Gauteng, which restricts direct statistical generalisation to all public healthcare facilities across South Africa. Second, the investigation focused exclusively on physical equipment readiness, structural layout, and presence of contents; it did not evaluate clinician awareness, operational knowledge, prior training, or individual clinical competency regarding the location and practical utilisation of the trolleys. Finally, equipment functionality was evaluated through visual inspection and basic mechanical testing during data collection, without assessing real-time device performance or retrieval efficiency under simulated clinical emergency conditions.

Recommendations

To address the identified deficits and enhance perioperative patient safety, institutional management and departmental leadership must implement several interventions. Public sector healthcare facilities should establish a standardised trolley layout across all operating complexes, organising Drawers 1 through 4 strictly according to DAS algorithmic steps A (Intubation), B (Supraglottic Airway), C (Facemask Ventilation), and D (Surgical Airway Access). To ensure continuous readiness, attach mandatory daily physical-check logs directly to every trolley, requiring verification and sign-off by designated nursing and anaesthetic personnel before the start of daily operating lists. Furthermore, clear, laminated local and international cognitive airway algorithms must be mounted prominently on all trolleys and emergency grab bags to facilitate clinical decision-making during crisis management. Hospital executive leadership must prioritise capital expenditure for dedicated video laryngoscopes and surgical cricothyroidotomy sets assigned directly to equipment carts rather than central locked storerooms. Lastly, standardised emergency difficult airway grab bags containing emergency invasive airway equipment should be procured and deployed across all satellite theatre complexes, maternity suites, emergency departments, and remote diagnostic locations.

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The author/s declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

List of Abbreviations

AIMS Australian Incident Monitoring Study
ANZCA Australian and New Zealand College of Anaesthetists
ASA American Society of Anesthesiologists
CHBAH Chris Hani Baragwanath Academic Hospital
CICO Cannot Intubate, Cannot Oxygenate
CMJAH Charlotte Maxeke Johannesburg Academic Hospital
DA Difficult Airway
DAS Difficult Airway Society
DAT Difficult Airway Trolley
HJH Helen Joseph Hospital
LMIC Low- and Middle-Income Country
NAP4 Fourth National Audit Project
RAE Ring-Adair-Elwyn
RMMCH Rahima Moosa Mother and Child Hospital

Conflicts of Interest:

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this paper.

Author contributions

H.R. Pentela conceptualised the study, developed the

research protocol, designed the REDCap[®] data collection instrument, performed all audit data collection across the four hospital sites, conducted the initial statistical data processing and descriptive analysis, and prepared the primary manuscript draft. H.J. Moutlana provided overall academic supervision, guided ethical clearance and institutional governance processes, participated in audit tool face validation, helped with the REDCap data collection sheet design, critically edited the structural manuscript content, and approved the final version for submission. S. Dingezweni participated in study design validation, conducted face validation of the audit tool, assisted in statistical data interpretation, critically reviewed and revised the manuscript for essential intellectual content, and approved the final version for submission.

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