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RESEARCH PAPER

EFFICACY OF DISINFECTANTS COMMONLY USED IN SOME MEDICAL FACILITIES IN KUMASI, GHANA

Boata Mark, *Johnson Raphael, Yaa Asantewaa Osei, Boakye Yaw Duah, Francis Kwaku Amankwah, *Frederick William Akuffo Owusu, Stephen Yao Gbedema

Department of Pharmaceutics, Faculty of Pharmacy and Pharmaceutical Sciences, Kwame Nkrumah University of Science and Technology (KNUST) Kumasi, Ghana.

***Corresponding author: rjohnson.pharm@knust.edu.g, frederickakuffo.owusu@knust.edu.gh**

ABSTRACT

Hospital-acquired infections (HAI) are known to be responsible for prolonging hospital admissions and increasing mortality rates worldwide. Disinfectants are used to clean surfaces to reduce the risk of transmission of pathogens responsible for HAI in medical facilities. This study sought to determine the efficacy of disinfectants prepared and used in some medical facilities in the Kumasi metropolis. Forty-two disinfectants were sampled from the sanitary departments of fourteen health facilities selected in the Kumasi Metropolis. The antimicrobial activity of the selected disinfectants was evaluated on test microorganisms using the Agar well diffusion method and Chick martin tests. All 42 disinfectants sampled from the health facilities were identified to be different brands and concentrations of sodium hypochlorite solution. At the stated concentrations of dilution (1.2 -1.8 % v/v) of use, none of the 42 disinfectants showed any zone of inhibition against the test organisms (E. faecalis, E. coli, P. aeruginosa, S. aureus, S. typhi, and C. albicans) used. The study revealed that the concentration of sodium hypochlorite was lower than what was stated on the manufacturer's label. However, the prepared concentrations (between 2.0 and 6.0 % v/v) of the disinfectants showed antimicrobial activity against the test organisms. The study has shown that at the stated concentrations of use in various health facilities, the selected disinfectants did not display any antimicrobial activity against the test organisms and therefore cannot prevent the transmission of HAI in the medical facilities. At the stated concentration, thick perfumed and Madar bleach produced better antimicrobial activity. Higher concentrations prepared of at least 2.0 % v/v of selected disinfectants are recommended to achieve effective disinfection in health facilities.

Keywords: Disinfectants, Hospital-acquired infections, antimicrobial resistance.

INTRODUCTION

Hospital-acquired infections refer to infections that were neither present nor incubating at the time of admission, but have developed during the course of stay in a health facility within 48 hours of admission. Hospital-acquire infections (HAI) pose a serious threat to both staff and patients of health facilities worldwide (Kuruno *et al*., 2017). HAI leads to high rates of morbidity, mortality, socioeconomic loss, and prolonged hospitalization (Jroundi *et al*., 2007; Wang *et al*., 2015). HAI has also been recognized as a significant problem in terms of quality of care and operational cost for hospitals and governments in most countries (WHO Food Safety Program, 2002; Margetts and Dunleavy, 2002; Leseva *et al*., 2013; Ramasethu, 2017). Commonly occurring HAIs are central line-associated bloodstream infections, catheter-associated urinary tract infections, ventilator-associated pneumonia, and surgical site infections (Exner *et al*., 2004; Yen *et al*., 2006). Olivier *et al*. (2018) reported that HAIs affect 5 to 15 % of hospitalized patients in the developed world. The annual HAIs are also estimated to be 1.7 million in the United States of America and 2.5 million in Europe, with more than 90,000 deaths in both regions (Despotovic *et al*., 2018). HAIs appear very high in third-world countries, but very few studies have been conducted to support this fact. A review report by Dramowski *et al*. (2017) stated that the overall prevalence of these infections in African countries is around 15.5 %, which is relatively higher than in the developed world. In Ghana, there is no established surveillance system to provide estimates of the HAIs burden across our rapidly growing population (Labi *et al.,* 2019). The most recent estimate of HAI prevalence of 6.7 % was derived from a single-centre study published in 2009 (Newman, 2009).

Contamination of hospital surfaces plays an important role in the spread of HAI-associated pathogens such as vancomycin-resistant *Enterococcus*, *Clostridium difficile*, *Acinetobacter*, Methicillin-resistant *Staphylococcus aureus* (MRSA), and norovirus (Dehghani *et al.,* 2008; Ali *et al.,* 2017). Several evidence-based studies have shown that inadequate surface disinfection can lead to increased rates of HAI (Zareniya *et al.,* 2017; Puchter *et al.,* 2018; Weber *et al.,* 2019). One of the interventions to reduce the occurrence of HAI is the use of protective barriers (e.g., gloves, gowns, face masks, protective eyewear, and face shield) to reduce occupational transmission of pathogens from patients to healthcare providers and vice versa (Vandini *et al.,* 2014; Brusaferro *et al.,* 2015). Other control measures for HAIs such as the development of effective antibiotics to combat the resistance of pathogens have been in vogue (Dancer, 2014). Point prevalence surveys for HAI have been implemented to mitigate the burden, but some other studies have shown a number of limitations to these interventions and therefore the increase in HAI rates (Hammuel *et al*., 2014). Therefore, minimizing the occurrence of HAI is a priority to ensure safe healthcare delivery. Therefore, consistent evaluation and monitoring of the efficacy of disinfectants employed in healthcare facilities have been suggested to help reduce the spread of HAI (Urban *et al*., 2003; Alfa, 2019).

HAI in Ghana has basically been attributed to improper disinfection and overcrowding in healthcare facilities (Weinstein and Hota, 2004; Adongo *et al*., 2017). Poor and improper disinfection in our health facilities results in selective pressure, which in turn leads to the development and multiplication of the antimicrobial-resistant surface pathogen (Lowe *et al.,* 2013; Addie *et al*., 2015; Kohzadi *et al*., 2018). These pathogens, when transmitted to patients, are difficult to treat with currently available antibiotics in clinical use (Lowe *et al.,* 2013; Addie *et al*., 2015; Kohzadi *et al*., 2018; Song *et al*., 2019). In a resource-constrained nation like Ghana, regular and consistent monitoring of the efficacy of disinfectants used in our health facilities is necessary to reduce the rates of HAI. In addition, disinfectants are purchased from healthcare facilities as concentrates that require dilution prior to use. Cleaning is mostly done by illiterates and/or semi-literates and therefore issues of incorrect dilutions could not be ruled out. In this study, we sought to report on the efficacy of disinfectants prepared and used in some health facilities in the Kumasi metropolis of Ghana.

MATERIAL AND METHODS

Materials

Staphylococcus aureus ATCC 25923, *Enterococcus faecalis* ATCC 29212, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 4853, *Salmonella typhi* (clinical strain) and *Candida albicans* (clinical strain) obtained from the KNUST Department of Pharmaceutics Microbiology Laboratory were used for the study. All reagents used were of analytical grade and were used as received. The various microbiological culture media used were prepared according to the manufacturer's instructions.

Methods

Study sites

Fourteen health facilities in Kumasi Metropolis (Figure 1) were selected for the study. The facilities comprised one tertiary, regional, and specialist hospital, four district hospitals, four clinics, and two health centres. These health facilities are noted to significantly contribute to the healthcare delivery needs of the populace in the metropolis.

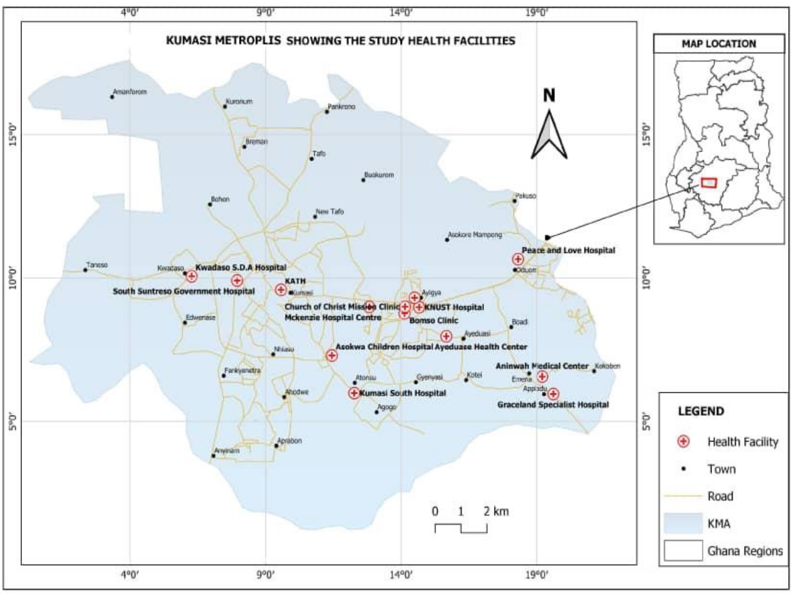

Figure 1. Map of Kumasi Metropolis showing the selected health facilities

Sampling of Disinfectants

About 250 ml of each of the 42 samples of disinfectants (as prepared) were collected from the sanitation departments of the 14 selected health facilities in the Kumasi metropolis. Two other disinfectants (Thick

Perfumed and Madar Bleaches) purchased from a retail shop were used as reference disinfectants.

Antimicrobial activity of the disinfectants

The antimicrobial activities of the disinfectants sampled from various health facilities were evaluated using the agar well diffusion method. Higher concentrations of disinfectants (2.0, 4.0, and 6.0 % v/v) were also prepared and their antimicrobial properties were also evaluated using the agar well diffusion method (Boakye *et al*., 2016). Twenty millilitres of nutrient agar and potato dextrose agar were seeded with 100 µL (1.5 x 10^8 CFU/mL) of test bacteria and fungus, respectively, and transferred aseptically into sterile petri dishes. Four equidistant wells (8 mm) were cut using sterile cork borer number 4 after the agars were set. The wells were filled with the stated concentrations of use of the selected disinfectants and allowed to stand at room temperature (25 °C) for 1 h. Zones of growth inhibition were measured after incubation (bacteria at 37 °C for 24 h; fungus at 28 °C for 72 h). The procedure was performed in independent triplicate and the mean zones of growth inhibition were determined. Thick perfumed bleach and Madar bleach were used as reference disinfectants in the evaluation.

Determination of the amount or strength of sodium hypochlorite in the selected bleaches

Accurately 6.4 g of sodium thiosulphate was weighed and dissolved in about 100 ml of distilled water in a 250 ml volumetric flask. It was made up to the mark with distilled water. 10 ml of the selected bleaches were pipetted into a 100 ml volumetric flask and diluted to 100 ml with distilled water and shaken well. 25 ml of the diluted bleach was pipetted into a 250 ml conical flask and carefully 1 g of potassium iodide was added to form an iodine solution. 10 ml of 1 M sulphuric acid was carefully pipetted into the iodine solution and was titrated against the standardized sodium thiosulphate solution until the colour of the solution has diminished from red-brown to pale straw yellow. 2 ml of starch solution was added and the titration continued dropwise with constant swirling until the solution became colourless. The colourless solution signaled the endpoint of the titration. The burette volume was recorded to the nearest 0.05 ml. The procedure was repeated in triplicate for all the selected health facility's bleaches (Jonnalagadda and Gengan, 2010).

Determination of the effect of organic matter on the antimicrobial activity of disinfectants

The Chick martin's test was used to determine the activity of the selected disinfectants against test organisms in the presence of organic matter. An organic suspension was prepared by adding 3 g of sterile dried faeces to 100 ml of sterile water. This organic suspension was aliquoted into each 2.5 ml of the respective test organisms and the bacteria suspension was added and gently swirled to mix. This was followed by the addition of the stated concentrations of 0.5 ml of the selected disinfectants. The suspension was then allowed to stand on the bench for 30 minutes at room temperature before incubation at 37 ºC for a fixed time of 30 minutes (Prakasam *et al.,* 2021). Phenol (1 % v/v) was used as a positive control. A mixture of the organic suspension and test bacteria was used as the negative control. The presence or absence of growth was determined by adding diphenyl tetrazolium bromide (MTT) (Osimani *et al.,* 2014). The same procedure was repeated for 2, 4, and 6 % v/v concentrations of the selected disinfectants.

RESULTS AND DISCUSSION

Types of disinfectants used in the selected medical facilities

Based on the samples collected, it was realized that all the facilities used one common disinfectant (bleach) with sodium hypochlorite as the main active ingredient but at different stated concentrations (1.2 to 1.8 % v/v) of dilution of use (Table I). However, analysis of the actual concentration of the active ingredient from all samples revealed that, the samples contained a lesser amount of the active ingredient in comparison to what was stated on their labels. The standards (Reference 1 and 2), however, contained the right amounts of the active ingredient as stated on their labels (Table 1). The disinfectants are procured as concentrates from the manufacturers, and concentration required for disinfection is indicated on the product label with directions for dilution. This concentration range is in line with the US Environment Protection Agency (EPA) standard concentrations (1 to 4 % v/v) for surface disinfection in hospital settings (Lowe *et al.,* 2013; Suwa *et al.,* 2013; Ciofi-Silva *et al.,* 2019). However, dilutions which were carried out at the various hospitals produced lesser concentrations than expected due to lesser amount of the active ingredient. The main excipient present in the disinfectants was surfactants. This observation was not surprising, as some surfactants are also known to impart antimicrobial properties in formulations in addition to their wetting properties.

Table I: Disinfectants used for cleaning by the health facilities and their concentrations

Health facilities	Disinfectants used	API/Constituents	Stated concentration of sodium hypochlorite in stock (% w/v)	Actual concentration sodium hypochlorite in stock (% w/v)	Stated Concentrations for Use (% v/v)
KH	KH bleach	Sodium hypochlorite, Surfactants	5.0	1.33 ± 0.13	1.4
KSH	KSH bleach	Sodium hypochlorite, Surfactants	8.0	1.22± 0.39	1.7
SGH	Pagato bleach	Sodium hypochlorite, Sodium carbonate	4.0	1.13 ± 0.04	1.6
SDAH	SDAH bleach	Sodium hypochlorite, Sodium carbonate	10.0	1.42 ± 0.06	1.8
KTH	Koos bleach	Sodium hypochlorite, Surfactants	5.0	1.34 ± 0.12	1.5
ACH	ACH bleach	Sodium hypochlorite, Surfactants	9.5	1.26 ± 0.10	1.2
EH	EH bleach	Sodium hypochlorite	5.0	1.25 ± 0.08	1.7
PLH	PLH bleach	Sodium hypochlorite	10.0	1.48 ± 0.24	1.5
GSH	GSH bleach	Sodium hypochlorite, Sodium carbonate	8.5	1.22 ± 0.27	1.5
BC	Densu bleach	Sodium hypochlorite	3.5	1.29± 0.20	1.2
CCMC	CCMC bleach	Sodium hypochlorite	5.o	1.15± 0.17	1.5

Table I continued

AHC	AHC bleach	Sodium hypochlorite, Anionic surfactant	6.5	1.05± 0.11	1.3
VMC	VMC bleach	Sodium hypochlorite, Surfactants	8.0	1.34± 0.08	1.7
MMC	MMC bleach	Sodium hypochlorite, Anionic surfactant	3.5	1.23± 0.45	1.6
Reference 1	Thick Perfume bleach	Sodium hypochlorite, Caustic soda, Soda ash, Industrial salt, perfume	3.5	3.45± 0.02	1.0
Reference 2	Madar bleach	Sodium hypochlorite, Anionic surfactant, perfume	3.5	3.43± 0.06	1.0

Antimicrobial activity of stated concentrations of disinfectants used by the health facilities

The susceptibility of *E. faecalis*, *E. coli*, *P. aeruginosa*, *S. aureus*, *S. typhi*, and *C. albicans* to disinfectants used by selected health facilities was determined using the agar diffusion method (Boakye *et al.,* 2016). The results of the agar well diffusion test of the disinfectants of the selected health facilities indicated that all the disinfectants selected (sodium hypochlorite solutions) according to their stated concentrations (1.2 to 1.8 % v/v) of dilutions being used in the various hospitals did not show antimicrobial activity or zero zones of inhibition against all the test organisms (Table II). This is due to the fact that the concentrate from the manufacturers in the first instance contained a lesser amount of the active ingredient than what was stated on their labels (Table I). Hence dilution of the concentrates (as stated on the manufacturers label) produced a lower concentration of the active ingredient and thus was unable to elicit any antimicrobial activity. Reduction in concentration of the active ingredient is potentially further exacerbated due to over dilution by janitors in the various health facilities. This was corroborated during personal interactions with the janitors, where it was observed that the janitors were given fixed volumes of bleach by the management of the facilities to be used over a certain period of time (probably for economic reasons) without considering the area/floor space to be cleaned. This study does not conform to the observation of Tartari *et al.* (2015), who reported that the use of sodium hypochlorite solution alone on both floors and patient room furniture led to a decrease of approximately 70 % of bacterial contamination on the environmental surfaces of the patients after cleaning. Recently, many researchers have reported that sodium hypochlorite solution at 1 % v/v concentration had greater efficiency in killing test microbes, but this study reported otherwise. However, Thick perfumed bleach and Madar bleach at a stated concentration of 1 % v/v respectively showed antimicrobial activity (zone of inhibition) against the same test organisms (Table II).

Table II: Antimicrobial activity of health facilities disinfectants at stated concentrations

Disinfectant	Stated concentrations (% v/v)	Test organisms					
		E. coli	*E. faecalis*	*S. aureus*	*S. typhi*	*C. albicans*	*P. aeruginosa*
		Zones of inhibition (mm)					
KH bleach	1.4	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
KSH bleach	1.7	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Pagato bleach	1.6	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
SDAH bleach	1.8	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Koos bleach	1.5	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
ACH bleach	1.2	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
EH bleach	1.7	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
PLH bleach	1.5	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
GSH bleach	1.5	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Densu bleach	1.2	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
CCMC bleach	1.5	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
AHC bleach	1.3	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
VMC bleach	1.7	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
MMC bleach	1.6	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Thick perfume bleach	1.0	32.63 ± 1.72	30.23 ± 1.53	26.67 ± 0.53	24.45 ± 1.69	28.33 ± 1.54	31.64 ± 0.58
Madar bleach	1.0	30.33 ± 1.15	28.67 ± 1.15	29.52 ± 1.54	27.33 ± 1.53	26.82 ± 0.53	29.76 ± 1.15

Susceptibility of test organisms to the selected disinfectants in the presence of organic matter

The selected disinfectants were introduced into a suspension of dried human faeces (organic matter) to simulate the hospital complex environment using the Chick Martin test (Derrick, 2005; Walker, 2020). The disinfectants selected at their respective stated concentrations were unable to inhibit the test organisms in the presence of organic matter. However, thick perfume bleach, and Madar bleach were effective in killing the same organisms in the presence of organic matter at a stated concentration of 1 % v/v, respectively. The Chick Martin test again confirmed that the stated concentrations of the selected disinfectants were not powerful enough to kill microbes in the presence of organic matter. This result does not conform to a report by Dettenkofe *et al*., (2004) which indicated that sodium hypochlorite at a concentration of 1 % v/v showed antimicrobial activity against organisms in the presence of organic matter. However, increased concentrations (2, 4 and 6 % v/v) of the selected disinfectants had more efficacy to kill or inhibit test microbes *(E. faecalis, E. coli, P. aeruginosa, S. aureus, S. typhi*, and *C. albicans*) in the presence of organic matter which is in agreement with that reported by Dettenkofe *et al*. (2004) (Table III).

Table III: Chick Martin test of disinfectants at increased concentrations

Health Facility	Microorganisms																	
	E. coli			*S. typhi*			*P. aeruginosa*			*S. aureus*			*E. faecalis*			*C. albicans*		
	2 %	4 %	6%	2%	4%	6%	2%	4%	6%	2%	4%	6%	2%	4%	6%	2%	4%	6%
KH bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KSH bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pagato bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SDAH bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Koos bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLH bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EH bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACH bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GSH bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Densu bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CCMC bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VMC bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MMC bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AHC bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thick perfumed bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Madar bleach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenol (1 %)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Presence = (+) Absence = (-)

* The stated concentrations of all the selected disinfectants (Table 1) showed the presence of growth (+) for all the selected microorganisms in the presence of organic matter

Antimicrobial activity of selected disinfectants at increased concentrations

Concentrations of the selected disinfectants were further increased to 2, 4, and 6 % v/v and were tested against the same organisms. There was dose-dependent antimicrobial activity (zones of inhibitions) against all the test organisms (Dettenkofe *et al*., 2004). Zones increased as the concentration of selected disinfectants increased, which was in line with the US EPA standards for low-level disinfectants (figures 2-7) and Tables SI-SVII of the supplementary data. The increased concentrations of disinfectants were prepared according to the manufacturer's dilution protocols which may be the reason why these concentrations inhibited the growth of test organisms. This result is in agreement with that of Ciofi-Silva *et al*., (2019), who reported the use of sodium hypochlorite solution for surface disinfection in hospital.

It is also similar to Donskey (2019), who reported the use of sodium hypochlorite alone to clean the floors and furniture of the patient room. There was a decrease in the bacterial load after cleaning.

Thick perfumed bleach and Madar bleach are standard bleach purchased from the Market in Kumasi, Ghana. The susceptibility of test organisms to these standard bleaches was determined using the agar well diffusion method (Boakye *et al.,* 2016). These reference bleaches showed better antimicrobial activity against all test organisms at a concentration of 1 % v/v (Table II). This showed that the reference disinfectants were prepared following the manufacturers stated dilution factors even at 1 % v/v, these reference bleaches were able to kill all the test organisms.

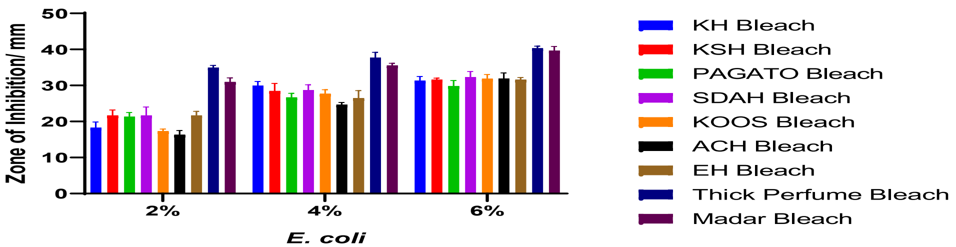

Figure 2. Antimicrobial activity of different bleaches against *E. coli*

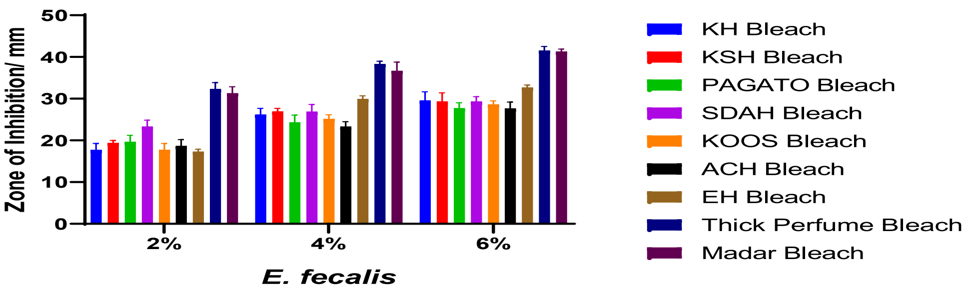

Figure 3. Antimicrobial activity of different bleaches against *E. fecalis*

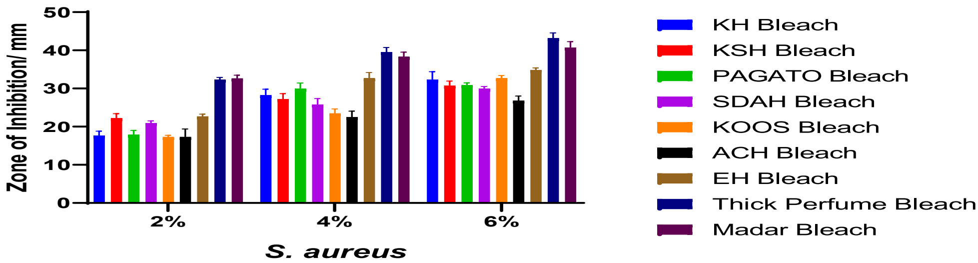

Figure 4. Antimicrobial activity of different bleaches against *S. aureus*

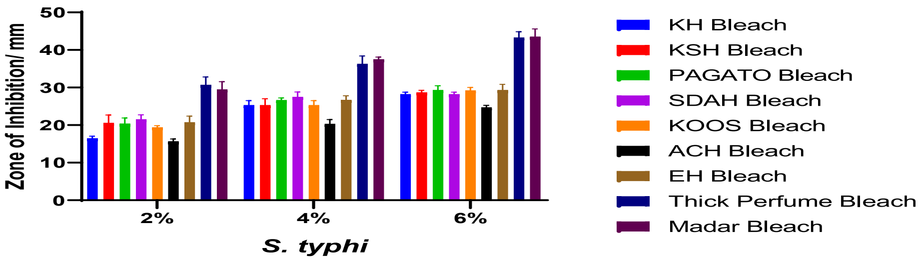

Figure 5. Antimicrobial activity of different bleaches against *S. typhi*

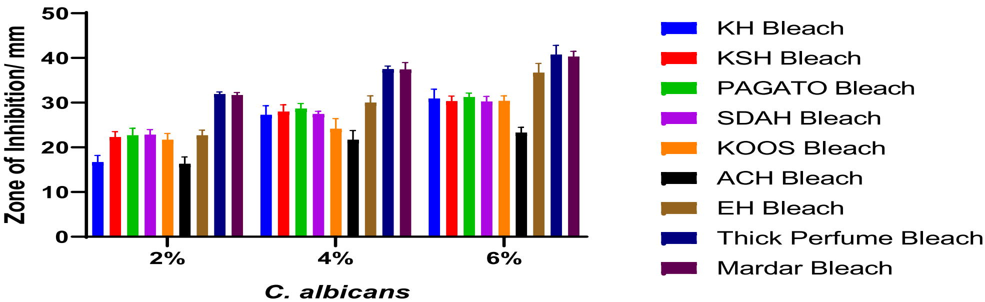

Figure 6. Antimicrobial activity of different bleaches against *C. albicans*

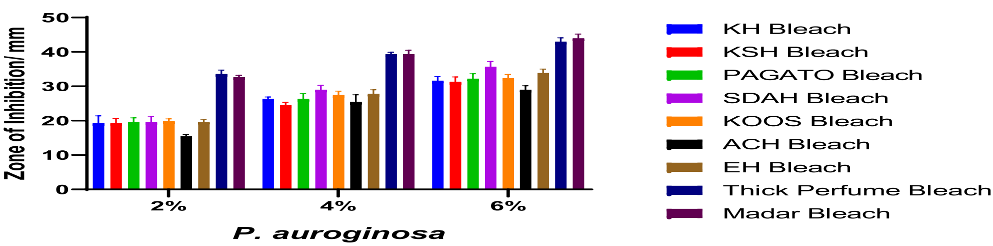

Figure 7. Antimicrobial activity of different bleaches against *P. auroginos*

CONCLUSION

This study has revealed that the amount of sodium hypochlorite in the concentrates are far less than what is stated by the manufacturers. Subsequently, dilutions carried out in the various health facilities (1.2 to 1.8 % v/v) did not show antimicrobial activity against all test organisms. However, the prepared concentrations (2, 4, and 6 % v/v) of the selected disinfectants showed dose-dependent antimicrobial activity against all the test organisms that was also evident in the presence of organic matter. The disinfection in the health facilities is not good enough and therefore management of the facilities should take pragmatic measures to increase the concentration of the disinfectants to prevent hospital-acquired infections by patients.

AUTHORS CONTRIBUTIONS

Mark Boata: Methodology, data collection, sample analysis, data analysis, and initial draft writing.

Raphael Johnson: Conceptualisation, project leadership, project management, methodology, data analysis, and writing revision.

Yaa Asantewaa Osei: Conceptualisation, project management, methodology, and writing revision.

Boakye Yaw Duah: Conceptualisation, methodology, project leadership, data analysis, and writing revision.

Francis Kwaku Amankwah: Methodology, data collection and data analysis.

Frederick William Akuffo Owusu: Data analysis, writing the initial draft, and revisions.

Stephen Yao Gbedema: Conceptualisation, project management, and writing-revisions.

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