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Infection prevention and control practices and their associated factors among anesthesia service providers at health facilities in central Uganda

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Abstract

Background

The incidence of spinal epidural abscesses, bloodstream infections, surgical site infections, and ventilator-associated pneumonia, all of which are linked to anesthesia care, is increasing. The same is true in the Ugandan context; however, despite being an indication of Infection Prevention and Control (IPC) practice gaps, Ugandan anesthesia provider-IPC practices have not been objectively assessed before.

Objective

To assess infection prevention and control practices and their associated factors among anesthesia service providers at health facilities in central Uganda.

Method

This cross-sectional study included 216 anesthesia care service providers in central Uganda. Hospitals and health center IVs in the region were purposively and randomly sampled, respectively, while anesthesia care service providers were consecutively sampled and engaged in structured interviews. Data were analyzed using descriptive statistics and a log-binomial model with 95% confidence and 5% significance.

Results

The optimal IPC practice level was found to be 12%. Being attached to a facility with a dedicated IPC supervisor (aPR = 3.469), an IPC committee (aPR = 8.588, p = 0.030) that provides dedicated training in IPC for anesthetists (aPR = 2.808), a very strong IPC culture at the facility (aPR = 6.848), and documented standard procedures for IPC during anesthesia care (aPR = 5.805) increased the prevalence of optimal IPC practices. Surprisingly, a history of formal training in IPC reduced optimal IPC practice prevalence (aPR = 0.424).

Conclusions

The proportion of anesthesia service providers in central Uganda who optimally practice infection prevention and control is low; only one in every 100 does so. Thus, of the reported 670 anesthesia care providers in central Uganda, about 80 provide care in a manner that guarantees patient safety from potentially fatal nosocomial infections. Given the steadily increasing surgical volume in Uganda, there may be an increase in the incidence of anesthesia-related nosocomial infections and perioperative mortality if the status quo is maintained. The IPC practices of anesthesia providers in central Uganda are almost entirely related to institutional characteristics, implying a need to improve work policies on IPC for a wider impact on anesthesia infection prevention and control practices.

Introduction

Infection prevention and control (IPC) refers to the procedures, practices, and policies implemented to control and minimize the transmission of infections (nosocomial) in healthcare settings (Habboush et al., 2023; World Health Organization [WHO], 2024). Thus, the aim of IPC is nosocomial infection control and prevention, which is imperative because nosocomial infections are currently one of the greatest threats to public health globally (Melariri et al., 2024;

Yang et al., 2021; Liu et al., 2023; Nimer, 2022; Sands et al., 2023). More than 100 million cases of nosocomial infections are registered annually worldwide, and the World Health Organization (WHO) (2026) reported that at least 1 in every 10 patients are affected by nosocomial infections. These infections include sepsis, central line-associated bloodstream infections (CLABSI), pneumonia, catheter-associated urinary tract infections (CAUTI), surgical site infections (SSI), osteomyelitis, ventilator-associated pneumonia (VAP), skin and soft tissue infections (SSTI), meningitis, endocarditis, and peritonitis (Monegro et al., 2023; Yang et al., 2021; Nimer, 2022; Sands et al., 2023). They cause immense morbidity, necessitating prolonged length of stay, high direct health care costs, and an increased risk of catastrophic health expenditure (Monegro et al., 2023; Yang et al., 2021; Haddadin et al., 2022). It comes as no surprise that they are directly associated with approximately 350,000 deaths annually, with at least 1 in 10 patients diagnosed with a nosocomial infection succumbing to it (WHO, 2022). Therefore, the prevention of nosocomial infections through optimal IPC practice is a global health priority, especially during the provision of healthcare services that are associated with a high risk of such infections. One such category of healthcare services is anesthesia care, which for decades has been known to result in a significant nosocomial disease burden when not aseptically done (Schmidt et al., 2023; Munoz-Price et al., 2019; Calderwood et al., 2023; Brima et al., 2022).

Infections that directly arise from anesthesia care are considered more severe than those that arise from other forms of healthcare (Schulz-Stübner et al., 2024). They range from central nervous system infections (CNSI), such as fungal meningitis, which typically occurs following spinal epidural anesthesia (WHO, 2023; CDC, 2023; Heeba et al., 2024), spinal epidural abscess (SEA) (Ameer et al., 2023), and central line-associated bloodstream infections (CLABSI) (Durgesh et al., 2023; Haddadin et al., 2022; Allahbachayo, 2022). In addition to severe respiratory tract infections (RTIs) (Chen et al., 2021; Cifuentes et al., 2022), aseptic meningitis and streptococcal necrotizing fasciitis are caused by peripheral nerve blocks (Schulz-Stübner et al., 2024). Anesthesia-related nosocomial infections are associated with severe morbidity and a very high mortality risk (Ameer et al., 2023; Schwab and Shah, 2020) and occur following access to the subarachnoid, epidural, or peripheral nerve tissue and its surroundings during anesthesia (Schulz-Stübner et al., 2024).

It has been established that most of the microorganisms that cause infection during or following anesthesia are from exogenous sources, notably from the flora of the anesthesia service provider and from the use of non-aseptic equipment (Schulz-Stübner et al., 2024; Sharma et al., 2020). Thus, optimal IPC practice on the part of anesthesia service providers is currently important, and global targets include an increase in surgical volume and reduction in perioperative mortality (Zadey et al., 2023; Davies et al., 2021; Shirley and Wamai, 2022). Sadly, it has been reported that such IPC practices are suboptimal, especially in low- and middle-income countries, where the nosocomial infection burden is disproportionate (WHO, 2026), along with an increase in antimicrobial resistance, a leading cause of silent mortality in such countries (Osena et al., 2025). While there is still little quantitative documentation of the level of IPC practice optimality among anesthesia care providers, evidence from sub-Saharan Africa indicates that less than half of them optimally practice IPC (Yetneberk et al., 2021). Hailu et al. (2023) reported that anesthesia care providers are most likely to contaminate the hospital environment, further indicating gaps in their IPC practices. Although not quantified and published, anesthesia-related nosocomial infections are routinely registered in several health centers in central Uganda, where most anesthesia providers operate. Epidural abscesses and CLABSI are reportedly non-rare among patients who receive spinal anesthesia, which is one of the most common forms of anesthesia used (Olawin and Das, 2022; Tawfeeq et al., 2023). An estimated 7–36% of postoperative patients at hospitals (public and private) (Atumanyire et al., 2023) in central Uganda are routinely diagnosed with surgical site infections following general anesthesia. Some anesthesia care providers in central Uganda could probably have IPC practice gaps, yet several studies have assessed IPC practices in Uganda (e.g., Greco & Magombe, 2011; Ssekitoleko et al., 2020; Seni et al., 2013; Opollo et al., 2021; Asasiira et al., 2023) but did not focus on anesthesia care providers. Therefore, there was justification for assessing IPC practices among anesthesia service providers at health facilities in central Uganda.

Methodology

Study design

An analytical cross-sectional design was used for this study, given that the assessment of IPC practices during anesthesia care provision is best performed quantitatively, as has been the case in many studies that have had such a scope of study (Alemayehu et al., 2022; Abdi et al., 2024; Yosef, 2023; Alhassan et al., 2021; Abalkhail et al., 2021; Abu Awwad et al., 2023; Mudenda et al., 2023). The study involved descriptive analysis of IPC practices and inferential analysis of their association with selected intrapersonal characteristics of anesthesia service providers. These two processes are supported by an analytical cross-sectional design (Delgado-Rodriguez and Llorca, 2004; Lorraine et al., 2015; Thomas, 2023), hence this design is the most suitable for this study. All data (exposure and outcome) were collected simultaneously from each anesthesia provider at the same time.

Study area

The study was conducted in central Uganda, which comprises 26 districts, including Buikwe, Bukomansimbi, Butambala, Gomba, Kalangala, Kalungu, Kyotera, Lwengo, Lyantonde, Masaka, Mpigi, Rakai, Sembabule, Wakiso, Buvuma, Kassanda, Kayunga, Kiboga, Kyankwanzi, Luwero, Mityana, Mubende, Mukono, Nakaseke, and Nakasongola. The central region was chosen as the study area because it is not only the operational area for 75% of all anesthesiologists in the country, but also has some cases of anesthesia-related nosocomial infections (Association of Anesthesiologists of Uganda, 2022b). The entire region was considered in the geographical scope of this study, premised on the fact that facilities at center IV and general hospital levels each have fewer than five anesthetists, implying that sample size obtainment could be guaranteed with the whole region considered in the study scope. The central region is composed of two sub-regions, including central 1 and central 2, of which central 1 has 294 clinics, 422 health center II's, 310 health center IIIs, 33 health center IV's, 28 general hospitals, one regional referral hospital, and two national referral hospitals (Ministry of Health, 2018). Central 2 has 91 clinics, 316 health centers, 140 health centers, 22 health centers, 12 hospitals, and one regional referral hospital. As anesthesia service providers typically work at health center IV and hospital-level facilities, the sampling frame of health facilities in central Uganda had 55 health center IVs, 40 hospitals, and 2 regional referral hospitals (Ministry of Health, 2018). Both private and public health facilities were considered in this study because many anesthesia service providers work in either or both categories of health facilities (Law et al., 2021; Association of Anesthesiologists of Uganda, 2022b).

Study population

The study population consisted of anesthesia care service providers (both physician and non-physician anesthetists) attached to health facilities in central Uganda. Both categories of anesthesia care service providers were included in the study, premised on the fact that, while physician anesthesia service providers are the most fundamental providers of anesthesia for cases of all levels of complexity, they are sparsely populated in Uganda (Anesthesiologists of Uganda, 2022). This leaves non-physician anesthesia care service providers the main providers of the larger volume of anesthesia care in Uganda (Association of Anesthesiologists of Uganda, 2022). They also ought to optimally practice IPC when delivering care, as their physician counterparts ought to. The study included anesthesia care service providers who had provided anesthesia care at any sampled health facility in central Uganda for at least six months. That was based on the presumption that a six-month period is sufficient to influence or modify the IPC practices of a given anesthesia service provider. Therefore, by including service providers who had spent six months or more, there was high certainty that the findings on IPC from each service provider were significantly attributable and contextual to central Uganda. The study excluded anesthesia care service providers who, when prompted, declared that they did not have at least 30 minutes to spare for an interview. Eleven anesthesia care providers were excluded from the study.

Sample size

The sample size for this study was determined using Yamane's (1977) formula, given that the population of anesthesia service providers in Uganda is known as well as an estimate of their population size in central Uganda (Anesthesiologists of Uganda, 2022b). The Anesthesiologists of Uganda (2022b) estimated that Uganda has **70** anesthesia specialists (physician anesthesia service providers), more than 75% of whom are based and work in Kampala City. A recent study by Bulamba et al. (2022) also reported that there are approximately **600** non-physician anesthesia care providers in the country, a considerable proportion of whom are based in the central region. Therefore, using the formula by Yamane (1977) to estimate the sample size was suitable, given that the population size is known and there is no documented prevalence of IPC practice prevalence among anesthesia providers in the country. The formula is given by; $n = (Z)^2(\pi)(1-\pi)(N) / (Z)^2(\pi)(1-\pi) + (N)l^2$ Where; π = population variance from the Dichotomous Variable equal to 0.50, z = z score at significance level α (where z = 2 at α = 0.05 and z = 3 at α = 0.01), N = The estimated existing workforce of non-physician and physician service providers in central Uganda ≈ 670 (Bulamba et al., 2022) and e = Margin of error = 0.05. Therefore, n = 216 anesthesia service providers

Sampling procedures

As noted earlier in the study area section, the health system in central Uganda is composed of 55 health center IVs, 40 hospitals, and three national referral hospitals (Ministry of Health, 2018). Therefore, to ensure high odds of obtaining the required sample size (216), all 42 hospitals had to be purposively sampled, on the premise that they are high-volume facilities with the largest number of anesthesia service providers in the central region. However, for health center IVs, simple random sampling was used to sample 75% of them using a lottery approach. To conduct simple random sampling, a numbered list of the health center IVs was made, and each of those numbers was noted on pieces of paper that were folded to conceal the numbers and put in a box. The box was shaken to ruffle the pieces of paper therein, and after every episode of ruffling, one piece of paper was picked, and that process was completed until 41 of those pieces were ultimately picked.

Therefore, in total, the study was conducted at 83 health facilities in the central region, 41 of which were health center IV's and 42 of which were hospitals (with two national referral hospitals). Given that, on average, there are about three to four anesthesia service providers per facility at level 4, and up to five of them at the hospital level, a sample size of 216 was obtainable. However, this was only possible with the use of a non-random sampling method when it came to sampling anesthesia service providers at the facility level. The most suitable non-random sampling method for those service providers was consecutive sampling, in which each potential respondent was approached, assessed for eligibility, and if eligible, sampled, and interviewed (Polit and Beck, 2017). Consecutive sampling is considered the best of all non-random sampling methods when it comes to controlling sampling bias (Polit and Beck, 2017), which was used in this study because of the small population size of anesthesia service providers targeted (about 470), almost half of whom were needed as respondents. Therefore, random sampling was inappropriate.

Data collection techniques

Knowledge, attitude, and practice assessments are typically quantitative, and are conducted using multiple-choice questions (Xu et al., 2021; Hartmann et al., 2022; Jones et al., 1998; World Health Organization, 1988; Andrade et al., 2020; World Health Organization, 2008). Therefore, since closed-ended questions were asked, the most suitable data collection method was structured interviews. Structured interviews involve asking closed-ended questions along with a predetermined set of response questions per question, from which a respondent chooses what they view as appropriate (Bergelson et al., 2022). Therefore, with structured interviews, all 216 anesthesia service providers were

asked the same set of questions, without any deviation, hence guaranteeing no interview bias and hence high findings reliability (Bergelson, Tracy, and Takacs, 2022; Levashina et al., 2014).

All data collected were captured using a structured questionnaire, in which the questions were arranged in sections covering socio-demographics / intrapersonal (Part A), anesthesia IPC practice assessment (Part B), and Institutional characteristics (Part C). The IPC practice questions were adopted from the anesthesia infection prevention and control tool developed by Dolan et al. (2013). These items were organized into four domains: hand hygiene and glove use, personal protective equipment, environmental cleanliness, workflow, and safe injection practices. In addition to the IPC practice assessment questions, the other section (Section I) had questions that were developed based on the literature, implying that the questionnaire used (attached as a supplementary file) was not used in any other study.

Measurement of study variables

Each of the 20 IPC practice questions was given a score of 1 for a correct response, implying that each anesthesia service provider would have to score 16 out of 20 (80%) on each of the assessments. An 80% score is typically considered indicative of adequate practice, compliance, and even knowledge, since it is above the average of 50%, yet it does not call for a 100% score (Bloom, 1956; Feleke et al., 2020; Ashebir et al., 2022). Each practice question was scored as 1, and for questions that assessed the consistency of a given practice, it was the response “Always” that took that score (1).

Data management and analysis

Each of the IPC practice assessment questions captured earlier in the tool was given a name and a label for the purpose of entering them into the variable view of SPSS version 25. Each of the labeled variables had its predetermined codes entered, and thereafter, each of the mobilized questionnaires was serially entered into the data screen of SPSS version 25 for Windows. After entering all 216 questionnaires, the data screen was manually used to search for any code entry errors or code entry omissions. After manual perusal, sample descriptive analyses were performed for each of the entered variables to further confirm the accuracy of data entry and cleanliness of the data. Once all entries were ascertained as apt, descriptive analysis was performed for all variables using frequency distributions. In other words, each of the variables for assessing IPC knowledge, attitudes, and practices were descriptively analyzed, with the findings for each reported in terms of frequencies and valid percentages. However, as per the suppositions of the extended version of the KAP model, each of the variables of knowledge, attitude, and practice had the intrapersonal characteristics of the anesthesia service providers analyzed against them in the bivariable and multivariable analyses.

Bivariate analysis was performed using a log-binomial model based on the finding that the magnitude of IPC practices exceeded 10%, as has been observed in previous studies (Alemayehu et al., 2022; Fernandez et al., 2015; Abdi et al., 2024; Yosef, 2023). The findings at this point were reported in terms of crude prevalence ratios (cPR) with a 95% confidence interval. All variables that had p-values less than 0.2 were considered for multivariable analysis, at which stage adjustment for confounders was made. All intrapersonal characteristics that were found to be significant (with p-values less than 0.05), after being fitted in a multivariate log-binomial model, were considered to be associated with knowledge, attitude, and practices of infection prevention and control. The findings obtained were reported in terms of adjusted prevalence ratios along with their confidence intervals.

Results

Sociodemographic characteristics of respondents

Table 1: Sociodemographic characteristics of anesthesia care providers who were sampled

Variable	Categories	n = 216
Sex of respondent		
Female	123	56.9
Male	93	43.1
Current age (in completed years)		
20 – 29	53	24.5
30 – 39	94	43.5
40 – 49	52	24.1
50 and above	17	7.9
Marital status		
Married / cohabiting	171	79.2
Never married	37	17.1
Separated	8	3.7
Highest level of education		
Diploma	129	59.7
Graduate	40	18.5
Post-graduate	47	21.8
Category of anesthesia service providers		
Physician anesthetist	76	35.2
Non-physician anesthetists	140	64.8
Duration in providing anesthesia care, in general (years)		
Less than 5	91	42.1
5 – 10	90	41.7
>10	35	16.2
Duration of providing anesthesia care in central Uganda		
Less than 5 years	105	48.6
Between 5 and 10 years	83	38.4
More than 10 years	28	13.0

Most respondents were female (123, 56.9%) and married (171, 79.2%). Almost half of the anesthesia care providers were aged between 30 and 39 years (94, 43.5%), with a mean age of 34 years. More respondents were educated to the diploma level (129, 59.7%), and almost two-thirds of them were non-physician anesthetists (140, 64.8%). More than three-quarters (188, 87.0%) of the anesthesia care providers had previously received formal training in IPC. Most respondents (176, 81.5%) were attached to private facilities and the general hospital service level (156, 72.2%). Slightly more than half of the respondents were attached to health facilities that reportedly did not have all the equipment required to ensure that anesthesia care service providers execute all necessary IPC protocols (111, 51.4%). Almost half

of the providers reported that they were attached to facilities whose IPC culture was not so strong (102, 47.2%), and the majority (148, 68.5%) were attached to facilities that had no documented standard procedures for IPC during anesthesia care.

The infection control and prevention practices of anesthesia service providers at health facilities in central Uganda

Table 2: Infection control and prevention practices among anesthesia service providers

Variable	n	%
Wash hands before performing invasive procedures (e.g., catheter insertion, epidurals, surgery)		
Yes	216	100.0
Frequency of hand washing		
Always	196*	90.7
Sometimes	16	7.4
Rarely	4	1.9
Frequency of soaking the laryngoscope in a 0.5% chlorine solution		
Always	90*	41.7
Sometimes	31	14.4
Rarely	95	44.0
Frequency of wearing double gloves during airway manipulation		
Always	58*	26.9
Sometimes	44	20.4
Rarely	114	52.8
Frequency of wearing non-sterile gloves during NGT insertion		
Always	166*	76.9
Sometimes	39	18.1
Rarely	11	5.1
Frequency of wearing non-sterile gloves during tracheostomy extubation		
Always	196*	90.7
Sometimes	13	6.0
Rarely	7	3.2
Frequency of non-sterile gloves during Intravenous line insertion		
Always	168*	77.8
Sometimes	18	8.3
Rarely	30	13.9
The frequency of using the same tray for holding syringes for more than one patient		
Always	21	9.7
Sometimes	39	18.1
Rarely	151	69.9
Never	5*	2.3
The frequency of refilling a syringe when administering medication to the same patient		

Always	8	3.7
Sometimes	45	20.8
Rarely	163*	75.5
Scrub hands before conducting spinal and epidural anesthesia		
Yes	212*	98.1
No	4	1.9
Use the aseptic technique for every patient before intravenous administration.		
Yes	190*	88.0
No	26	12.0
Wipe a multi-dose vial with alcohol before use.		
Always	45*	20.8
Sometimes	47	21.8
Rarely	124	57.4
Constantly use a breathing circuit filter and humidifier for every case.		
Yes	91	42.1
No	125*	57.9
Constantly reuse ETT, airway, and suction tips for every case.		
Yes	29	13.4
No	187*	86.6
The time within which antibiotic prophylaxis is administered before an incision is made		
Within two hours	7	3.2
Within an hour	38*	17.6
Within 30 minutes	171	79.2
Frequency of disinfecting the stethoscope after every use.		
Always	74*	74.0
Sometimes	22	22.0
Rarely	4	4.0
Frequency of cleaning the anesthesia machine and face mask with disinfection after every procedure.		
Always	80*	80.8
Sometimes	15	15.2
Rarely	4	4.0
Frequency of recapping needles before disposing of them		

Always	36	16.7
Sometimes	32	14.8
Rarely	148*	68.5
Duration of immersing the laryngoscope in a 0.5% chlorine solution		
Less than 5 minutes	32	14.8
5-10 minutes	123	56.9
More than 10 minutes	59*	27.3
Never	2	.9
Frequency of eating or drinking in the operating room		
Always	1	.5
Sometimes	9	4.2
Rarely	203	94.0
Never	3*	1.4
Do not recap needles before disposing of them.		
Always	137*	63.4
Sometimes	33	15.3
Rarely	46	21.3
Infection control and prevention practices of anesthesia service providers at health facilities in central Uganda		
Optimal IPC practice	26	12.0
Suboptimal IPC practice	190	88.0

All anesthesia service providers reported that they washed their hands before performing invasive procedures (e.g., catheter insertion, epidurals, and surgery) (216, 100.0), with most of them doing it always (196, 90.7%). However, most always wore non-sterile gloves during Nasal Gastric Tube (NGT) insertion (166, 76.9%), with almost all of them wearing non-sterile gloves during tracheal extubation (196, 90.7%), and during intravenous line insertion (168, 77.8%). More than two-thirds of the respondents rarely used the same tray to hold syringes for more than one patient (151, 69.9%) and rarely refilled a syringe when administering medication to the same patient (163, 75.5%). Almost all respondents scrubbed their hands before conducting spinal and epidural anesthesia (212, 98.1%), and the majority used the aseptic technique for every patient before intravenous cannulation (190, 88.0%). More than three-quarters of the respondents reported that they administered antibiotic prophylaxis within 30 minutes before an incision (171, 79.2%). More than half (116, 53.7%) of the anesthesia care service providers reported that they did not clean the anesthesia machine and face mask with disinfection after every procedure, but the majority of those who did so always engaged in it (80, 80.8%). The other data are shown in Table 2.

Level of IPC practice

The data in Table 2 were quantified according to the measurement approach described in Section 5.8, and the result of this effect, as shown in Figure 4, indicates that the proportion of anesthesia care providers that optimally practiced infection prevention and control was 12%.

Associated factor assessment

Table 3: Factors associated with knowledge, attitude, and infection prevention and control practices

Variable	uPR (95% CI)	P-value	aPR (95% CI)	P value
Received formal training in IPC before				
Yes	0.404 (0.187 – 0.873)	**0.021**	0.424 (0.194 – 0.927)	**0.032***
No	1.000			
The facility has a dedicated supervisor for infection control and prevention.				
Yes	3.689 (1.444 – 9.424)	**0.006**	3.469 (1.347 – 8.935)	**0.010***
No	1.000		1.000	
The health facility has an infection prevention and control committee.				
Yes	9.421 (2.284 – 38.871)	**0.002**	8.588 (2.050 – 35.976)	**0.030***
No	1.000		1.000	
The facility provides dedicated training in IPC, specifically for anesthetists.				
Yes	4.062 (1.853 – 8.904)	**<0.001**	2.808 (1.088 – 7.247)	**0.033***
No	1.000		1.000	
IPC culture at the facility				
Very strong	7.062 (2.778 - 17.948)	**<0.001**	6.848 (2.675 - 17.530)	**<0.001***
Moderately strong	0.987 (0.244 - 3.987)	0.985	1.006 (0.247 - 4.095	0.993
Not so strong	1.000			
The facility has documented standard procedures for IPC during anesthesia care.				
Yes	5.908 (2.608 - 13.381)	**<0.001**	5.805 (2.528 - 13.331)	**<0.001***
No	1.000		1.000	

Six characteristics, five of which are institutionally inclined, had significant associations with IPC practices (Table 3), and the optimal IPC practice was 58% lower among anesthesia care providers who had received formal training in IPC before (aPR = 0.424, 95% CI = 0.194–0.927, p = 0.032) compared to those who had not received such training. Optimal IPC practice was three times higher among anesthesia care providers who were attached to facilities that had a dedicated supervisor for infection control and prevention (aPR = 3.469, 1.347–8.935, p = 0.010) than among those who were attached to facilities that did not have a dedicated supervisor. Optimal IPC practice was higher by 8-fold higher

among anesthesia care providers who were attached to health facilities that had an infection prevention and control committee (aPR = 8.588, 95% CI = 2.050 - 35.976, p = 0.030) compared to those attached to health facilities that did not have an IPC committee. It was twice as high among anesthesia care providers who were attached to health facilities that provided dedicated training in IPC, specifically for anesthetists (2.808, 95% CI = 1.088–7.247, p = 0.033), and twice as high among anesthesia care providers who were attached to health facilities that had a very strong IPC culture at the facility (aPR = 6.848, 95% CI = 2.675–17.530, p ≤ 0.001). Optimal IPC practices were also twice as high among respondents who were attached to facilities that had documented standard procedures for IPC during anesthesia care (aPR = 5.805, 95% CI = 2.528–13.331, p <0.001).

Discussion

This study found that 12 proportion of anesthesia care providers in central Uganda optimally practiced infection prevention and control. This finding is also concerning since it implies that only one in every 10 providers complied with all IPC domains meant to be complied with. The proportion of anesthesia care providers who adequately practiced IPC in this study is also perhaps one of the lowest reported over the past decade. Studies by Hamid et al. (2017) (24.6%) in the KSA, Bayleyegn et al. (2017) (36%), Yakob and Lamaro (2015) (33%), Desta et al. (2018) (33%), and Al-Ahmari et al. (2021) (49.5%) in Ethiopia, Unakal et al. (2017) (44%) in Trinidad and Tobago, Abuduxike et al. (2021) (46.1%) in Northern Cyprus, and Sarani et al. (2019) (42%) in Iran also reported higher IPC practices. More studies, including Sarkhell et al. (2023) (41.25%), Al-Ahmari et al. (2021) (49.5%), Adeke et al. (2021) (47.7%), Naji et al. (2022) (51.6%), Gasaba et al. (2020) (50%), Melesse et al. (2021) (53.6%), and Alhassan et al. (2021) (55%) have also reported higher IPC practice adequacy. Thus, with an adequate IPC practice level of 12%, which leaves 9 of every 10 anesthesia service providers not complying with all IPC domains, it may not be surprising to learn that Uganda has one of the highest perioperative mortality rates (Anderson et al., 2017; Onen et al., 2022; Hewitt-Smith et al., 2018). There are some justifiably higher proportions of adequate IPC practitioners across the aforementioned studies. Adeke et al. (2021) were conducted after an outbreak of nosocomial Lassa fever in one of the tertiary hospitals in Nigeria, which implies that the entire hospital culture was at an all-time high when the study was conducted. The study by Bayleyegn et al. (2021) was conducted at a Comprehensive Specialized Hospital, which, like such hospitals, is also renowned for having higher patient safety culture standards compared to non-specialized hospitals, which constituted the majority of the study areas in the current study. On the other hand, studies such as that by Alhassan et al. (2021) were conducted among surgeons, who, by virtue of being involved in providing invasive care, can be more cautious in preventing infection transmission.

The only IPC practice that happened to be universally embraced by anesthesia care providers in central Uganda was hand hygiene; 100% of them reported complying with it, which was even higher than studies that have previously reported laudable compliance with hand hygiene (Harun et al., 2023; CDC, 2024; Isse et al., 2024; Nagassar and Wallace-Sankarsingh, 2025). While this is a laudable practice and can prevent a myriad of nosocomial infections during surgery, its effect can easily be outweighed by non-compliance with other important IPC practices, such as sterilization, reuse of ETT, airway, and suction tips for every case, and well-timed antibiotic prophylaxis. Thus, universally complying with handwashing will not be sufficient to prevent anesthesia-related perioperative mortality in Uganda, further emphasizing that IPC practices among anesthesia providers are still significantly low.

While the general Knowledge Attitude Practice (KAP) model portrays the associations between Knowledge Attitude Practice, the extended KAP model also portrays an association between various individual characteristics and each of the constructs in the KAP model. This theoretical supposition was tested in this study, and the findings revealed that IPC practice is indeed associated with intrapersonal and institutional characteristics, although institutional factors featured significantly more. This implies that IPC practices among anesthesia care providers in central Uganda are

almost entirely influenced by work environment characteristics. Such an outcome was expected given that IPC behavior is a work policy issue, requires institutional regulation, is related to workplace safety culture, and is driven by institutional infrastructure status as well (Falana et al., 2024; Rickard et al., 2020; Le et al., 2024; Basu, 2024; Makau and Muna, 2020).

Evidence from human resource management literature (Hassan Imam et al., 2023; Lee and Shin, 2023; Lucia et al., 2023; Mphaluwa et al., 2025; Juliarti, 2022) suggests that staff performance and productivity are certainly improved when there is effective supervision. Supervision and the decentralization of power can promote employee engagement, motivation, and productivity. The health literature also indicates that such characteristics can promote patient safety culture and generally improve staff performance (Martin et al., 2021; Seo and Lee, 2022; Alingh et al., 2019), as supervision can keep staff performance in check, ensuring compliance with all set standards. This explains why the prevalence of optimal IPC practice was three times higher among anesthesia care providers who were attached to facilities that had a dedicated supervisor for infection control and prevention. It also explains why the prevalence of optimal IPC practices was 8-fold higher among anesthesia care providers who were attached to health facilities that had an infection prevention and control committee. This is because infection prevention and control committees, like direct supervisors, also oversee all IPC practices in a given health facility (Lee et al., 2024), ensuring that all IPC moments are fully compliant. In addition to IPC oversight, these committees have also organized periodic IPC training programs for healthcare workers (Leet al., 2024), which have been reported to improve IPC knowledge and practices (Yousef et al., 2019; Abdo et al., 2020; Osman et al., 2021; Singh et al., 2023; Harsvardhan et al., 2023). It was not surprising that anesthesia care providers who were attached to health facilities provided dedicated training in IPC, specifically for anesthetists, also exhibited twice the prevalence of optimal IPC practice (Table 3).

One of the roles of infection prevention and control committees and health facility administrations, with an interest in patient safety culture, is the formulation of IPC protocols, policies, and regulations. With good pro-staff leadership, health facilities usually draw up clear local policies and guidelines to be followed, especially on issues related to patient safety (Basu, 2024; Makau and Muna, 2020). Such documentation creates a culture of responsibility and accountability to the extent that all staff members feel obliged to abide by it. In an anesthesia provision context, having those documents in place can instill the need for high safety and IPC standards among anesthetists, which makes it more likely to uphold every standard procedure stipulated in IPC, and consequently adequately practice it. Therefore, the prevalence of optimal IPC practices was five times higher among anesthesia care providers who were attached to health facilities that had documented standard procedures for IPC during anesthesia care. Facility possession of standard IPC guidelines is one of the hallmarks of high/proactive patient safety culture maturity levels; with such maturity or high safety culture, most staff conform to the same culture and adequate practice of IPC. This is supported by the finding that adequate IPC practice prevalence was six times higher among anesthesia care providers who were attached to health facilities that had a very strong IPC culture at the facility. Such a safety culture also often does not come with the provision of safety training to staff, especially anesthesia providers, and that training can guarantee higher performance, which in a healthcare context can translate into more adequate IPC practices (WHO, 2016; WHO, 2020; Geberemariyam et al., 2018; Anwar et al., 2016; Arinze-Onyia et al., 2018; Al-Ahmari et al., 2021). Consistent with these studies, the current study also established that anesthesia care providers at facilities whose IPC culture they rated as very strong exhibited an optimal IPC prevalence that was six times higher than that of their colleagues who rated it lower.

The only rather surprising finding was that optimal IPC practice was 58% lower among anesthesia care providers who had received formal training in IPC before, contrary to findings by Yousef et al. (2019), Abdo et al. (2020), Osman et al. (2021), Singh et al. (2023), and Harsvardhan et al. (2023). Training in IPC is ideally expected to increase practice at work; however, the fact that it had an inverse relationship with practice means that those who were trained before

received practical training in IPC and not much of its theoretical side. Anesthesia care providers with a history of IPC training reception were not optimally knowledgeable about IPC, as reported in previous studies (Yetneberk et al., 2021; Alemayehu et al., 2022). This knowledge gap certainly affects their practice of IPC (Abalkhail et al., 2021; Abu Awwad et al., 2023), which can occur even at a facility with an IPC committee, policy documents, and IPC supervisors who do not focus on IPC knowledge improvement.

Limitations of the study

While the level of IPC practice was reported to be low at 12%, there could have been a chance that some of the anesthesia care providers exaggerated their practice and inflated it, causing social desirability bias. This is because the study did not rely on observations but rather on self-reports when assessing IPC practices. However, the principal investigator and his assistants endeavored to reassure the study participants that the assessment was not meant to result in a blame game and that it was their valid responses that could be used to possibly show the cause for interventions meant to augment IPC practice adequacy among anesthesia practitioners in Uganda. This possibly minimized the cases of exaggeration.

Another limitation is that this study was conducted among anesthesia practitioners in central Uganda, who constitute a relatively small community of healthcare service providers in Uganda. Therefore, it is possible that some of those who had already been interviewed communicated to their colleagues about the potential for being sampled, which might have made them prepare for the interview beforehand. This could have led to an increase in the proportion of anesthesia care providers who are optimally knowledgeable about IPC.

The total estimated population size of anesthesia service providers in central Uganda, as provided by their governing bodies, is 670. The sample size for this study was 216, implying that the study sampled approximately one-third of the participants. However, adjustment for non-response was not performed, yet it could have increased the sample size proportion, making it more representative. The non-adjustment may have reduced the study power and caused some cases of type 1 errors.

Conclusion

The proportion of anesthesia service providers in central Uganda who optimally practice infection prevention and control is low; only one in every 100 does so. Thus, of the reported 670 anesthesia care providers in central Uganda, about 80 provide care in a manner that guarantees patient safety from potentially fatal nosocomial infections. Given the steadily increasing surgical volume in Uganda, there may be an increase in the incidence of anesthesia-related nosocomial infections and perioperative mortality if the status quo is maintained. The IPC practices of anesthesia providers in central Uganda are almost entirely related to institutional characteristics, implying a need to improve work policies on IPC for a wider impact on anesthesia infection prevention and control practices. However, at the intrapersonal level, facilities with anesthesia care providers with a history of IPC training must consider providing IPC knowledge augmentation training to them. The interventions required will include the inclusion of IPC-aligned topics of discussion in continuing medical education sessions at each health facility. The CMEs can be designed and set up every week by **facility in-charges**, with the key target audience being anesthesia care providers. The need for such CMEs can be reechoed by the Association of Anesthesiologists of Uganda, which can further influence the cause. Some of the CME sessions should focus on IPC practice: during the IPC practice-aligned augmentation sessions, emphasis should be placed on providing theoretical and/or practical sessions to anesthetists, on issues related to the frequency of soaking the laryngoscope in a 0.5% chlorine solution, wearing of double gloves during airway manipulation, the frequency of using the same tray for holding syringes for more than one patient, the frequency of refilling a syringe when administering medication to the same patient, use of a breathing circuit filter and humidifier for

every case, use of ETT, airway, and suction tips for every case, time within which antibiotic prophylaxis is administered before an incision is made, and anesthesia machine and face mask use. The association of anesthesiologists in Uganda should encourage all surgery-providing health facilities to have dedicated IPC supervisors and IPC committees, as these have been proven to improve IPC practices through the improvement of safety culture.

Abbreviations

IPC Infection Prevention and Control

CME Continuing Medical Education

CLABSI: Central line-associated bloodstream infections

CAUTI Catheter-associated urinary tract infections

SSI Surgical site infections

VAP Ventilator-associated pneumonia

SSTI: Skin and Soft Tissue Infections

CNSI Central Nervous System Infection

SEA Spinal Epidural Abscess

RTIs: Respiratory Tract Infections

CDC Centers for Disease Control and Prevention

KAP Knowledge Attitude Practice

WHO World Health Organization

Declarations

Consent for publication

Not Applicable

Availability of data and materials

All the data generated in this study are available upon request from the corresponding authors.

Competing interests

The authors declare no conflict of interest

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Authors' contributions

KC and JN conceptualized the study, wrote the main manuscript text, trained data collection assistants, analyzed frequency distributions, performed regression analysis, edited the manuscript, and made a final review before publication.

SPK and RN supervised the study, reviewed the manuscript text, edited the manuscript, made a final review before publication, and approved the manuscript for publication.

MR, CN, and BK reviewed and edited the manuscript, made a final review before publication, and approved the manuscript for publication.

Ethical approval and consent to participate

In accordance with the guidelines provided by the World Medical Association (2025) on ethics to be followed by all studies involving human subjects, this study upheld several ethical considerations. Approval to conduct this study was obtained from the Makerere University School of Public Health Research and Ethics Committee (**MakSPH-REC 553**), whose introductory letter was used to seek permission from district health officers (DHOs). Permission to access health center IV's was obtained from the DHOs of each district in which such a health facility was sampled, whereas for general hospitals and regional referral hospitals, permission was sought from the respective hospital administrations. At each facility, every anesthesia service provider was given a comprehensive brief about the study and then, at their discretion, the entire consent form/information sheet for them to review. Following their perusal of the consent form, those who, at their discretion, had an interest in the participants, provided written informed consent.

All responses provided by anesthesia providers were captured anonymously (with no personal identifiers). All study questionnaires were kept in the custody of the principal investigator, and the data they contained were entered into software installed on the principal investigator's personal, password-protected computer. All interviews held with anesthesia service providers were conducted in a place with auditory privacy. Participation and withdrawal from this study were voluntary, and withdrawal was inconsequential. Fortunately, there were no cases of withdrawal from the study; all sampled anesthesia care providers who started the interviews completed them.

References

1. Abalkhail A, Al Imam MH, Elmosaad YM, Jaber MF, Hosis KA, Alhumaydhi FA, Alslamah T, Alamer A, Mahmud I. Knowledge, Attitude and Practice of Standard Infection Control Precautions among Health-Care Workers in a University Hospital in Qassim, Saudi Arabia: A Cross-Sectional Survey. Int J Environ Res Public Health. 2021 Nov 11;18(22):11831. doi: 10.3390/ijerph182211831. PMID: 34831585; PMCID: PMC8624606.
2. Abdi, I. A., Kasumba, J. M., Wabule, A., Nabukenya, M. T., Kayongo, J., Kyoheirwe, B., Sheikdon, A. A., & Osman, K. D. (2024). Knowledge, Attitudes and Practices Regarding Use of Local Anaesthetics Among Non-Anaesthesia Healthcare Professionals at Mulago National Referral Hospital. *Local and regional anesthesia*, *17*, 29–37. https://doi.org/10.2147/LRA.S428661
3. Abdo NM, Ramadan MA, Tosson MM, Al-Fadhli MA. Effectiveness of an educational program on knowledge and practices regarding care of central venous catheters among Dialysis nurses. Egypt J Community Med. 2020;38(1):1–11.
4. Abu Awwad D, Hill S, Lewis S, Jimenez Y. Knowledge, attitudes and practice of infection prevention and control in the CT suite. BMC Health Serv Res. 2023 Jul 8;23(1):741. doi: 10.1186/s12913-023-09779-9. PMID: 37422620; PMCID: PMC10329788.
5. Abuduxike G., Acar Vaizoglu S., Asut O., Cali S. An Assessment of the Knowledge, Attitude, and Practice Toward Standard Precautions Among Health Workers From a Hospital in Northern Cyprus. *Saf. Health Work.* 2021;**12**:66–

73. doi: 10.1016/j.shaw.2020.09.003

6. Adeke AS, Onoh RC, Umeokonkwo CD, Azuogu BN, Ogah EO. Knowledge, attitude and practice of infection prevention and control among healthcare workers: one year after an outbreak of nosocomial Lassa fever in a tertiary hospital in southeast Nigeria. *Afr J Clin Exp Microbiol*. 2021;22:457-464.
7. Al-Ahmari, A.M.; AlKhaldi, Y.M.; Al-Asmari, B.A. Knowledge, attitude, and practice about infection control among primary care professionals in Abha City, Kingdom of Saudi Arabia. *J. Fam. Med. Prim. Care* **2021**, *10*, 662–668
8. Alemayehu, T., Tesfaye, B., Woldeyohannes, M., Regasa, T., & Neme, D. (2022). Anesthetists' knowledge, practices, and associated factors towards infection prevention in Addis Ababa public hospitals, Addis Ababa, Ethiopia. *International Journal of Surgery Open*, *49*, 100573. https://doi.org/10.1016/j.ijso.2022.100573
9. Alhassan, A. R., Kuugbee, E. D., & Der, E. M. (2021). Surgical Healthcare Workers' Knowledge and Attitude on Infection Prevention and Control: A Case of Tamale Teaching Hospital, Ghana. *The Canadian Journal of Infectious Diseases & Medical Microbiology = Journal Canadien des Maladies Infectieuses et de la Microbiologie MéDicale*, *2021*. https://doi.org/10.1155/2021/6619768
10. Alingh, C. W., van Wijngaarden, J. D. H., van de Voorde, K., Paauwe, J., & Huijsman, R. (2019). Speaking up about patient safety concerns: the influence of safety management approaches and climate on nurses' willingness to speak up. *BMJ quality & safety*, *28*(1), 39–48. https://doi.org/10.1136/bmjqs-2017-007163
11. Allahbachayo, S. (2022). Prevention of Central Line-Associated Blood Stream Infection (CLABSI) in Adult ICU Patients. [Doctoral project, University of St Augustine for Health Sciences]. SOAR @ USA: Student Scholarly Projects Collection. https://doi.org/10.46409/sr.OUAU3057
12. Ameer MA, Knorr TL, Munakomi S, et al. Spinal Epidural Abscess. [Updated 2023 Aug 13]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK441890/
13. Anderson GA, Ilcisin L, Abesiga L, et al. Surgical volume and postoperative mortality rate at a referral hospital in Western Uganda: measuring the Lancet Commission on Global Surgery indicators in low-resource settings. Surgery 2017;161:1710–9
14. Andrade, C., Menon, V., Ameen, S., & Kumar Praharaj, S. (2020). Designing and Conducting Knowledge, Attitude, and Practice Surveys in Psychiatry: Practical Guidance. *Indian Journal of Psychological Medicine*. https://doi.org/10.1177/0253717620946111
15. Anwar M, Majeed A, Saleem RM, Manzoor F, Sharif S. Assessment of infection control practices in teaching hospitals of Quetta. J Pakistan Med Assoc. 2016;66(8):947–51.
16. Arinze-Onyia SU, Ndu AC, Aguwa EN, Modebe I, Nwamoh UN. Knowledge and practice of standard precautions by health-care Workers in a Tertiary Health Institution in Enugu, Nigeria. Niger J Clin Pract. 2018;21(2):149–55
17. Ashebir W, Yimer B, Alle A, Teshome M, Teka Y, Wolde A. Knowledge, attitude, practice, and factors associated with prevention practice towards COVID-19 among healthcare providers in Amhara region, northern Ethiopia: A multicenter cross-sectional study. PLOS Glob Public Health. 2022 Apr 11;2(4):e0000171. Doi: 10.1371/journal.pgph.0000171. PMID: 36962177; PMCID: PMC10021359.
18. Association of Anesthesiologists of Uganda (2022). Anesthesia and Critical Care Call Centre. Available from https://anesthesiaug.org/anesthesia-call-centre-grant/
19. Atumanyire, J., Muhumuza, J., Talemwa, N., Molen, S. F., Kithinji, S. M., Kagenderezo, B. P., & Hakizimana, T. (2023). Incidence and outcomes of surgical site infection following emergency laparotomy during the COVID-19 pandemic in a low-resource setting: A retrospective cohort. *International Journal of Surgery Open*, *56*, 100641. https://doi.org/10.1016/j.ijso.2023.100641

20. Basu, R. (2024). The Importance Of HR Policies On Employee Performance, Employee Engagement, And Employee Motivation In Various Organizations. *Educational Administration: Theory and Practice*, *30*(5), 4272–4279. https://doi.org/10.53555/kuey.v30i5.3617
21. Bayleyegn, B., Mehari, A., Damtie, D., & Negash, M. (2021). Knowledge, Attitude, and Practice on Hospital-Acquired Infection Prevention and Associated Factors Among Healthcare Workers at University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia. *Infection and Drug Resistance*, *14*, 259–266. https://doi.org/10.2147/IDR.S290992
22. Bergelson, I., Tracy, C., & Takacs, E. (2022). Best Practices for Reducing Bias in the Interview Process. *Current Urology Reports*, *23*(11), 319-325. https://doi.org/10.1007/s11934-022-01116-7
23. Bloom, B. S. (1956). Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. New York: David McKay Co Inc.
24. Brima N, Morhason-Bello IO, Charles V*, et al* Improving quality of surgical and anaesthesia care in sub-Saharan Africa: a systematic review of hospital-based quality improvement interventions. *BMJ Open* 2022;**12:**e062616. doi: 10.1136/bmjopen-2022-062616
25. Bulamba, F., Bisegerwa, R., Kimbugwe, J., Ochieng, J.P., Musana, F, and Nabukenya, M.T. (2022). Development of the anesthesia workforce and organisation of the speciality in Uganda: a mixed-methods case study. Southern African Journal of Anaesthesia and Analgesia Vol. 28, No. 3. https://doi.org/10.36303/SAJAA.2022.28.3.2646
26. Calderwood MS, Anderson DJ, Bratzler DW, et al. Strategies to prevent surgical site infections in acute-care hospitals: 2022 Update. *Infection Control & Hospital Epidemiology*. 2023;44(5):695-720. doi:10.1017/ice.. 2023.67
27. CDC. (2023). Important Updates on Outbreak of Fungal Meningitis in U.S. Patients Who Underwent Surgical Procedures under Epidural Anesthesia in Matamoros, Mexico. Available from https://emergency.cdc.gov/han/2023/han00492.asp
28. CDC. (2024). Clinical Safety: Hand Hygiene for Healthcare Workers. Available from https://www.cdc.gov/clean-hands/hcp/clinical-safety/index.html
29. Chen, T., Yasen, Y., Wu, J., & Cheng, H. (2021). Factors influencing lower respiratory tract infection in older patients after general anesthesia. *The Journal of International Medical Research*, *49*(9). https://doi.org/10.1177/03000605211043245
30. Cifuentes, E. A., Sierra, M. A., Yepes, A. F., Baldión, A. M., Rojas, J. A., Álvarez-Moreno, C. A., Anzola, J. M., Zambrano, M. M., & Huertas, M. G. (2022). The endotracheal tube microbiome in hospitalized patients is defined largely by the hospital environment. *Respiratory Research*, *23*. https://doi.org/10.1186/s12931-022-02086-7
31. Delgado-Rodriguez M and Llorca J. J Epidemiol Community Health. 2004;58:635–641.
32. Desta M., Ayenew S., Nibretie T., Dires G. Knowledge, practice and associated factors of infection prevention among healthcare workers in Debre Markos referral hospital, Northwest Ethiopia. *BMC Health Services Research*. 2018;18(1):p. 465. doi: 10.1186/s12913-018-3277-5.
33. Dolan, S. A., Heath, J., Potter-Bynoe, G., & Stackhouse, R. A. (2013). Infection prevention in anesthesia practice: A tool to assess risk and compliance. *American Journal of Infection Control*, *41*(11), 1077-1082. https://doi.org/10.1016/j.ajic.2013.06.012
34. Falana, R. O., Ogidan, O. C., & Fajemilehin, B. R. (2024). Barriers to infection prevention and control implementation in selected healthcare facilities in Nigeria. *Infectious Diseases Now*, *54*(3), 104877. https://doi.org/10.1016/j.idnow.2024.104877
35. Feleke BT, Wale MZ, Yirsaw MT. Knowledge, attitude, and preventive practice towards COVID-19 and associated factors among outpatient service visitors at Debre Markos Comprehensive Specialized Hospital, north-west

Ethiopia, 2020. PLoS One. 2021 Jul 15;16(7):e0251708. Doi: 10.1371/journal.pone.0251708. PMID: 34264940; PMCID: PMC8282282.

36. Fernandez, P.G., Loftus, R.W., Dodds, T.M., Koff, M.D., Reddy, S., Heard, S.O., Beach, M. L., Yeager, M P., Brown, J.R. (2015). Hand Hygiene Knowledge and Perceptions Among Anesthesia Providers. Anesthesia & Analgesia 120(4): :p 837-843, April 2015. | DOI: 10.1213/ANE.0000000000000408
37. Fukada T, Tachibana C, Tsukazaki Y, Satoh K, Furuya Y, Ohe Y. Bacterial contamination of anesthesiologists' hands and the efficacy of handwashing. *Masui.* 1996;45(8):1026–1030
38. Gasaba, E., Niciza, J., Muhayimana, D. and Niyongabo, E. (2020). Infection Control Measures among Healthcare Workers: Knowledge, Attitude, and Practice. *Open Journal of Nursing*, **10**, 1068-1080. doi: 10.4236/ojn.2020.1011076.
39. Geberemariyam BS, Donka GM, Wordofa B. Assessment of knowledge and practices of healthcare workers towards infection prevention and associated factors in healthcare facilities of West Arsi District, Southeast Ethiopia: a facility-based cross-sectional study. Arch Public Health. 2018;76:69.
40. Habboush Y, Yarrarapu SNS, Guzman N. Infection Control. [Updated 2023 Sep 4]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK519017/
41. Haddadin Y, Annamaraju P, Regunath H. (2022). Central Line–Associated Blood Stream Infections. [Updated 2022 Nov 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK430891/
42. Hailu, S., Mulugeta, H., Girma, T., Asefa, A., & Regasa, T. (2023). Evidence-based guidelines on infection prevention and control in operation theatres for anesthetists in a resource-limited setting: Systematic review/meta-analysis. *Annals of Medicine and Surgery*, *85*(6), 2858. https://doi.org/10.1097/MS9.0000000000000689
43. Hamid H, Mustafa MM, Al-Rasheedi M, et al. Assessment of hospital staff knowledge, attitudes, and practices (KAPS) on activities related to prevention and control of hospital-acquired infections. *Int J Prev Treat*. 2019;8:1-7.
44. Harsvardhan R, Kushwaha R, Mishra R, Prasad N. A study to assess the impact of appropriate intervention/s on compliance Wrt key hospital infection control parameters in Dialysis unit of a tertiary healthcare teaching Institute in India. J Indira Gandhi Inst Med Sci. 2023;9(1):75–84.
45. Hartmann, J. B., Rego, A. T., Khoury, J. V., Bernuci, M. P., & Yamaguchi, M. U. (2022). E-Questionnaire on health knowledge, attitudes, and practices (KAP-Health) for Brazilian students in distance learning. *Global Health Action*, *16*(1). https://doi.org/10.1080/16549716.2022.2153441
46. Harun, M., Anwar, M., Sumon, S., Mohona, T., Hassan, M., Rahman, A., Abdullah, S., Islam, M., Oakley, L., Malpiedi, P., Kaydos-Daniels, S., & Styczynski, A. (2023). Hand hygiene compliance and associated factors among healthcare workers in selected tertiary-care hospitals in Bangladesh. *Journal of Hospital Infection*, *139*, 220-227. https://doi.org/10.1016/j.jhin.2023.07.012.
47. Hassan Imam, Anu Sahi, Mobina Farasat; The roles of supervisor support, employee engagement, and internal communication in performance: a social exchange perspective. *Corporate Communications: An International Journal* 17 April 2023; 28 (3): 489–505. https://doi.org/10.1108/CCIJ-08-2022-0102
48. Hewitt-Smith, A., Bulamba, F., Olupot, C., Musana, F., Ochieng, J., Lipnick, M., & Pearse, R. (2018). Surgical outcomes in eastern Uganda: a one-year cohort study. *Southern African Journal of Anaesthesia and Analgesia*, *24*(5), 122–127. https://doi.org/10.1080/22201181.2018.1517476
49. Isse SA, Doğan A, Ali TA, Wehlie JA, Adam AA, Öztürk H. Hand Hygiene Compliance and Its Associated Factors Among Health Care Workers at Mogadishu Somali Turkiye Recep Tayyip Erdoğan Training and Research in a Tertiary Care Hospital. *Risk Manag Healthc Policy*. 2024;17:2415-2425 https://doi.org/10.2147/RMHP.S481057

50. Jones JT, Furner M, Initiative WGSH. Health-promoting schools: a healthy setting for living, learning and working [Internet]. Report No.: WHO/HPR/HEP/98.4. World Health Organization; 1998 [cited 2022 Jun 13]. p. 12. Available from: https://apps.who.int/iris/handle/10665/63868

51. Juliarti NP (2022). The role of charismatic leadership and work-life balance in organizational commitment through employee job satisfaction in the broadcasting industry. Genius. 5(2)

52. Kim T.R., Ross J.A., Smith D.P. KOREA: Trends in Four National KAP Surveys, 1964–1967. *Stud. Fam. Plan.* 1969;**1**:6–11. doi: 10.2307/1965090

53. Kondor V. D. *Health Worker Compliance with Infection Prevention and Control Policy in Ghana: A Case Study of La General Hospital.* Accra, Ghana: UG Space; 2018. pp. 1–37

54. Law, T.J., Subhedar, S., Bulamba, F. *et al.* Factors affecting job choice among physician anesthesia providers in Uganda: a survey of income composition, discrete choice experiment, and implications for the decision to work rurally. *Hum Resour Health* 19, 93 (2021). https://doi.org/10.1186/s12960-021-00634-8

55. Lee, M.H., Yi, Y.M., Noh, EY. *et al.* Effects of establishing infection control program with core components of World Health Organization on reducing the risk of residents' infections and improving staff infection control competency in a nursing home. *Antimicrob Resist Infect Control* **13**, 136 (2024). https://doi.org/10.1186/s13756-024-01492-4

56. Lee, S. E., & Shin, G. (2023). The Effect of Perceived Organizational and Supervisory Support on Employee Engagement During COVID-19 Crises: Mediating Effect of Work-Life Balance Policy. *Public Personnel Management*, *52*(3), 401. https://doi.org/10.1177/00910260231171395

57. Liu X., Long Y., Greenhalgh C. A systematic review and meta-analysis of risk factors associated with healthcare-associated infections among hospitalized patients in Chinese general hospitals from 2001 to 2022. *J Hosp Infect.* 2023; **135**: 37-49https://doi.org/10.1016/j.jhin.2023.02.013

58. Lucia B. Oliveira, Priscila Sarmento Najnudel; The influence of abusive supervision on employee engagement, stress and turnover intention. *Revista de Gestao* 23 January 2023; 30 (1): 78–91. https://doi.org/10.1108/REGE-02-2021-0025

59. Makau, M. M. & Muna, W. (2020). Effects of internal organizational policies on performance of government owned commercial banks in Kenya. International Academic Journal of Law and Society, 1(2), 1-27

60. Martin, P., Lizarondo, L., Kumar, S., & Snowdon, D. (2021). Impact of clinical supervision on healthcare organisational outcomes: A mixed methods systematic review. *PLoS ONE*, *16*(11), e0260156. https://doi.org/10.1371/journal.pone.0260156

61. Melariri, H., Freercks., van der Merwe, E., Ham-Baloyi, W.T., Oyedele, O., Murphy, R.A. (2024). The burden of hospital-acquired infections (HAI) in sub-Saharan Africa: a systematic review and meta-analysis. DOI:https://doi.org/10.1016/j.eclinm.2024.102571

62. Melesse G, Belda N, Zelalem JW. Knowledge, attitude and practice of infection prevention among health care workers in public health facilities in West Guji Zone, Oromia. *J Womens Health Care*. 2021;10:1-7.

63. Monegro AF, Muppidi V, Regunath H. (2023). Hospital-Acquired Infections. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK441857/

64. Mphaluwa, G., Hui, L., Marere, R. S., & Banda, L. O. (2025). How do leadership styles influence employee engagement and performance in SMEs? *Humanities and Social Sciences Communications*, *12*(1), 1-14. https://doi.org/10.1057/s41599-025-05707-w

65. Mudenda S, Chizimu J, Chabalenge B, Kasanga M, Matafwali SK, Daka V, Yamba K, Mulomba M, Mufwambi W, Katowa-Mukwato P, Godman B. Knowledge, attitude, and practices toward infection prevention and control among undergraduate pharmacy students in Zambia: findings and implications. Antimicrob Steward Healthc Epidemiol. 2023 Sep 11;3(1):e154. doi: 10.1017/ash.2023.428. PMID: 37771733; PMCID: PMC10523556.

66. Munoz-Price, LS, Bowdle, A, Johnston, BL, et al. Infection prevention in the operating room anesthesia work area. Infect Control Hosp Epidemiol 2019;40:1–17.
67. Nagassar, R.P., Wallace-Sankarsingh, S. Hand hygiene basic compliance rate monitoring among healthcare workers of a public hospital in Trinidad and Tobago. *Discov Public Health* **22**, 149 (2025). https://doi.org/10.1186/s12982-025-00546-1
68. Naji, A. T., Abu-hadi, T., Abu-hadi, B., Al-Yemeni, S., Al-dhobhani, R., Mohy Al-deen, B., & Jaber, A. A. (2022). Assessment of Knowledge, Attitude, and Practice Toward Infection Prevention and Control Among Diagnostic Radiographers in Yemen. *Journal of Radiology Nursing*, *41*(4), 339-346. https://doi.org/10.1016/j.jradnu.2022.06.008
69. Nimer, N. A. (2022). Nosocomial Infection and Antibiotic-Resistant Threat in the Middle East. Infection and Drug Resistance, 15, 631-639. https://doi.org/10.2147/IDR.S351755
70. Olawin AM, Das, J.M. (2022). Spinal Anesthesia. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK537299/
71. Onen, B.C., Semulimi, A.W., Bongomin, F. *et al.* Surgical Apgar score as a predictor of outcomes in patients following laparotomy at Mulago National Referral Hospital, Uganda: a prospective cohort study. *BMC Surg* **22**, 433 (2022). https://doi.org/10.1186/s12893-022-01883-7
72. Osena, G., Kapoor, G., Kalanxhi, E., Ouassa, T., Shumba, E., Brar, S., Alimi, Y., Moreira, M., Matu, M., Sow, A., Klein, E., Ondoa, P., Laxminarayan, R., & Group, M. S. (2025). Antimicrobial resistance in Africa: A retrospective analysis of data from 14 countries, 2016–2019. *PLOS Medicine*, *22*(6), e1004638. https://doi.org/10.1371/journal.pmed.1004638
73. Osman FK, El Banna HM, Sharaf AY, Mohammed YF. The effects of educational interventions on nurses' knowledge and practices in Hemodialysis unit regarding infection control practices. Egypt J Hosp Med. 2021;84(1):1739–48
74. Polit D, Beck C. *Essentials of Nursing Research: Appraising Evidence for Nursing Practice*. 9th edition ed. Philadelphia: Lippincott Williams & Wilkins; 2017.
75. Rickard, J., Beilman, G., Forrester, J., Sawyer, R., Stephen, A., Weiser, T.G. (2020). Surgical infections in low- and middle-income countries: a global assessment of the burden and management needs. Surg Infect (Larchmt), 6 (2020), pp. 478-494, 10.1089/sur.2019.142
76. Sands KE, Blanchard EJ, Fraker S, Korwek K, Cuffe M. Health Care–Associated Infections Among Hospitalized Patients With COVID-19, March 2020-March 2022. *JAMA Netw Open.* 2023;6(4):e238059. doi:10.1001/jamanetworkopen.2023.8059
77. Sarani, H.; Balouchi, A.; Masinaeinezhad, N.; Ebrahimitabas, E. Knowledge, Attitude and Practice of Nurses about Standard Precautions for Hospital-Acquired Infection in Teaching Hospitals Affiliated to Zabol University of Medical Sciences (2014). *Glob. J. Health Sci.* **2015**, *8*, 193–198
78. Sarkhell, A. F, Salar I.A., Seenaa M. A. (2023). Knowledge, Attitude, and Practices of Infection Control Amongst Medical Staff. University of Thi-Qar Journal Of Medicine Vol. 26 No. 2 (2023)
79. Schmidt, A. P., & Bevilacqua Filho, C. T. (2023). The impact of anesthesia on postoperative outcomes: The effect of regional anesthesia on the incidence of surgical site infections. *Brazilian Journal of Anesthesiology*, *73*(1), 1-2. https://doi.org/10.1016/j.bjane.2022.12.001
80. Schulz-Stübner, S., Pottinger, J.M., Coffin, S.A., and Herwaldt, L.A. (2024). Infection Control in Regional Anesthesia. Available from https://www.nysora.com/topics/complications/infection-control-regional-anesthesia/#:~:text=The%20anesthetic%20agents%20injected%20into,growth%20of%20bacteria%20and%20fungi.
81. Schwab JH, Shah AA (2020) Spinal Epidural Abscess: Diagnosis, Management, and Outcomes. JAAOS - J Am Acad Orthop Surg 28:e929. https://doi.org/10.5435/JAAOS-D-19-00685

82. Seo, J. K., & Lee, S. E. (2022). Hospital management, supervisor support and nurse speaking-up behaviours: The mediating role of safety culture perception. *Journal of nursing management*, *30*(7), 3160–3167. https://doi.org/10.1111/jonm.13737
83. Sharma, A., Fernandez, P. G., Rowlands, J. P., Koff, M. D., & Loftus, R. W. (2020). Perioperative Infection Transmission: The Role of the Anesthesia Provider in Infection Control and Healthcare-Associated Infections. *Current Anesthesiology Reports*, *10*(3), 233-241. https://doi.org/10.1007/s40140-020-00403-8
84. Shirley H., Wamai R. A narrative review of kenya's surgical capacity using the lancet commission on global surgery's indicator framework. *Glob Health Sci Pract.* 2022;10 doi: 10.9745/GHSP-D-21-00500
85. Singh S, Pandey H, Aggarwal HK, Pal S. Assessing the impact of training on healthcare providers' adherence to infection control measures in hemodialysis services. Cureus. 2023;15(8)
86. Tawfeeq NA, Hilal F, Alharbi NM, Alowid F, Almaghrabi RY, Alsubhi R, Alharbi SF, Fallatah A, Aloufi LM, Alsaleh NA. The Prevalence of Acceptance Between General Anesthesia and Spinal Anesthesia Among Pregnant Women Undergoing Elective Caesarean Sections in Saudi Arabia. Cureus. 2023 Sep 10;15(9):e44972. doi: 10.7759/cureus.44972. PMID: 37822429; PMCID: PMC10563372.
87. Thomas, L. (2023). *Cross-Sectional Study | Definition, Uses & Examples.* Scribbr. Retrieved August 5, 2024, from https://www.scribbr.com/methodology/cross-sectional-study/
88. Unakal C. G., Nathaniel A., Keagan B., et al. Assessment of knowledge, attitudes, and practices towards infection prevention among healthcare workers in Trinidad and Tobago. *International Journal of Community Medicine and Public Health.* 2017;7(4):2240–2247. doi: 10.18203/2394-6040.ijcmph20172813
89. Wall RT, Datta S, Dexter F, Ghyasi N, Robinson ADM, Persons D, et al. Effectiveness and feasibility of an evidence-based intraoperative infection control program targeting improved basic measures: a post-implementation prospective case-cohort study. J Clin Anesth. 2022;77: 110632.
90. WHO. (2022). WHO launches first ever global report on infection prevention and control. Available from https://www.who.int/news/item/06-05-2022-who-launches-first-ever-global-report-on-infection-prevention-and-control
91. WHO. (2023). Outbreak of suspected fungal meningitis associated with surgical procedures performed under spinal anaesthesia – the United States of America and Mexico. Available from https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON470
92. WHO. (2024). Infection prevention and control. Available from https://www.who.int/health-topics/infection-prevention-and-control#tab=tab_1
93. WHO. (2026). Key facts and figures: World Hand Hygiene Day. Available from https://www.who.int/campaigns/world-hand-hygiene-day/key-facts-and-figures
94. World Health Organization. [Guidelines on Core Components of Infection Prevention and Control Programmes at the National and Acute Health Care Facility Level]. World Health Organization. Country Office for Thailand; 2020.
95. World Health Organization. (2016). Guidelines on core components of infection prevention and control programs at the national and acute health care facility level. Geneva: WHO; 2016.
96. World Medical Association (2025). World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Participants. *JAMA*, *333*(1), 71–74. https://doi.org/10.1001/jama.2024.21972
97. Xu, Y., Lin, G., Spada, C., Zhao, H., Wang, S., Chen, X., Chen, Y., Zhang, Y., Marraro, G. A., Zeng, X., Ye, X., Zhang, L., & Zeng, Y. (2021). Public Knowledge, Attitudes, and Practices Behaviors Towards Coronavirus Disease 2019 (COVID-19) During a National Epidemic—China. *Frontiers in Public Health*, *9*. https://doi.org/10.3389/fpubh.2021.638430
98. Yakob E, Lamaro T, AH. Knowledge, attitude and practice towards infection control measures among Mizan-Aman general hospital workers, south West Ethiopia. Commun Med Health Educ. 2015;5:5–9.

99. Yang, X., Guo, R., Xie, B. et al. Drug resistance of pathogens causing nosocomial infection in orthopedics from 2012 to 2017: a 6-year retrospective study. J Orthop Surg Res 16, 100 (2021). https://doi.org/10.1186/s13018-021-02234-7
100. Yetneberk, T., Firde, M., Adem, S., Fitiwi, G., & Belayneh, T. (2021). An investigation of infection prevention practices among anesthetists. *Perioperative Care and Operating Room Management*, *24*, 100172. https://doi.org/10.1016/j.pcorm.2021.100172
101. Yosef, T. (2023). Healthcare Professionals' Knowledge, Attitude and Practice of Infection Prevention in Southwest Ethiopia. *Environmental Health Insights*. https://doi.org/10.1177/11786302231218819
102. Yousef YE, Elashir UM, Mahmoud SR, Maghraby N. The effect of nursing educational program on knowledge and practice of nurses regarding infection control measures for children under Hemodialysis. Egypt Nurs J. 2019;16(1):1–9
103. Zadey S, Iyer H, Nayan A, Shetty R, Sonal S, Smith ER, Staton CA, Fitzgerald TN, Nickenig Vissoci JR. Evaluating the status of the Lancet Commission on Global Surgery indicators for India. Lancet Reg Health Southeast Asia. 2023 Apr 5;13:100178. doi: 10.1016/j.lansea.2023.100178. PMID: 37383563; PMCID: PMC10306037.

Figures

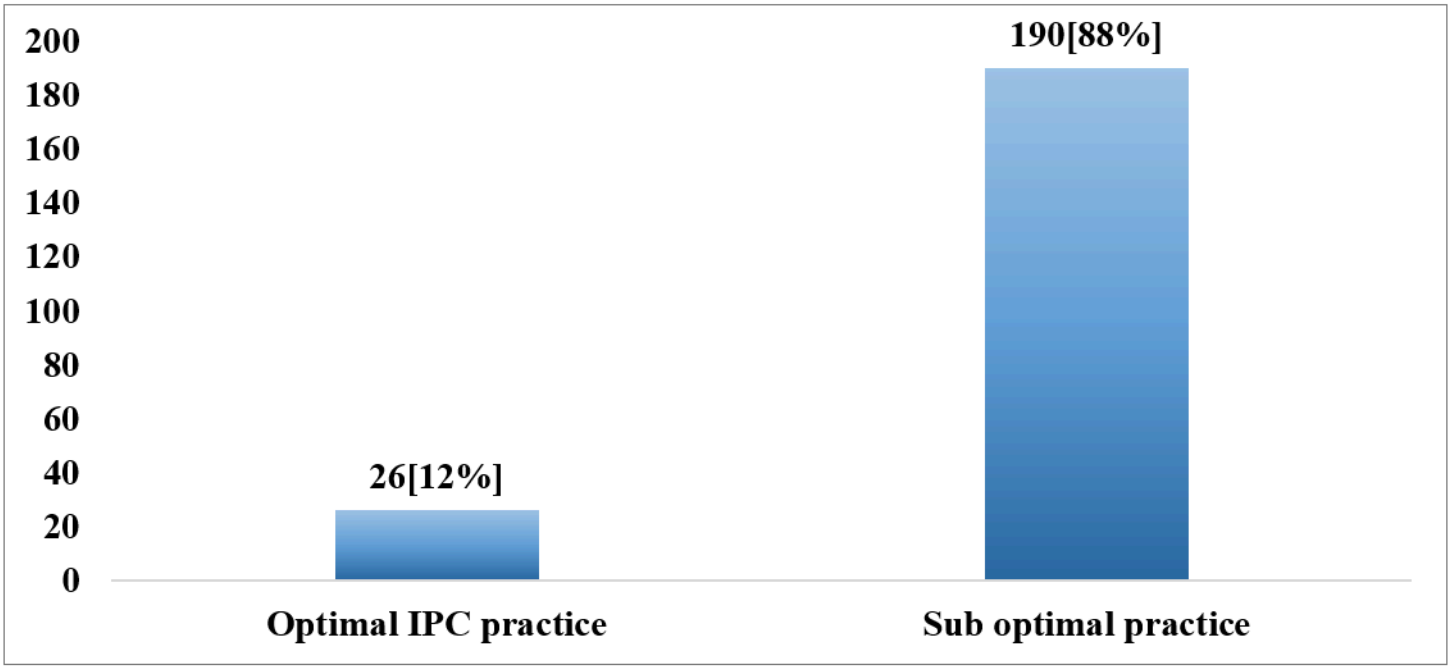


Figure 1

The proportion of anesthesia service providers at health facilities in central Uganda who optimally practice infection prevention and control

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