

Original Article

Aetiology, factors associated with injury severity, and bacterial susceptibility patterns among burn patients in six selected hospitals in Uganda

Byamungu P Kagenderezo¹, Joshua Muhumuza¹, Mugisho M Leocadie¹, Funmileyi Awobajo³, Selamo F Molen¹, Godefroy N Basara¹, Musa A Waziri¹, Franck K Sikakulya¹, Stephen M Kithinji¹, Emmanuel I Obeagu⁵, Kiyaka M Sonye¹, Ibe Usman⁴, Agwu Ezer², Okedi F Xavier¹

¹Department of Surgery, Faculty of Clinical Medicine and Dentistry, Kampala International University, Western Campus, Ishaka, Uganda; ²Department of Microbiology, Faculty of Allied Sciences, Kampala International University, Western Campus, Ishaka, Uganda; ³Directorate of High Degrees and Research, Kampala International University, Western Campus, Kampala, Uganda; ⁴Department of Human Anatomy, Faculty of Allied Sciences, Kampala International University, Western Campus, Ishaka, Uganda; ⁵Department of Medical Laboratory Science, Kampala International University, Western Campus, Kampala, Uganda

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Abstract: Background: Globally, burn injury is of public health concern; it is a significant health problem in both children and older adult populations. In Africa and especially in Uganda, burn injuries remain a major cause of prolonged hospital stays, disability, disfigurement and death. A lot of factors may be associated with the injury severity of burn wounds. Bacterial microorganisms take short hours to invade the burn wound and can be identified in the burn wounds less than 24 hours old. When a patient is alive after 3 days following a burn, then the commonest cause of death is infection. Bacterial infection is still the serious complication that might compromise with the patient's life after the early phase of the management, and the bacterial pathogens isolated from these wounds might still be resistant to the most common used antibiotics in our setting. Objectives: The aim of this study was to determine the most common etiology, the factors associated with injury severity, and the bacterial susceptibility patterns of burn patients in six selected hospitals in Uganda. Methods: This cross-sectional study was conducted in the departments of surgery at the six selected hospitals from April to July 2022. Results: Around 76 patients admitted to those hospitals with burns during our study period were included. Those who were very severe without caretakers eligible to consent for them were excluded. The average age was 17.7 years. There were slightly more males with a male-to-female ratio of 1.05. The majority were from the rural areas accounting for 76.3%. The common etiology was thermal, accounting for 80.8%, dominated by scalds (60.5%). Patients with burn wounds at the sites mandating admission were 22 times more likely to have a severe injury. The most common organism isolated was staphylococcus aureus accounting for 45.2%, followed by Pseudomonas, accounting for 15.5%, and they % were resistant to most of the antibiotics used in our study. Despite that identified bacteria were resistant to most of antibiotics, a good number of them were sensitive to imipenem, amikacin, ciprofloxacin, and cloxacillin. Conclusions: Implementation of burn infection control policies is needed. There is a need to include sites mandating admission in the parameters of the ABSI score. Based on microorganisms isolated, empirical treatment with ciprofloxacin or cloxacillin should be considered.

Keywords: Burn, factors associated with severity, etiology, bacterial susceptibility patterns, low-income setting

Introduction

Globally, burn injury is of public health concern; it is a significant health problem in both children and older adult populations [1-3].

The risk of burns increases with lower socioeconomic status of the patient, and over 90% of burns occur in low- and middle-income countries [9, 12]. The World Health Organization (WHO) predicts that the majority of post-burn

deaths occur in low- and middle-income countries (LMICs); victims typically are from disabled families in rural areas [10, 15]. In Uganda, burns highly contribute to the burden of surgical disease, morbidity, and mortality [12]. The etiology of burns may be due to thermal, radiation, electrical agents, and frostbite, though the most common etiology in our settings remained unclear [4, 17]. Factors of injury severity are known and are given in terms of scores [2]. There are several tools to assess the severity of burn patients; the Abbreviated Burn Severity Index (ABSI) is one of them [14]. Ryan, revised BAUX, and BOBI scores are good in predicting the severity of burn injury; however, their accuracy is related to the inhalational injury concept [11]. A study done by Herlianita et al. shows that the ABSI model has better sensitivity, specificity, and accuracy compared to the rest of the burn severity scores. It has five parameters, including age, sex, inhalation, thickness and TBSA; scored over 18 and graded as follows: very low, moderate, moderately severe, serious, severe, and maximum (see [Appendix 1](#)). A need to assess more other factors that tend to be associated with injury severity even though they are not part of the ABSI score, was one of the targets of this study.

The destruction of the skin by burn exposes to microorganisms [3, 5]. The microorganisms, especially the bacterial pathogens, invade burn wounds a few hours after injury and have been reported to be the major cause of death after the acute phase of the disease [4, 5, 7, 16]. Culturing procedures are common in microbiology, and they can reveal a lot about bacterial characteristics [11, 19]. Many has been worked on about bacterial susceptibility patterns in burns; different bacteria's identified differ from one place to another [12-14, 20, 21]. Infection is a major complication that commonly occurs in the early post-injury period and is the main contributor to death and disability in this category of patients [22-24]. In those patients that are alive on the third day following burn injury, infection of the burns is the commonest reason found to have caused death [8, 16, 23]. Burn victims are highly susceptible to infection because the skin is breached by the burn injury in addition to prolonged hospital stays and therapeutic and diagnostic procedures [7, 15, 16]. Remarkably, over 75% of deaths caused by burns are a result of

wound infection bacteria [24]. In Uganda, like in any other African country, the bacterial infections are still the serious complication which might compromise with the patient's life after the early phase of the management and the bacterial pathogens isolated from these wounds might still be resistant to most commonly used antibiotics in our setting [3, 6, 22].

This study has determined the common etiology of burns in our setting and identified the factors associated with the injury severity of burns. This enables early surveillance for patients so as to reduce associated complications. With the identification of the bacterial pathogens and the antibiotics they are sensitive to, help the clinician to select the appropriate antibiotics to administer, which improves the management of those patients.

Methodology

This study was a cross-sectional study conducted in the departments of surgery at the six selected hospitals. The most common cause of burns was determined and factors associated with injury severity were identified using ABSI score; a sample for culture and sensitivity was taken to determine the bacterial susceptibility patterns. All patients with burns despite gender, were targeted. Patients in a coma and mentally disabled ones without caretakers who were eligible to consent for them were excluded from the study.

The number of participants was calculated using the Kish Leslie 1965 formula.

The incidence of burn wounds is not well known in Africa, the sub-Saharan region, and in Uganda; however, in central Malawi, the epidemiological study reports 4.7% [25].

$N = pqz^2/d^2$; p is the incidence of burns ($p = 0.047$); $q = 1-p = 0.953$; e is acceptable sample error (0.05).

On substitution, $n = 69$. On adding 10% to cater for loss of follow-up, the sample size required was 76.

Participants were consecutively recruited from the accidents and emergency (A and E) department, surgical ward, or surgical outpatient by the investigator or the research assistants,

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Table 1. The characteristics of the study participants

Characteristic	Statistic	
	Min = 0.08 Max = 72 Mean = 17.70 SD = 19.11	
Age in years	Frequency	Percentage
Sex		
Male	39	51.3
Female	37	48.7
Residence		
Rural	58	76.3
Urban	18	23.7
Marital Status		
Single	52	68.4
Married	13	17.1
Separated	8	10.5
Widowed	3	3.9
Jehovah witness	3	3.9
Education level		
Pre School	27	35.5
Nursary	5	6.6
Primary	29	38.2
Secondary	11	14.5
Tertiary	2	2.6
None	2	2.6
Hospital		
Mubende	22	28.9
FRRH	21	27.6
KIU-TH	11	14.5
Jinja	10	13.2
Kiryandongo	6	7.9
HRRH	6	7.9

SD: Standard deviation, Min: Minimum, Max: Maximum. In this study, the average age was 17.7 years. There were slightly more males with a male to female ratio of 1.05. Majority were from the rural areas accounting for 76.3%. Majority of the patients were from Fortportal regional referral hospital and Mubende hospital accounting for 27.6 and 28.9% respectively. The rest of the characteristics are shown in **Table 1** above.

with help from clinicians on duty who had identified the clients with burns. The patient was screened for eligibility to join the study and consented to it. Written consent was obtained from the participant or his/her parent after thorough explanation about the research.

Forms were used to document the participant identification (number, age, sex, profession, marital status, location, and others as indicated on the data collection form in the [Appendix 2](#)), independent variables (ABSI score as indicated in the [Appendix 1](#)), and materials used.

Data was being statistically analyzed using IBM Statistics SPSS 24 series for Windows. The most common etiology of burns was determined by percentages and frequency tables (see **Table 1**). Using descriptive statistics. The severity according to ABSI was divided into two categories: non-severe, which included the very low and moderate grades, and severe, which incorporated the rest of the grades. Those were used as the dependent variables (age, sex, TBSA, inhalation, and depth). The values with ABSI ≤ 5 were grouped as non-severe and coded as 0, and the values ≥ 6 as severe and coded as 1. Binary logistic regression was done both at bivariate and multivariate. Values that had a *p*-value of less than 0.2 at bivariate were taken to multivariate, and those values with a *P*-value less than 0.05 at multivariate were considered significant. The bacterial susceptibility patterns were established and computed in percentages and frequency tables using descriptive statistics. Technically, the swabs were dipped in Stuart's transit medium before being inoculated on Mannitol Salt Agar, an enriched medium, and Stuart's selective and differential medium (blood agar). Following an incubation period of 18 to 48 hours, the isolates were identified using traditional identification methods at

37°C. The isolates of gram-negative bacteria were identified using the API (Analytical Profile Index) 20E system. While gram-positive bacteria submitted to identification tests were identified using gram stains, catalase tests, hemolysis on blood agar, coagulase, and other assays. Also, the latex agglutination test was sometimes used as a confirmation stage of the investigation. After 18-24 hours, the zone of inhibition was measured in mm using a ruler and compare with a standard chart to determine the resistant, intermediate and susceptibility of the bacterial to the antibiotics disc. For more detail, see [Appendix 3](#).

Table 2. The most common etiology of burn patients in the six selected hospitals

Etiology	Frequency	Percentage
Thermal	69	80.8
Scald	46	60.5
Flame	19	25.0
Contact	4	5.3
Chemical	7	9.2
Liquid	7	9.2
Gaz	00	00
Radiational	00	00
Ultraviolet	00	00
Ionised	00	00
Electrical	00	00
Frostbite	00	00

In this study, the majority of the burns were thermal accounting for 80.8%, dominated by scalds 60.5%. The chemical burns accounted for only 9.2%. There were no radiational, frostbite and electrical burns.

Results

During the study period, 76 patients eligible for the study were recruited and consented. During culture, there was no growth seen in 6 of the samples. Of the 70 samples that had growth, 8 had two organisms isolated. The second organism in all cases that isolated two organisms was *Staphylococcus aureus*.

In this study, the average age was 17.7 years. There were slightly more males with a male-to-female ratio of 1.05. The majority were from the rural areas, accounting for 76.3%. The majority of the patients were from Fort Portal Regional Referral Hospital and Mubende Hospital, accounting for 27.6% and 28.9%, respectively. The rest of the characteristics are shown in **Table 1** below. In this study, the majority of the burns were thermal, accounting for 80.8%, dominated by scalds (60.5%). The chemical burns accounted for only 9.2%. There were no radiation, frostbite, or electrical burns (**Table 2**).

In bivariate analysis, pre-existing conditions, sites mandating admission, and marital status had a significant relationship with burn severity. Having epilepsy increases the risk of having a severe burn by 4.818 times. Having a burn site mandating admission increased the risk of having a severe burn by 5.3 times. A separated patient was 16.333 times more likely to have a

severe burn compared to one who was single, and a married patient was 26.133 times more likely to have a severe burn compared to a single one. The only significant factor at multivariate that was independently associated with severity was site mandating admission. A patient who had a burn mandating admission was 22.449 times more likely to have a severe burn compared to one that had a burn site not mandating admission (**Table 3**).

Different bacterial microorganisms were identified in 92.1% of the samples. 7.9% didn't manifest the growth of any microorganism. 10.5% of the patients had two microorganisms isolated, and the second microorganism was *Staphylococcus aureus*. The following microorganisms were isolated: *Staphylococcus aureus* (45.8%), *Pseudomonas spp.* (15.7%), *E. coli* (9.6%), *Klebsiella spp.* (6%), *Neisseria spp.* (6%), *Enterococcus faecalis* (6%), *Proteus* (3.6%), and *Enterobacter spp.* (1.2%) (**Table 4**). *Staphylococcus aureus* was susceptible to imipenem (71.8%), amikacin (28.2%), ciprofloxacin (28.6%), cloxacillin (15.4%), gentamicin (7.7%), Tri-sul (7.7%), and ceftriaxone (5.1%). *Pseudomonas spp.* were sensitive to imipenem (46.2%) and amikacin (15.4%); intermediate to ciprofloxacin (53.8%), gentamicin (15.4%), cloxacillin (7.7%), and tri-sul (7.7%); and resistant to the rest of the antibiotics. *E. coli* were sensitive to tri-sul (12.5%), intermediate to ciprofloxacin (25%), and resistant to the rest of the antibiotics used in the study. *Klebsiella* was 60% sensitive to imipenem and 20% (**Table 5**).

Discussion

Burn patients who consulted the six hospitals had thermal injuries 90.8%, while 9.2% had chemical injuries. This sounds similar to what is described by Love as the most common etiology of burn results from accidental pouring of fluids at high temperatures, from matchboxes and experiments with burning gases and liquids [26]. He also described that adults suffer most of the burns from electricity and chemicals. This is significantly different from our findings in this study, where no patient had a burn injury due to electricity. In Colombia, it's a bit different from our findings, where Ramirez-Blonco et al. mentioned that gasoline was the second most common etiological agent, followed by electricity, fire, and chemicals [18]. The same applied to the findings in Korea. Electrical causes were among the most com-

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Table 3. The bivariate and multivariate analysis of the factors associated burn injury severity

Characteristic	Non Severe N = 58 n (%)	Severe, N = 18 n (%)	Bivariate analysis			Multivariate analysis		
			Cor	80% CI	P value	AOR	95% CI	P value
Hospital								
Mubende	16 (72.7)	6 (27.3)	Ref					
FRRH	19 (90.5)	2 (9.5)	0.281	0.090-0.872	0.151			
KIU-TH	6 (54.5)	5 (45.5)	2.222	0.826-5.976	0.301			
Jinja	8 (80.0)	2 (20.0)	0.667	0.204-2.179	0.661			
Kiryandongo	5 (83.3)	1 (16.7)	0.533	0.115-2.468	0.599			
HRRH	4 (66.7)	2 (33.3)	1.333	0.375-4.739	0.771			
Residence								
Rural	41 (70.7)	17 (29.3)	Ref					
Urban	17 (94.4)	1 (5.6)	0.142	0.036-0.558	0.068	0.171	0.008-3.581	0.255
Marital status								
Single	49 (94.2)	3 (5.8)	Ref					
Married	5 (38.5)	8 (61.5)	26.133	9.092-75.116	<0.001	1.888	0.068-52.137	0.707
Separated	4 (50.0)	4 (50.0)	16.333	4.998-53.375	0.003	2.312	0.075-58.987	0.901
Widowed	0 (0.0)	3 (100.0)	N/A					
Education level								
Pre School	26 (96.3)	1 (3.7)	Ref					
Nursary	5 (100.0)	0 (0.0)	N/A					
Primary	24 (82.8)	5 (17.2)	5.417	1.271-23.091	0.135	3.424	0.130-90.111	0.461
Secondary	0 (0.0)	11 (100.0)	N/A					
Tertiary	2 (100.0)	0 (0.0)	N/A					
None	0 (0.0)	2 (100.0)	N/A					
Etiology								
Thermal	53 (76.8)	16 (23.2)	Ref					
Chemical	5 (71.4)	2 (28.6)	1.325	0.427-4.113	0.75			
Site								
NMA	53 (81.5)	12 (18.5)	Ref					
MA	5 (45.5)	6 (54.5)	5.300	2.204-12.746	0.015	22.449	1.401-60.666	0.028
Form								
Non circ	49 (77.8)	14 (22.2)	Ref					
Circumfrancial	9 (69.2)	4 (30.8)	1.556	0.657-3.685	0.512			
Pre existing condition								
None	53 (82.8)	11 (17.2)	Ref					
Epilepsy	4 (50.0)	4 (50.0)	4.818	1.771-13.107	0.044	3.782	0.123-96.437	0.447
Malnutrition	1 (50.0)	1 (50.0)	4.818	0.749-30.996	0.279	2.365	0.098-99.765	0.754
Mental D/O	0 (0.0)	1 (100)	N/A					

NMA: A burn site that is not an indication for admission, MA: A burn site mandating admission eg perineal burns, Non Circ: non circumfrancial burn, D/O: Disorder, N/A: not applicable (because odds could not be computed since one of the outcomes was not seen in that category). At bivariate analysis, pre existing condition, Site and marital status had a significant relationship with burn severity. Having Epilepsy increase the risk of having a severe burn by 4.818 times. Having a burn site mandating admission increased risk of having a severe burn by 5.3 times. A separated patient was 16.333 times more likely to have a severe burn compared to one who was single and a married patient was 26.133 times more likely to have a severe burn compared to a single one. The only significant factor at multivariate that was independently associated with severity was site. A patient who had a burn mandating admission was 22.449 times more likely to have a severe burn compared to one that had a burn site not mandating admission (Table 3).

Table 4. The organisms isolated from burn patients in six selected hospitals in Uganda

Site	Combined n (%)	FRRH n	HRRH n	Jinja N	Kiryandongo N	KIU-TH n	Mubende N
None	5 (6.0)	0	0	0	1	1	3
<i>Staphylococcus aureus</i>	38 (45.8)	10	4	7	2	4	11
<i>Pseudomonas spp</i>	13 (15.7)	3	2	2	1	2	3
<i>E. Coli</i>	8 (9.6)	3	1	1	2	1	0
<i>Klebsiella spp</i>	5 (6.0)	3	0	0	0	2	0
<i>Neisseria spp</i>	5 (6.0)	1	0	2	1	0	1
<i>Enterococcus Fecalis</i>	5 (6.0)	1	0	0	0	0	4
<i>Proteus</i>	3 (3.6)	1	0	0	0	1	1
<i>antrobacter spp</i>	1 (1.2)	0	0	1	0	0	0
Total	83	22	7	13	7	11	22

The commonest organism isolated was staphylococcus aureus accounting for 45.2% followed by pseudomonas accounting for 15.5% (Table 4).

mon etiologies according to the study done by Seo et al. in South Korea at the largest burn center in Asia, Angang Sacred Hospital [27]. We did not have patients with electrical burns. Perhaps it's because electricity is limited and it's not available in some rural homes in our setting, which is different from the developed countries where electricity is available to every home and used for almost everything in the kitchen. Because of the high rate of chemical manufacturability in developed countries, chemicals are also common, despite the fact that we had very few of them.

Among patients with thermal burns, the most common etiology was scald (66.7%), followed by flame (27.5%) and contact (5.8%). This finding is similar to the one done in the Douala General Hospital in Cameroon by Fomukong et al. (2019), where most of the burns were due to scalds followed by flame and contact. The same findings were observed by Amouzou et al. (2019) in the retrospective analysis of medical files of burn patients admitted to Sylvanus Olympia Teaching Hospital in Lome, Togo, during seven years. In that study, most burns were due to hot liquid, flames, and contact. In Tanzania, Temu et al. (2008) found that burns were due to high temperature liquids or food and flames from charcoal, lanterns, candles, and kerosene stoves, which is also similar to our findings described above. Odondi et al., (2020) in Kenya found that scald was the most common etiology of burns. This similarity might be explained by the fact that the life style in Cameroon, Tanzania, Togo and Kenya is almost similar to ours in Uganda and the conditions of life and daily habits are almost the same.

As per the second objective, the study aimed at identifying the factors associated with the injury severity of burn patients in six selected hospitals in Uganda. Many variables were investigated, and bivariate analysis revealed statistically significant relationships ($P < 0.2$) among the following variables: Marital status: unlike many other studies, married patients were 26.133 times more likely to have severe burns compared to single people. This is most likely due to the multiple tasks of married people to care for the family and the stress due to multiple factors like financials, parenting concerns, care of household, social responsibility, difficult behavior of the partner, and relationships with former boy or girl friends. Separated patients were 16.333 times more likely to have severe burns compared to singles. This might result from the challenges that a separated person faces while adjusting to the new reality and trying to do things on his/her own. Stress during divorce proceedings, such as the use of family or friend mediation, the amount of court time spent during asset division may expose a separated person to a severe burn.

Patients with burn wounds at the sites that mandated admission were 5.3 more likely to have severe burns compared to those whose wounds were at the sites that don't mandate admission. As reported by Alemayehu and colleagues, in Ethiopia found that the severity of burns depends on the location of the injury; patients who sustained burns on their head, face, and neck were associated with greater injury severity than other parts of the body [1], which is similar to our findings. Kelly and Johnson describe that patients with burns to

Table 5. The susceptibility patterns among patients with burns in six selected hospitals in Uganda

		<i>Staphylococcus aureus</i> N = 39	<i>Pseudomonas</i> SPP N = 13	<i>Klebsiella</i> SPP N = 5	<i>Neisseria</i> SPP N = 5	<i>E. Coli</i> N = 8	<i>Proteus</i> N = 3	<i>antrobacter</i> SPP N = 1	<i>Enterococcus Fecalis</i> N = 5
Imipenem	S	71.8%	46.2%	60.0%	20.0%	100.0%	66.7%	100.0%	40.0%
	I	25.6%	46.2%	40.0%	80.0%	0.0%	0.0%	0.0%	40.0%
	R	2.6%	7.7%	0.0%	0.0%	0.0%	33.3%	0.0%	20.0%
Amikacin	S	28.2%	15.4%	20.0%	100.0%	0.0%	100.0%	0.0%	80.0%
	I	38.5%	61.5%	40.0%	0.0%	100.0%	0.0%	100.0%	0.0%
	R	33.3%	23.1%	40.0%	0.0%	0.0%	0.0%	0.0%	20.0%
Ciprofloxacin	S	25.6%	0.0%	20.0%	20.0%	0.0%	0.0%	0.0%	20.0%
	I	17.9%	53.8%	40.0%	0.0%	25.0%	0.0%	100.0%	0.0%
	R	56.4%	46.2%	40.0%	80.0%	75.0%	100.0%	0.0%	80.0%
Cloxacillin	S	15.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	I	2.6%	7.7%	0.0%	0.0%	0.0%	33.3%	0.0%	0.0%
	R	82.1%	92.3%	100.0%	100.0%	100.0%	66.7%	100.0%	100.0%
Gentamicin	S	7.7%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	40.0%
	I	35.9%	15.4%	40.0%	0.0%	0.0%	66.7%	0.0%	0.0%
	R	56.4%	84.6%	40.0%	100.0%	100.0%	33.3%	100.0%	60.0%
Tri-Sul	S	7.7%	0.0%	0.0%	0.0%	12.5%	0.0%	0.0%	40.0%
	I	7.7%	7.7%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%
	R	84.6%	92.3%	100.0%	80.0%	87.5%	100.0%	100.0%	60.0%
Ceftriaxone	S	5.1%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	40.0%
	I	5.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	R	89.7%	100.0%	100.0%	100.0%	100.0%	0.0%	100.0%	60.0%
Amoxiclav	S	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	I	28.2%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
	R	71.8%	100.0%	100.0%	100.0%	100.0%	0.0%	100.0%	100.0%
Cefixime	S	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	I	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	R	97.4%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Penicillin	S	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	R	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Ampicillin	S	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	R	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Metronidazole	S	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	R	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

S: Sensitive, R: Resistant, I: Intermediate, Tri-Sul: Trimethoprim/Sulfamethoxazole.

the face and those with clinically significant smoke inhalation require proper management due to the severity of the injury [28]. In Iraq, Ja and colleagues suggest that face or neck burns, vibrisa or eyebrow burns should be given priority in management due to their severity and associated complications. The reason could be that those sites are the exposed area of the body and are mostly likely going to be in contact with Burn agent before involvement of other area which are covered with clothes.

Pre-existing conditions; epileptic patients were 4.818 times more likely to have severe burns compared to those who didn't have any preex-

isting condition. In his cross-sectional descriptive study on clinical patterns and early outcomes of burn injuries in patients admitted at the Moi Teaching and Referral Hospital in Eldoret, Kenya, Odondi et al, found similar information; in his study, 16% of epileptic patients were associated with severity and different complications. According to Liet al. (2017), the comorbidity of the patient, including epilepsy at admission, increases the severity of the burn condition. This might be due to the fact that most epileptic patients got burned during the crisis. Being in an unconscious state, the normal defense mechanism and rescue process might not have been initiated.

On multivariate analysis, we found that patients with burn wounds at the sites that mandated admission were 22.449 more likely to have severe burns compared to those whose wounds were at the sites that don't mandate admission. That's similar to the findings of other research as discussed above. This factor has been shown to have a significant impact on severity in both bivariate and multivariate analyses, so its inclusion as a factor associated with injury severity is not insignificant.

Different bacterial microorganisms were identified in 92.1% of the samples. 7.9% didn't manifest the growth of any microorganism. This might be due to the antibiotics they were on for a long time. 10.5% of the patients had two microorganisms isolated, and the second microorganism was *Staphylococcus aureus*. This is in agreement with the study done by Maharjan and colleagues in Nepal in which they came up with the conclusion that bacteria isolated from burn wounds may either be monobacteria or polybacteria [6]. The following microorganisms were isolated: *Staphylococcus aureus* (45.8 %), *Pseudomonas SSP* (15.7%), *E. coli* (9.6%), *Klebsiella ssp* (6%), *Neisseria ssp* (6%), *Enterococcus Faecalis* (6%), *Proteus* (3.6%), and *anterobacter ssp* (1.2%). These bacterial microorganisms were isolated in both wounds less than and more than 24 hours old. This is in agreement with the findings of the study done by Maharjan and colleagues at Golden gate International College in Nepal, South Asia where microorganisms were isolated from burn wounds less than 24 hours old [6]. This might be due to the normal pathophysiology; the destruction of the skin exposes it to microorganisms. When the wound is exposed, the contamination starts, which peaks at a time interval of 5 hours. Though many other studies support that the infection occurs 24, 48, or 72 hours after the destruction of the skin, this difference might be explained by the fact that most of our burn patients were from rural areas where poor hygiene conditions are reported to be a major risk factor for developing early infection in burn wounds but also it could be a function of what was applied as first aid treatment before presentation in the Hospitals.

In our study we were able to isolate both gram negative and positive in burn patients. This is similar to Aljanaby in Iraq, who identified multiple bacterial microorganisms which included

both gram positive and negative even though some of the bacteria isolated were different from ours [29]. Even though Lachiewicz et colleagues found that the first days following burn injury, the inpatients usually have more susceptible gram positives, but later during admission, more resistant gram negatives are isolated [29]. This may be due to the fact that most of our patients didn't come immediately to the hospitals after the trauma. Some passed through health centers where they benefited from antibiotics, others were on auto-medication at home before they came to our hospitals.

From this study, the most common bacterial microorganism isolated from burn wounds was *Staphylococcus aureus*. This is similar to the findings of some studies done in the USA, Germany and chine, and who found that the most commonly isolated specie was *Staphylococcus spp* [25, 26, 28, 30]. The same finding was found in the USA, Germany and Turkey [27, 28], but in the study done in Iraq by Aljanaby found that *P. aeruginosa* was the most common microorganism isolated from burn wounds [29]. In Mumbai india in Masina hospital the most common microorganism isolated was *Klebsiella* [29]. These differences support the idea that the bacterial organisms isolated from burn wounds differ from one region to another.

A dozen antibiotics were used to test the bacterial susceptibility patterns. We found that the microorganisms isolated from burn wounds are resistant to most of the antibiotics commonly used in our set up. The same observation was made by Chen and colleagues in Taiwan in a study on Trends in the microbial profile of burn patients following an event of dust explosion at a tertiary medical center. He found that bacteria isolated were highly resistant to most antimicrobials commonly used in his area [29]. The same findings are similar to the findings of the studies done in india at Masina hospital and in chine and Germany [25, 26, 28]. This might be due to the misuse of antibiotics in our area, where some patients can access drugs, specifically antibiotics, without a prescription from the doctor, but also strong antibiotics are used as first line drugs by some medical personnel.

Staphylococcus aureus was susceptible to imipenem (71.8%), amikacin (28.2%), ciprofloxacin (28.6%), cloxacilin (15.4%), gentamicin (7.7%),

Tri-sul (7.7%), and ceftriaxone (5.1%); intermediate to amoxiclav (28.2%) and cefixime (2.6%); and completely resistant to penicillin, ampicillin, and metronidazole. In his study done in Kufa in Iraq, Aljanaby found that *S. aureus* was highly resistant to most antibiotics, especially amoxicillin + clavulanic acid (20/10 mg) and third-generation cephalosporins [29]. This challenge is multifactorial, like over prescription of antibiotics, not completing the dose prescribed and mutation of the microorganism.

Pseudomonas spp were sensitive to imipenem (46.2%) and amikacin (15.4%); intermediate to ciprofloxacin (53.8%), gentamicin (15.4%), cloxacilin (7.7%) and tri-sul (7.7%) and resistant to the rest of the antibiotics. These findings can be compared to those of Maharjan et al., 2020. They did in Nepal isolate the pseudomonas which was sensitive to piperacine/tazobactam (63.8%), imipenem (59.5%), amikacin (19.1%), ciprofloxacin (17%), gentamicine (17%), etc. This supports the idea that the pseudomonas isolates from burn wounds are sensitive to a good number of antibiotics.

E. coli were sensitive to tri-sul (12.5%), intermediate to ciprofloxacin (25%) and resistant to the rest of the antibiotics used in the study. *Klebsiella* was 60% sensitive to imipenem and 20% to gentamicin, ciprofloxacin, and amikacin and resistant to the remaining antibiotics. *Neisseria* was 20% sensitive to ciprofloxacin and imipenem and resistant to the rest of the antibiotics. The *E. coli*, *klebsiella*, and *Neisseria* identified by Chen and colleagues were resistant to most of the antibiotics he used for susceptibility patterns [23]. This may be due to the change of microorganism's overtime and they are no longer responding to the drugs designed to work on them but also to the misuse of antibiotics in some areas. *E. faecalis* were 80% sensitive to amikacin, 40% to gentamicin, imipenem, ceftriaxone, and tri-sul, and 20% to ciprofloxacin. Resistant to the remaining Unlike our study, Maharjan et al., 2020, done in Nepal, found that the *E. faecalis* isolated from burn wounds was sensitive to a good number of the antibiotics he used [6]. *Proteus* was sensitive to imipenem (66.7%), intermediate to gentamicin (66.7%) and cloxacilin (33.3%) and resistant to the remaining compounds on our list. *Anterobacter* was isolated from one patient and it was resistant to the dozens of antibiotics used in our study. It might be difficult to draw

conclusions about this microorganism as one case might not give valid information.

Conclusions

Burns can occur in both adults and children, and while there are a number of potential causes, thermal, specifically scalding, is by far the most prevalent in our region. Sites that mandate admission were the factors predicting the severity of the injury. Burned patients are at risk of developing a variety of infections. *Staphylococcus aureus* and *pseudomonas spp.* were the most often isolated microorganisms. Despite that identified bacteria were resistant to most of antibiotics, good number of them were sensitive to imipenem, amikacin, ciprofloxacin and cloxacilin.

Disclosure of conflict of interest

None.

Address correspondence to: Byamungu Pahari Kagenderezo, Department of Surgery, Faculty of Clinical Medicine and Dentistry, Kampala International University, Western Campus, Ishaka, Uganda. E-mail: byamungupk@yahoo.fr

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Appendix 1

ABSI Score

Parameters	Finding	Points
Sex	Female	1
	Male	0
Age (Years)	0-20	1
	21-40	2
	41-60	3
	61-80	4
	81-100	5
Inhalation Injury	Yes	1
	No	0
Presence of full-thickness burn	Yes	1
	No	0
BSA burns (%)	1-10	1
	11-20	2
	21-30	3
	31-40	4
	41-50	5
	51-60	6
	61-70	7
	71-80	8
	81-90	9
	91-100	10

ABSI score and predictors

Treat to life	ABSI	Probability of survival
Very low	2-3	≥99
Moderate	4-5	98
Moderately severe	6-7	80-90
Serious	8-9	50-70
Severe	10-11	20-40
Maximum	≥12	≤10

Appendix 2

Questionnaire

Topic: Etiology, injury severity and bacterial pathogens in burns wounds at KIU-THs.

I. Burn Patient

1. Initials (Use first letters and not the complete Name).....
2. Date of Admission: Date.....Month.....Year.....
3. Sex ☐ Female ☐ Male ☐
4. Age.....
5. Residence: Rural ☐ Urban ☐
6. Marital status: Single ☐ Married ☐ Divorced ☐ Separated ☐ Widowed ☐
7. Religion: Protestant Catholic ☐ Muslim ☐ Jehovah witness ☐
Born again ☐ Others.....
8. Education level: Primary ☐ Secondary ☐ Tertiary/University ☐

II. Etiological Factors

1. Thermal: Flame ☐ Scald ☐ Heat Contact ☐ Others.....
2. Chemical: Gaz ☐ Liquid ☐ Others.....
3. Radiation: Ultraviolet ☐ Ionised ☐ Others.....
4. Cold/frost bite:.....
5. Electrical:.....
6. Others.....

III. Clinical Factors

1. Size (TBSA in %).....
2. Depth: Superficial ☐ Superficial partial ☐ Full thickness ☐ Others.....
3. Sites: Mandating admission ☐ Non mandating admission ☐
4. Form: Circumferential ☐ None Circumferential ☐ Others.....
5. Time since injury.....
6. Drugs received before consultation.....
7. Application of herbs or other substance.....

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8. Preexisting conditions: Epilepsy ☐ Malnutrition ☐ Peripheral neuropathies ☐

Physicals and cognitive disabilities (Yes ☐ No ☐)

If yes mention it.....

IV. ABSI Score results

Treat to life	ABSI	Tick bellow in this quadrant
Very low	2-3	
Moderate	4-5	
Moderately severe	6-7	
Serious	8-9	
Severe	10-11	
Maximum	≥12	

V. Culture

1. Identified microorganisms.....

.....

2. Sensitive to.....

.....

3. Intermediate to.....

.....

4. Resistent to.....

.....

Appendix 3

Laboratory techniques

Sample analysis

Sample inoculation: Collected samples were inoculated on Blood agar, Chocolate agar and MacConkey's agar. This was done with a wire loop sterilized by red hot method over a Bunsen burner. The sample was streaked over the surface of the medium in zig zag pattern for discrete colonies. Inoculated plate was incubated at 37°C inside incubator with chocolate agar plate placed in a candle jar to obtain 10% CO₂.

Identification procedures

Cultural characteristics: After 18-24 hours of incubation, all media were observed for the colonies appearance. On blood agar, a dome shaped and glistening area of green discoloration around them was recorded as alpha hemolysis while clearing of red blood cells around the colonies was recorded as beta-haemolysis. Other observations such as colour, shape, texture and size of colonies will be recorded.

Morphological identification (Gram stain)

A sterile wire loop sterilized over a Bunsen burner flame to red hot was used to make thin smear on the center of a clean, grease free dried slide mixing with a drop of normal saline. The smear was allowed to air dry, fixed by passing the beneath of the slide over a Bunsen burner flame. This was done as described by Cheesbrough (2006). Crystal violet, Lugol's iodine, 50% acetone alcohol and neutral red were used to stain all slide made each for 60 seconds and washing with clean water in between each staining reagent. After staining, the slide was allowed to air dry and bacteria morphology and arrangement was observed with the use of a microscope. Morphology and gram's staining reactions were recorded as gram negative rods, cocci and also the arrangement as cocci in pairs, chains or clusters. The bacteria that stains purple/blue were recorded as gram positive while those that will stain red/pink were recorded as gram negative bacteria.

Biochemical tests

Gram staining reaction and morphology of bacteria, were determined as first step towards bacteria identification test using biochemical reagents and medium.

Catalase test according to Cheesbrough (2006)

Catalase test was done to differentiate between *Staphylococcus* sp. and *Streptococcus* sp. The Catalase test is based on the ability of the bacteria to produce the enzyme catalase that breaks down hydrogen peroxide (H₂O₂) into H₂O and O₂ when mixed with 3% hydrogen peroxide. A disposable applicator loop was used to pick colony from chocolate agar plate and place it on a glass slide. 1.0 ml of 3% H₂O₂ will be added to the slide and mixed with the colonies. The suspension was observed immediately for bubbles. The absence of bubbles indicates *Streptococcus* species while the presence of bubbles indicates *Staphylococcus* species.

Mannitol Salt (MSA) Agar

This tested for the bacteria's ability to tolerate 7% salt concentration and ferment Mannitol. The media is selective because it selects for salt tolerant bacteria. Such as *Staphylococcus* species. It was done following results of catalase test for the confirmation of *Staphylococcus aureus*. A plate of MSA will be inoculated with a discrete colony of the test organism using a sterile wire loop by a streak plate method and incubated at 24-48 hours. If the organism was tolerant to salt it grew. If the organism was not tolerant to salt, it will not grow. If the salt tolerant organism fermented Mannitol, then there would be yellow zones around the colonies. If the salt tolerant organism did not ferment Mannitol, then the media remained pink and is not *Staphylococcus aureus*.

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Indole test

Indole test was performed to determine the ability of the organism to split the tryptophan molecule into indole as described by (Varghese & Joy, 2016). A broth (peptone water) was inoculated with the test organism and incubated at 37°C for 18 to 24 hours. After incubation, fifteen (15 drops) of freshly prepared Kovac's reagent were added down the inner wall of the tube. A development of bright red ring colour at the interface of the reagent and the broth within seconds was indicative of positive indole reaction and where there is no formation of red-ring colour, it was considered a negative test for indole test. *Escherichia coli* is indole positive while *Klebsiella* sp. is indole negative.

Simon's citrate test

The simon's citrate media assisted in the identification of *Enterobacteriaceae* organisms as described by (Varghese & Joy, 2016). The test principle is based on the ability of an organism to use citrate as its only source of carbon and ammonia as its only source of nitrogen. The procedure involved stabbing the butt and streaking the inoculum over the slant of sterile Simmon's citrate agar in a tube and incubating at 35-37°C for 24-48 hours. A growth on the slant and change in colour from green to blue of the medium is indicative of a positive result. *Klebsiella* sp. is citrate positive while *Escherichia coli* is citrate negative.

Urease test

The urease test was done to determine the bacteria's ability to hydrolyze urea to make ammonia using the enzyme urease as described by (Varghese & Joy, 2016). It was done by inoculating the organism in a urea media prepared in bijou bottle. A sterile straight wire was used to incubate the bacteria and incubate at 37°C for 18-24 hours. After incubation, the urea media which is yellow-orange color will turn bright pink colour in the presence of ammonia indicating a positive reaction and where there is no colour change of the media; it will indicate a negative reaction.

Triple Sugar Iron (TSI) agar

The TSI agar will be use to aid the identification and differentiation of *Enterobacteriaceae* for sugar fermentation, gas production and H₂S production as describe in (Varghese & Joy, 2016). A sterile straight wire was used to pick colonies and inoculate by stabbing in TSI medium butt then, streak on the slant. The cap was closed loosely and incubated at 35-37°C for 18-24 hours.

The medium which was all red in colour was after 18-24 hours was recorded as Alkaline indicated by (K/K) no acid production. Medium with acid production will be recorded as (A/A) which indicate fermentation of glucose, lactose and sucrose with gas production. Blackening of the medium indicated hydrogen sulphide production. A standard chart was used for the differentiation of the enterobacteriaceae.

Oxidase test

A filter paper soaked with the substrate tetramethyl-p-phenylenediaminedihydrochloride was moistened with sterile distilled water. Using a glass rod, a colony of the test organism was smeared on the filter paper. The development of a blue-purple color within ten seconds was indicative of positive test while absence of blue-purple color after ten seconds was considered a negative oxidase test. *Pseudomonas aeruginosa* is strong oxidase positive (Cheesbrough, 2006).

Antimicrobial susceptibility profiling

Antibiotic susceptibility testing was done by disc diffusion modified Kirby-Bauer's method on Mueller Hinton agar. The following antibiotics were used Cloxacillin (30 µg), Imipenem (10 µg), ciprofloxacin (5 µg), Amikacin (30 µg), Ceftriaxone (30 µg), Gentamicin (30 µg), Trimethoprim/Sulfamethoxazole (25 µg), Amoxicillin-clavulanic acid (30 µg), Penicillin (10 µg), Ampicillin (10 µg), Cefixime (30 µg) and metronidazole (30 µg).

Injury severity and bacterial susceptibility patterns among burn patients

Cheesbrough (2006)

With the help of a sterile wire loop, colonies will be picked from primary culture plate to make a suspension of the test organism in a sterile nutrient broth and compare the turbidity with McFarland standard. The surface of the Muller Hinton agar was swabbed using a sterile swab by rotating the plate approximately 60° to ensure even distribution on all surface. Antibiotics discs were placed on the inoculated media and incubate at 37°C for 18-24 hours. After 18-24 hours, the zone of inhibition was measured in mm using a ruler and compare with a standard chart to determine the resistant, intermediate and susceptibility of the bacterial to the antibiotics disc.