Epidemiology and antibiotic choice in hand infections requiring surgical drainage: a retrospective study of 414 cases

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Abstract

Background

Hand infections are exceedingly common conditions that are associated with significant morbidity. Sound anatomical and microbiological knowledge is required to effectively manage these entities and to prevent or limit disability. The cornerstones of treatment remain surgical drainage of pus collections, judicious use of antimicrobial agents, and rehabilitation. Empiric antibiotic guidelines should target common organisms based on regional aetiological patterns, with strong consideration of host factors. The aim of this study was, therefore, to evaluate the epidemiology and suitability of empiric antibiotics in hand infections requiring surgical drainage at a centre in the Northern Cape province of South Africa.

Methods

A retrospective chart review of patients with hand infections requiring surgical drainage was conducted over a 24-month period between 1 January 2018 and 31 December 2019. The data was collected at an institution in the Northern Cape, which serves as the referral centre for the majority of the rural areas in the province. Culture results were obtained from the specimens collected during surgical drainage and debridement, and were accessed from the National Health Laboratory Service (NHLS) website.

Results

Of the 414 specimens, 388 yielded positive cultures and 26 had no growth. In total, 403 organisms were cultured. This consisted of 374 Gram-positive organisms (93%), and 29 Gram-negative organisms (7%). *Staphylococcus* was the most common organism isolated in 368 cases. Three-hundred and forty (84%) of these were methicillin-sensitive *Staphylococcus aureus* (MSSA), and 24 (6%) were methicillin-resistant *Staphylococcus aureus* (MRSA). With the low rates of MRSA cultured, caution should be exercised when generalising these results for the population. The mean age of patients was 31 years 10 months (standard deviation 14 years 5 months), with a 4:1 ratio of males to females, and the most common site of infection was the webspace (27%).

Conclusion

Staphylococcus is still overwhelmingly the most common causative organism in hand infections in this population. Low numbers of MRSA were detected, but this still represents a five-fold increase in the region over the past decade. Urgent surgical drainage and bacteriological sampling before empiric antibiotics that target local common organisms remains the mainstay of treatment. Consultation with an infectious disease specialist to maximise efficacy of antibiotic selection and dosing can limit the growing problem of antibiotic resistance. In this setting, the use of cloxacillin as a single empiric agent is still recommended, though the increasing prevalence of MRSA needs to be monitored.

Level of evidence: Level 3

Keywords: hand infections, antibiotics, epidemiology, retrospective review

Introduction

Infections of the hand and fingers are common conditions and require intricate anatomical and microbiological knowledge to effectively treat these potentially devastating conditions.[1] They are associated with significant morbidity such as stiffness, loss of function, deformity and amputation.[2,3] Prompt recognition and expeditious treatment is of paramount importance to mitigate the risk of permanent disability.[3] A high index of suspicion with aggressive medical and surgical therapy is recommended to establish early control of the infection.[4] It has been well established that the cornerstones of effective management include surgical incision and drainage of collections, appropriate antibiotic therapy and rehabilitation therapy.[2] Additionally, the importance of initial immobilisation and oedema control followed by early mobilisation cannot be overemphasised.[1,3,5] However, the diagnosis may be challenging, as some hand infections may mimic other common conditions such as crystal deposit disease (gout and pseudogout), and viral infections such as herpetic whitlow, due to similar clinical presentations.[2,4,6]

Types of hand infections include cellulitis, superficial abscesses, deep abscesses, septic arthritis, osteomyelitis and necrotising fasciitis.[1,4] Deep abscesses involve compartments of the hand such as the tendon sheath, webspace, midpalmar space, thenar space and hypothenar space.[7] The most common causative organism remains methicillin-sensitive *Staphylococcus aureus* (MSSA), but the prevalence of community-acquired methicillin-resistant *Staphylococcus aureus (*MRSA) has continued to increase over the past few decades.[1,2,4,8] Host risk factors for MRSA include recent antibiotic exposure, exposure to medical environments, crowded living conditions, extremes of age, immunosuppression and athletes involved in contact sports or who share equipment.[8] *Streptococcus* species, polymicrobial infections, Gram-negative bacteria (GNB) and viruses are also commonly reported aetiological agents.[1,4] Fungal and atypical mycobacterial infections are described, though fortunately less frequently, as they are challenging to diagnose and treat.[1] The selection of treatment for hand infections is becoming increasingly troublesome due to increasing antibiotic resistance and the increased virulence of organisms.[4] This challenge is often exacerbated by a delay in presentation due to the fact that many of these patients are manual labourers in low-resource settings with limited access to healthcare services and poor sanitary conditions.[4,6] Additionally, there is a perceived low rate of follow-up at the local clinics for wound care and review of the culture results with antibiotic sensitivities. It is thus essential for the treating clinician and surgeon to have a good knowledge of local microbiological and resistance patterns, so that effective empiric antibiotic therapy may be started timeously while awaiting cultures and sensitivities after surgical intervention, or in low-resource settings where microbiological studies are not possible.[9]

The aim of this study was to evaluate the suitability of local empiric antibiotic guidelines by analysing the antibiotic sensitivities of the common causative organisms of hand infections in the Northern Cape, South Africa. The secondary objective was to evaluate the epidemiology of patients presenting with hand abscesses with regard to age, sex and site of infection.

Methods

The data was collected at an institute in the Northern Cape province of South Africa, which serves as the referral centre for the majority of the rural areas in the province. The manual register kept by Orthopaedics was used to identify the patients, and a retrospective review of the charts with hand infections was conducted over a 24-month period between 1 January 2018 and 31 December 2019. Inclusion criteria were patients presenting with hand infections requiring surgical drainage, with specimens sent for microscopy, culture and sensitivity testing.

Patients were excluded if they had missing specimens, incomplete demographic data, required debridements by non-orthopaedic disciplines or, if they had underlying fractures. Data collected from patient records included date of presentation, age, sex, folder number and type of hand abscess. Culture results were obtained from the specimens collected during surgical drainage and debridement and were accessed from the National Health Laboratory Service (NHLS) website. The culture results and antibiotic sensitivities were recorded on a Microsoft Excel database without patient names or folder numbers to maintain anonymity. If multiple organisms were cultured on a single specimen, each organism was considered as a separate entity to allow analysis of the antibiotic susceptibility. If patients presented more than once on different dates and had hand infections with new samples sent for analysis, they were also regarded as separate entities. All information was stored electronically and hosted at the main study centre. Ethical approval was obtained from a local review board (UFS-HSD2021/1971/2709). IBM SPSS Statistics version 28.0.1.0 (142) software was used for statistical analysis.

Results

Over the study period, 534 microbe samples were identified from 513 patients. Four patients had a second microbial sample taken over the two years and one patient had two additional samples taken. Fifteen patients produced two microbe samples from single specimens. Of the 534 microbe samples identified, 105 were not eligible for inclusion due to incomplete patient records and were excluded. This left 429 microbe samples for analysis in the study of 414 patients.

Of these 414 patients, 79% (328) were male and 21% (86) were female. Of the 414 specimens, 388 yielded positive results (94%), with 15 specimens growing two organisms each

Twenty-six samples (6%) showed no growth (*Figure 1*). The majority of cases with positive cultures were between the ages of 21 and 40 years (60%), with a modal peak in the age group of 26–30 years for males (22%) and 41–45 years for females (15%). The mean age of all patients was 31.8 (range 8 months to 83 years), with standard deviation 14.4 years.

Organism distribution

A total of 403 organisms were cultured from the 388 specimens that yielded positive results, with multiple organisms identified on 15 specimens (4% of the total 414 samples). Of the 403 cultured organisms, 374 were Gram-positive organisms (93%) and 29 were Gram-negative organisms (7%). *Staphylococcus* was the most frequently cultured organism in 368 (91%) of the 403 organisms cultured, with MRSA represented in 24 (6%) cases. Of the 29 GNB (7%), ten *Klebsiella pneumoniae* (3%) and six *Proteus* species (3%) were the most common organisms. The others were enteric organisms, including four *Citrobacter spp*. (1%), two *Enterobacter spp*. (1%), two *Escherichia coli* (1%), two *Klebsiella oxytoca* (1%), one *Morganella morganii* (0.3%) and one *Sphingomonas spp*. (0.3%). The single *Pseudomonas aeruginosa* (0.3%) cultured was from a flexor tenosynovitis.

Males were more likely to have MSSA infections compared to females (83% vs 71%), but the incidence of MRSA infections was the same between males and females (6%). Females had higher rates of *Klebsiella pneumoniae* (6% vs 1%) and *Proteus mirabilis* (2% vs 1%) infections versus males. The graph in *Figure 2* demonstrates a seasonal relationship with hand infections, peaking during the summer months with proportionally lower amount during the winter months. During this two-year period, 32 (8%) of the total

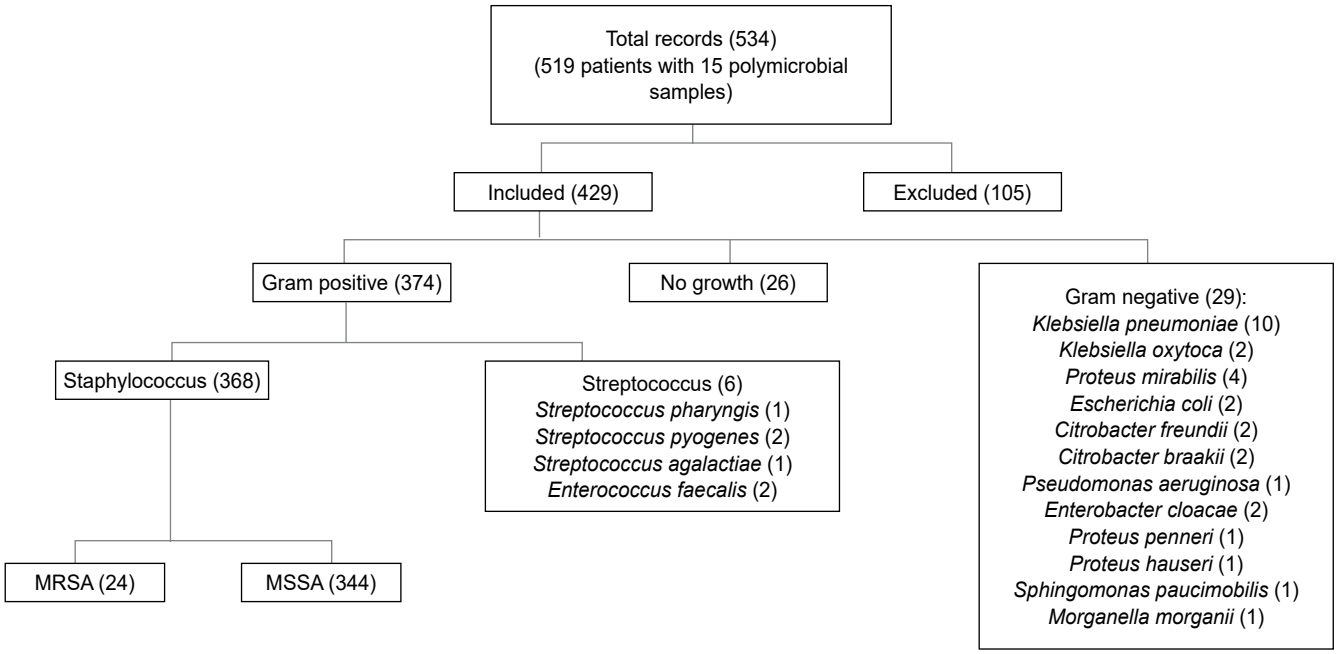

Figure 1. Line chart showing sorting of data

positive cultures occurred during the summer month of January 2019. Only seven (2%) of the total positive cultures occurred in the winter months of May 2018 and June 2019 respectively. The temporal distribution of positive MSSA cultures mirrored this seasonal pattern.

Site of infection

Webspace abscesses were the most common presentation with 112 cases (27%), followed by felons with 101 cases (24%), while abscesses in the hypothenar space represented six (0.2%), which were the least common (*Table I*). When analysing the distribution of culture site within each sex, paronychias were three times more likely in females (14% vs 5%) while webspace abscesses occurred more frequently in males (29% vs 20%).

Sensitivities

Organism-appropriate treatment antibiotics were tested on the cultured organisms. Results were displayed as either sensitive, intermediate or resistant. *Table II* summarises the sensitivity of MSSA and MRSA to the most frequently administered antibiotics. MSSA was shown to be sensitive to cloxacillin at 342 of 342 (100%), erythromycin/azithromycin at 334 of 342 (98%), clindamycin at 334 of 342 (98 %). It was substantially less susceptible to trimethoprim-sulfamethoxazole (29%) and penicillin/ampicillin (25%). MRSA was 100% sensitive to clindamycin, erythromycin/azithromycin and vancomycin at 24 of 24, but 100% resistant to penicillin/ampicillin, and 75% (18 of 24) to trimethoprim-sulfamethoxazole.

GNB were uncommon, occurring in only 29 (7%) of the 403 cultures (*Table III*). Of these, 27 were enteric organisms, and all of these were sensitive to ciprofloxacin and ertapenem. Extended spectrum resistance was present in three of these organisms in the enteric group, but were still sensitive to ertapenem and ciprofloxacin. The *Sphingomonas* was sensitive to ciprofloxacin. One *Pseudomonas aeruginosa* was cultured and had intermediate susceptibility to ciprofloxacin, but was sensitive to piperacillin-tazobactam.

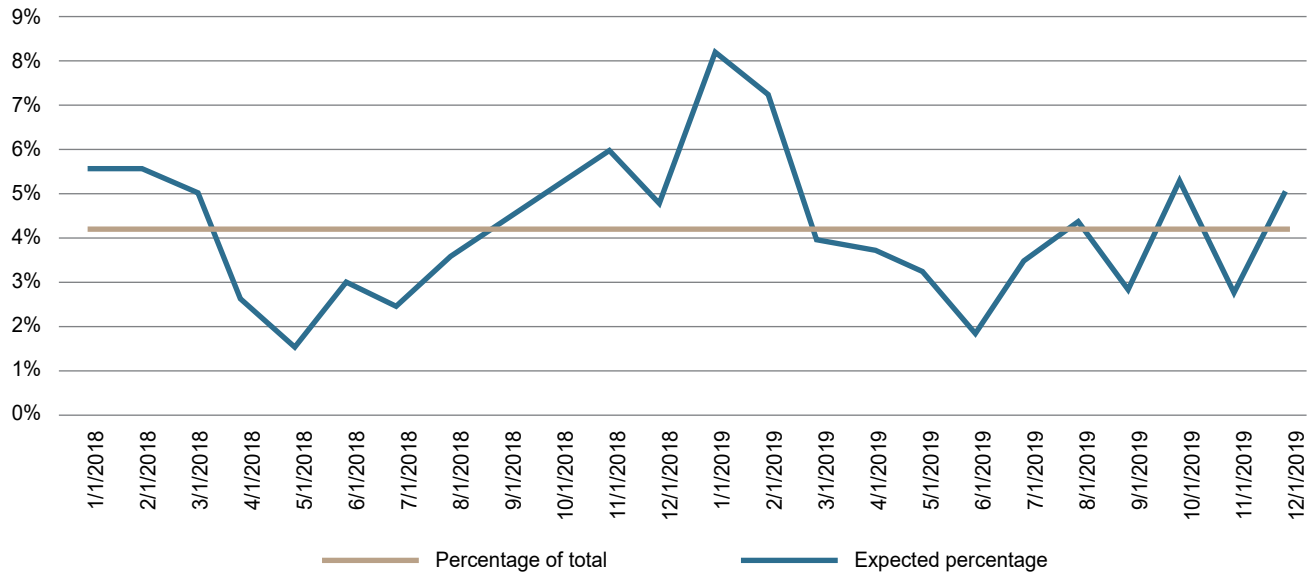

Figure 2. Percentage of total bacteria cultured per month

Table I: Distribution of culture site by sex

Site		Female	Male	Total
Webspace	Count	17	95	112
	% of total	4%	23%	27%
Felon	Count	23	78	101
	% of total	6%	19%	24%
Unspecified	Count	14	83	97
	% of total	3%	20%	23%
Paronychia	Count	12	15	27
	% of total	3%	4%	7%
Tenosynovitis	Count	8	19	27
	% of total	2%	5%	7%
Palmar	Count	6	20	26
	% of total	1%	5%	6%
Thenar	Count	5	13	18
	% of total	1%	3%	4%
Hypothenar	Count	1	5	6
	% of total	0.2%	1%	1%
Total	**Count**	**86**	**328**	**414**
	% of total	**21%**	**79%**	**100%**

Table II: Drug sensitivities of MSSA and MRSA

Drug	Susceptibility percentages and counts	
	MSSA (n = 342)	MRSA (n = 24)
Erythromycin/azithromycin	98% (334 /342)	100% (24/24)
Clindamycin	98% (334 /342)	100% (24/24)
Vancomycin	100% (342/342)	100% (24/24)
Cloxacillin	100% (342/342)	0% (0/24)
Trimethoprim-sulfamethoxazole	29% (98/339)	25% (6/24)
Penicillin/ampicillin	25% (83/339)	0% (0/24)

Discussion

Patients

This review of the records of 414 cases represents one of the larger retrospective reviews on the epidemiology and aetiology of hand infections in the current literature. In this population, there was a higher proportion of males to females of 4:1 (79% vs 21%), compared to most studies where the ratio of men to women is approximately 2:1.[6,10-13] The mean age of 31.8 years (median 30 years) in this cohort was also significantly younger than most patients in other studies, where the mean or median ages were between 40 and 50 years.[6,10-13] These differences may be attributable to multiple factors, including the high populations of male manual labourers, the large agrarian sector in the area, the heavy burden of intravenous drug users in this setting, and the incredibly high burden of HIV disease in South Africa, of which the prevalence in the Northern Cape was 8.3% in 2017.[4,14] The discrepancy in sex may be attributable to the tendency of women to present earlier for care, when the hand infections may be amenable to treatment with antibiotics and conservative wound management, without in-hospital surgical intervention.[15] Patients most commonly presented with webspace abscesses in 27% of cases, with paronychias in only 7% of cases. This is different from other publications, in which the most common reported hand infection is often a paronychia. The difference may be because there was a high rate of unspecified location of infection in this study (23%), and the fact that paronychias can often be managed conservatively with warm/cold compression and oral antibiotics, or can be surgically drained at primary healthcare facilities.[2]

Characteristics of infections

The positive culture rate in this study was 94%, with rates in the literature varying from as low as 30% as reported by Fowler and Ilyas, and up to 90% as reported by Trionfo et al. despite preoperative antibiotic use.[6,10,16] However, the low rates reported by Fowler and Ilyas may be due the inclusion of open wounds in their study.[10] A retrospective review of 470 patients by Dutton et al. found a 95% positive culture rate in patients who had not received antibiotics before surgical drainage and specimen collection, whereas patients who received preoperative antibiotics had a significantly lower positive culture rate of 81%.[13] This finding is in keeping with the recommendation that antibiotics should be given after correct specimens for culture have been obtained, whenever feasible.[1]

The increase of MRSA as an aetiological agent for hand infections has been widely described in the literature, with rates of up to 78% of cultures growing MRSA in certain studies.[1,2,4,17-19] Concordantly, the prevalence of MSSA in hand infections appears to be decreasing internationally, with rates as low as 13.5% in 2005.[19,20] This change in the pattern of organism distribution, appears to be most prominent in urban settings, and reflects antibiotic use in these areas.[10] However, in this study, MSSA was found in 342 of the 403 organisms grown (85%) in positive cultures, and MRSA

Table III: Gram-negative organisms and sensitivities

Gram-negative organisms	Number and %	Ceftriaxone sensitive	Ertapenem sensitive	Ciprofloxacin sensitive	Resistance to cephalosporins
Citrobacter spp.	4 (14%)	1	4	4	3
Enterobacter spp.	2 (7%)	0	2	2	2
Escherichia coli	2 (7%)	2	2	2	0
Klebsiella oxytoca	2 (7%)	2	2	2	0
Klebsiella pneumoniae	10 (35%)	10	10	10	0
Proteus spp.	6 (217%)	4	6	6	2
Morganella spp.	1 (3%)	1	1	1	0
Sphingomonas spp.	1 (3%)	0	0	1	1
Pseudomonas aeruginosa	1 (3%)	0	0	0	1
Total	**29**	**20**	**27**	**28**	**9**

spp. = species

only in 24 of 403 organisms (6%). This data is more consistent with a study by Greyling et al. at a tertiary centre in Bloemfontein, a region close to the study centre, which found MSSA in 82% of cases and MRSA in only 1% of cases.[5] Although the prevalence of MRSA in this study is still low at 6%, this should be monitored as an increasing prevalence will affect the empiric antibiotic choice in the future. The low prevalence of MRSA in this study may be due to the large proportion of patients referred from rural settings, in contrast to the heavy burden of community-acquired MRSA in urban areas where exposure to healthcare facilities and possible antibiotic exposure would be higher.[19,21]

The MSSA cases (342) were sensitive to cloxacillin in 100% of cases as per definition, as well as 100% sensitive to vancomycin, but only 98% sensitive to both clindamycin and erythromycin/azithromycin. As MSSA was overwhelmingly the most commonly cultured organism in 85% (342 of 403) of cases, the routine use of cloxacillin as a single empiric antibiotic is recommended in this setting.

The MRSA cases (24) were 100% sensitive to erythromycin/azithromycin, clindamycin and vancomycin. The sample size of 24 for the MRSA cultures is too small to generalise to the broader population. However, the results are still of value to monitor the trend of MRSA incidence and antibiotic susceptibility. Widespread use of amoxicillin/penicillin for respiratory tract infections and trimethoprim-sulfamethoxazole for HIV prophylaxis in the community makes resistance to them more likely, and they should not be used empirically until susceptibility results confirm susceptibility.[22] Clindamycin should still be used in patients with penicillin allergies in this setting, despite other authors reporting increases of MRSA resistant to clindamycin, until the data shows otherwise.[2] Long-acting lipoglycopeptides such as dalbavancin may offer an alternative to oral agents where adherence may be problematic in MRSA cases, so that patients can be discharged when no longer requiring intravenous (IV) antibiotics or observation in hospital.[23]

The infections caused by GNB in 29 of the 403 (7.2%) cases were more frequent in females and older patients. *Klebsiella pneumoniae* (10) (35%) was the most common GNB, followed by *Proteus spp*. (6) (21%), *Citrobacter spp*. (4) (14%), *Klebsiella oxytoca* (2*)* (7%)*, Enterobacter spp*. (2) (7%) and *Escherichia coli* (2) (7%). Only three of these organisms (one *Citrobacter* [3%] and two *Enterobacter* [7%]) were extended spectrum beta-lactamase producers, but early identification of GNB would be useful to modify treatment, as cloxacillin and macrolide antibiotics would be ineffective. Therefore, it is important to be aware of the risk of inadequate antibiotic cover for these organisms if only Gram-positive cover is used, but the surgical drainage remains the primary treatment.

The *Pseudomonas aeruginosa* was cultured from a patient with flexor tenosynovitis, and it was found to have intermediate susceptibility to ciprofloxacin. It was susceptible to the piperacillin-tazobactam combination which required IV therapy, and thorough surgical debridement was performed to remove any nidus of ongoing infection. Choice of antibiotics for these organisms should be guided by pharmacokinetic properties and susceptibility results, but ciprofloxacin seems to be a suitable empiric choice for patients at risk of having GNB as the cause of their hand infections. These risk factors include immunocompromised states, diabetes mellitus, and crush or blast injuries of the hand sustained in moist and contaminated environments that become complicated with infection.[4]

Infections caused by *Streptococcus* species (including *Enterococcus*) represented less than 1% of cultures, a prevalence lower than what is reported in other studies.[5,6] Polymicrobial infections were detected in 15 of the 414 specimens (5%), which is also significantly lower than the rate of 11.7% reported by Houshian et al. in their retrospective review of 418 patients, and the rates of 63.5% and 85% reported by Stern et al. and Dellinger et al. respectively.[6,24,25] *Streptococcus pyogenes* is known to be associated with necrotising fasciitis and is virulent; however, in the two cases represented in this series, one resulted in a webspace infection and the other was unspecified.

There were significantly more hand infections in the summer months than in the winter months. This was possibly due to a decrease in agricultural activities during the winter season, decreased soil microbial biomass during the winter to spring transition, and gloves being worn for warmth with a mechanical protective barrier effect.[26]

Culture and directed therapy is essential, as predicting susceptibility is more challenging with the ongoing emergence of resistance. The *Klebsiella* and *Proteus spp.* were still susceptible to ciprofloxacin and ceftriaxone during this period, providing a reasonable option for empiric treatment when risk factors for these pathogens can be identified before culture results are available.

Institutional antibiotic guidelines

Patients presenting to this institution with hand infections requiring surgical drainage are routinely started on a combination of cloxacillin 1 g intravenously six hourly and azithromycin 500 mg intravenously daily based on unpublished audits previously conducted in the region. Patients are discharged on oral flucloxacillin and oral azithromycin if in-hospital wound reviews are satisfactory. Clindamycin is used as a single antibiotic for patients with penicillin allergies, and has antibiotic cover for both MSSA and MRSA. Based on the results of this study, the routine use of a macrolide such as azithromycin in combination with cloxacillin combination is unnecessary and may potentiate the growing problem of antibiotic resistance. However, if cellulitis or sepsis are present, the adjunctive use of protein synthesis inhibitory antibiotics such as clindamycin, linezolid or macrolides may be indicated to suppress toxin production.[27] The Centers for Disease Control and Prevention has recommended that empiric antibiotics should only include agents for MRSA in regions where the prevalence is more than 10–15%, a rate significantly higher than found in this study.[28,29]

This study was a retrospective chart review and carries the inherent shortcomings of such a design. Furthermore, it was not noted if antibiotics were given before specimen collection, which has been shown to affect culture yield.[13] The chronicity of the infections were not documented, nor was the time to presentation, or specific causes of infection such as human or animal bite wounds, which have different bacteriology.[30] The site of infection was not documented in 24% of cases, which may distort the true reflection of the most common types of hand abscesses in this study.

Patient comorbidities were frequently not documented and thus not included, and patients with certain conditions such as HIV, diabetes mellitus, rheumatological conditions and patients on immunosuppressive therapy, are known to be at risk for a spectrum of organisms in hand infections.[2,5] Not all antibiotic sensitivities are reported for every organism cultured, due to the spectrum of activity being different for each specific organism. It should be noted that the culture results in this study cannot be generalised to other settings, as organism distribution and sensitivity patterns may differ based on location.

Conclusion

Staphylococcus is overwhelmingly the most common causative organism in hand infections in this population. The vast majority were MSSA, but despite the low numbers of MRSA that were detected, this still represents an almost five-fold increase in the

region over the past decade, and it represents the second most common organism in this study. *Klebsiella pneumoniae* was found to be the third most commonly cultured organism, followed by other enteric organisms, and surprisingly *Streptococcus* species were infrequently cultured. The authors recommend that other large centres conduct similar studies to monitor the increasing prevalence of MRSA, and to assess the appropriateness of their empiric antibiotic guidelines in order to avoid potentiating antibiotic resistance.

Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.
Prior to commencement of the study, ethical approval was obtained from the University of the Free State Ethics Committee (UFS-HSD2021/1971/2709).
All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed written consent was not obtained from all patients for being included in the study as the data was anonymised and the study is retrospective in nature.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

LW: study conceptualisation, study design, data collection, first draft preparation
WS: first draft preparation, manuscript revision
LF: data capture and analytics
EE: manuscript conceptualisation

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