PLASTIC AND RECONSTRUCTIVE SURGERY

Royal Australasian College of Surgeons

Is tropical pus in the hand special? A retrospective study comparing hand infection cases in Darwin and Adelaide

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Key words
Hand infections, Northern Territory, plastic and reconstructive surgery.

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Accepted for publication 29 December 2023.

doi: 10.1111/ans.18864

Abstract

Background: Hand infections are a common reason for presenting to hospital and can be associated with significant morbidity and prolonged antibiotic use. Factors recognized to influence patient outcomes include resistant organisms and delayed presentation. Surgeons working around Australia may assume that hand infections and appropriate treatment algorithms will be similar between sites. This is the first study to examine differences between hand infections presenting in Darwin (with its tropical climate) *vs.* those in a more temperate city (Adelaide).
Methods: This is a two-site retrospective study, where diagnostic discharge codes were used to identify cases for a 12-month period and patient age, sex and rurality, duration of hospital stay, microbiology results and subsequent trips to theatre were reviewed.
Results: Despite significant differences in rurality between FMC and RDH patients, there was no significant difference in length of hospital stay, duration of intravenous antibiotics or return trips to theatre across the two sites. RDH reported a 25% rate of MRSA, compared to 18% at FMC, as well as a statistically significant increase in uncommon microbes, with 30% compared to 12% of patients growing microbes that may not be covered by antibiotics routinely administered in metropolitan areas. A limitation of this study was that compliance with antibiotics and hospital stay were not accounted for.
Conclusion: It is often our training years that determine our norms of everyday practice, but fewer Australian surgical training posts are located in tropical centres. The results of this study highlight the importance of not assuming that the spectrum of organisms causing hand infections are the same as that in the surgeons' state of origin.

Introduction

Hand infections are a common cause of presentation to hospital and often result from bites, penetrating trauma or spontaneous soft tissue infection.[1] While many patients are managed swiftly and require brief hospital visits, others suffer long-term morbidity such as extended antibiotic requirements or functional compromise.[2] Patients with significant comorbidities or difficult-to-treat infections are at risk of sepsis, ICU admissions, and subsequently equate to a significant burden on the healthcare system.[3]

While the literature agrees that resistant organisms (such as MRSA), delayed presentation, patient comorbidities and socio-economic status all result in poor outcomes for patients with hand infections,[4] there is limited data that investigates how these factors vary across Australia. Understanding how geographical location influences patient outcomes and more importantly why, has the power to alter clinical practice, funding and health policy. By comparing patient and clinical variables to outcome measures such as time in hospital and unplanned surgical intervention across two climatically different sites, this preliminary study may identify the need for clear and accessible state by state epidemiological data and appropriate corresponding antibiotic protocols. Therapeutic Guidelines is a well-recognized and commonly referenced port of call for antibiotic guidelines across Australia.[5] Although providing tailored

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guidelines based on the aetiology of the infection, the guidelines do not acknowledge how microbiology may vary across different Australian locations or climates.

A focus of Australian hand infection literature has been the extremely high incidence of community onset methicillin resistant *Staphylococcus aureus* (Co-MRSA) in central Australia. Cameron *et al*. (2019) sought to identify how the incidence of Co-MRSA varies across all Australian states, only to find that the data available is very limited, with Tasmania being the only state to mandate reporting of Co-MRSA infection.[4] The data did demonstrate an estimated incidence of 329/100000 of inpatients in Alice Springs, 81/100000 in the Top End and 3.8/100000 in regional Victoria, suggesting a significant imbalance in prevalence of MRSA infections. No data was available from South Australia.[4] Furthermore, Secombe *et al*. examined the soft tissue infections that resulted in ICU admissions in Central Australia, with 60% of infections identified as MRSA and 85% of patients identifying as Indigenous. ICU admissions for soft tissue infection in Central Australia are estimated to be eight times higher than the national incidence.[6]

The hypothesis of this study was that the characteristics of hand infections in the Northern Territory would be different to Adelaide, as a reflection of the rurality and differences in climate. The aim of this study was to compare the demographics, comorbidities and microbiology of hand infections across two sites (Flinders Medical Centre [FMC] and Royal Darwin Hospital [RDH]). Additionally, to compare treatment outcomes, including time spent in hospital, unplanned surgical intervention and duration of antibiotics. This study is the first to compare state to state epidemiological data on both hand infection outcomes as well as micro-organisms, including rates of resistant organism groups.

Methods

This was a retrospective study of hospital digital and hard copy medical records based on selected clinical diagnostic ICD-10 (International Classification of Diseases, 10th revision) codes at FMC and RDH over a 12 month period. Patient admission episodes with diagnostic coding fitting our search criteria were retrieved for each site. All patients with a hand related illness were eligible for inclusion in our study. Chronic inflammatory and non-infective cases were excluded, as well as patients under the age of 18. Patient demographics including age, gender, site (FMC or RDH), ASA classification and diabetic status were collected. Duration of stay in hospital, duration of intravenous antibiotics, subsequent trips to theatre following their initial operation and microbiology results were also collected. Microbiology findings were then subdivided into sensitive or multi-resistant organisms, as well as two additional classification systems, generated by literature analysis of common grouping of skin and soft tissue infections.[7,8] Finally, data was gathered on length of oral antibiotics, requirement of a step-down facility and the duration of this stay.

Data was collected at each respective site, deidentified and then collated at Flinders Medical Centre. Statistical analysis was performed in SPSS v28.0[9] and involved analysis of all hand infections, then stratification by location.

The Modified Monash Model (MMM) of remoteness is a well-recognized tool used to define whether a location is a classified a city, rural, remote or very remote.[10] MM 1 is a major city, and areas classified MM2–MM 7 are rural or remote on a scaled increment.[13]

Table 1 Demographics divided by location

	FMC *n* (%)	RDH *n* (%)	Total *n* (%)
Site	49 (31%)	108 (69%)	157 (100%)
Gender			
Female	20 (41%)	37 (34%)	57 (36%)
Male	29 (59%)	71 (66%)	100 (64%)
Age group			
1–14	0 (0%)	2 (2%)	2 (1%)
15–24	1 (2%)	19 (18%)	20 (13%)
25–54	22 (45%)	70 (65%)	92 (59%)
55–64	6 (12%)	12 (11%)	18 (11%)
65+*	20 (41%)	5 (5%)	25 (16%)
ASA class			
0	0 (0%)	2 (2%)	2 (1%)
1	23 (47%)	36 (33%)	59 (38%)
2	26 (53%)	55 (51%)	81 (52%)
3	0 (0%)	14 (13%)	14 (9%)
4	0 (0%)	1 (1%)	1 (1%)
Diabetes			
No	39 (80%)	80 (74%)	119 (76%)
Yes	10 (20%)	22 (20%)	32 (20%)
Unknown	0 (0%)	6 (6%)	6 (4%)
MMR remoteness			
1*	39 (80%)	1 (1%)	40 (25%)
2*	2 (4%)	41 (38%)	43 (27%)
3	3 (6%)	0 (0%)	3 (2%)
4	0 (0%)	0 (0%)	0 (0%)
5	4 (8%)	5 (5%)	9 (6%)
6	6 (12%)	15 (14%)	21 (13%)
7*	1 (2%)	45 (42%)	46 (29%)
Unk/OS	0 (0%)	1 (1%)	1 (1%)
Duration of IV Abx			
>14 days*	20 (41%)	27 (25%)	47 (30%)
>5 days but <14 days	14 (29%)	30 (28%)	44 (28%)
48 h–5 days	10 (20%)	27 (25%)	37 (24%)
24–48 h	0 (0%)	7 (6%)	7 (4%)
<24 h	0 (0%)	10 (9%)	10 (6%)
1 dose	3 (6%)	1 (1%)	4 (3%)
No IV Abx	2 (4%)	4 (4%)	6 (4%)
Unk	0 (0%)	2 (2%)	2 (1%)
Length of stay			
<48 h	4 (8%)	12 (11%)	16 (10%)
2–5 nights	19 (39%)	46 (43%)	65 (41%)
>5 nights	26 (53%)	45 (42%)	71 (45%)
Unknown	2 (4%)	5 (5%)	7 (4%)
Trips to theatre			
0	4 (8%)	12 (11%)	16 (10%)
1	28 (57%)	59 (54%)	87 (55%)
2	11 (22%)	23 (21%)	34 (22%)
3	4 (8%)	7 (6%)	11 (7%)
4	2 (4%)	4 (4%)	6 (4%)
5	0 (0%)	1 (1%)	1 (1%)
6	0 (0%)	1 (1%)	1 (1%)
7	0 (0%)	1 (1%)	1 (1%)
Site of Infection			
Soft tissue	12 (24%)	35 (27%)	47 (28%)
Tendon sheath	1 (2%)	12 (9%)	13 (8%)
Joint involvement	16 (33%)	28 (22%)	44 (22%)
Cellulitis	2 (4%)	2 (2%)	4 (2%)
Tenosynovitis	9 (18%)	22 (17%)	31 (19%)
Osteomyelitis	9 (18%)	26 (20%)	35 (21%)
Infection from bite			
	12 (24%)	33 (26%)	45 (26%)

*Variable with level of significance $p < 0.05$.

Results

Over the 12 month period of the study, there were a total of 157 patients treated for hand infection at RDH (69%) and FMC (31%). Patients were predominantly male both overall (64%) and independently at both sites. Patients treated at RDH were significantly younger on average, with 82% of patients under the age of 55 years, whereas at FMC, 53% of patients were over the age of 54 years or older ($P < 0.001$) (Table 1). There were no significant differences in patient ASA (American Society of Anesthesiologists) classification between sites. The most common ASA class was 2, for both FMC (53%) and RDH (51%). 13% of patients from RDH had an ASA class 3 compared to none from FMC, however this was not statistically significant (Table 1). The site of infection was further divided as evident in Table 1, with no significant differences between RDH and FMC. Isolated soft tissue infection was the most common subdivision (28%), followed by joint (22%), osteomyelitis (21%) and tenosynovitis (19%). Overall, 26% of hand infections across both sites were secondary to animal/human bites, with no significant difference between groups.

The level of remoteness of residence varied significantly between cohorts, with 80% of FMC patients living in a MMR1 catchment (Fig. 1). Comparatively, 56% of RDH patients were MMR6 or higher (MMR6 = 14%, MMR7 = 42%) (Table 1). Remoteness was not significantly associated with a longer stay in hospital, a longer course of antibiotics or the number of trips to theatre (Table 2). Twenty percent of all patients had a diagnosis of diabetes and this was the same at both sites. All patients in the study had microbiological analysis based on swabs taken either peri or intraoperatively. 45% of patients grew a *S. aureus* microbe, 20% of which was MRSA (Table 3).

Details of the common organisms grown from hand infections are shown in Table 3. There were no differences between the two sites for common bacteria such as MSSA, MRSA, *Klebsiella* or *Pseudomonas*. A significantly higher incidence of B-haemolytic streptococcus was seen at RDH. Patients with more than one microbe identified were classified as polymicrobial. Forty-three percent of all patients had polymicrobial growth, with significantly more polymicrobial infections present in the RDH population. Table 4 demonstrates the variety of species seen in polymicrobial infections.

Discussion

Hand infections are a common presentation that can lead to significant morbidity for Australian patients.[11] Reporting hand infection statistics may help improve our understanding of the factors that influence morbidity and functional outcomes. Currently, the literature on hand infections is limited, including the rates of antibiotic resistant organisms such as MRSA and other common bacteria. In 2005, the Australian Government conducted a survey on laboratories across Australia to estimate the prevalence of MRSA in the population.[12] The rates seen in South Australian laboratories ranged from 15% to 29%, echoing the rate seen in this study conducted at FMC (18%). Data from the Northern Territory was amalgamated with Queensland data in the government led study and a range of 19%–36% was given. Despite the variation in catchment areas, the rates of resistant organisms are comparable to RDH (25%), suggesting data in this study is valid and may be useful in providing epidemiological data to add to the infectious disease armamentarium (Table 3). We suggest that literature describing the rates of resistant bacteria in Australia, and crucially, how it varies across states and climates is important for hospitals to understand and have access to. This study suggests that overall rates of MRSA in patient communities may reflect rates of MRSA seen in hand infections.

There was a significant difference seen in the remoteness of patient's residence in this study between FMC and RDH (Table 1). This clear divide in the data therefore enables the results seen in this study to act as a surrogate for comparing other metropolitan and remote tropical Australian locations. Currently, the Plastic Surgery service at the RDH is staffed by locum staff specialists, many of which travel sporadically to Darwin for short periods of time from their usual place of work.[13] In recent years, this has included

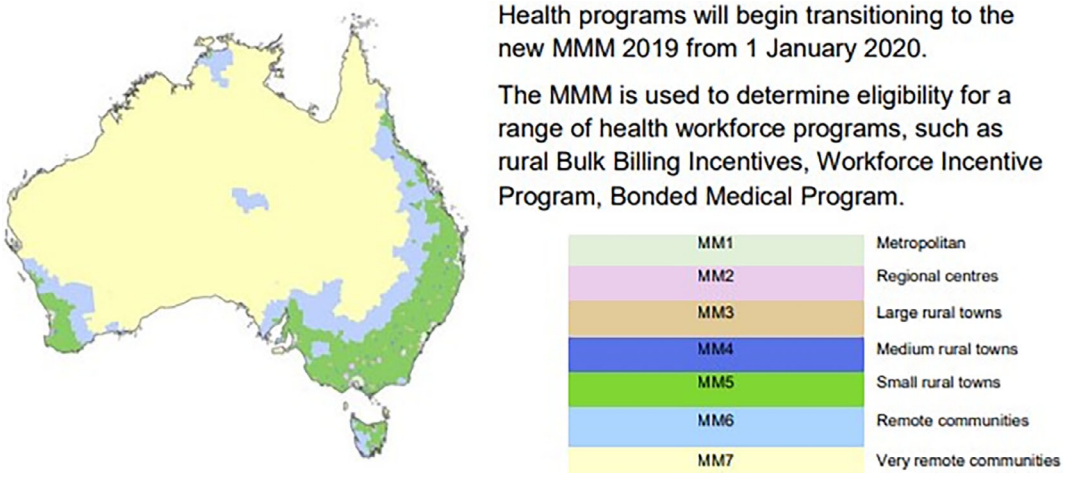

Fig. 1. Modified Monash Model (MMM) 2019, Australian Government, Department of Health Fact Sheet.

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Table 2 Length of stay in hospital, duration of antibiotics, and trips to theatre by MMR remoteness measure

	MMR remoteness								
Length of stay in hospital	1	2	3	5	6	7	Overseas	Total	%
>14 nights	7	5	1	1	1	4	1	20	12.74%
>7 but <14 nights	9	8	1	4	-	10	–	32	20.38%
7 nights	4	2	–	1	1	5	–	13	8.28%
6 nights	-	3	–	–	2	1	–	6	3.82%
5 nights	5	5	–	–	3	3	–	16	10.19%
4 nights	5	3	–	1	2	6	–	17	10.83%
3 nights	3	8	–	–	2	6	–	19	12.10%
2 nights	3	2	1	–	2	5	–	13	8.28%
1 night	2	4	–	1	2	5	–	14	8.92%
Unknown	2	3	–	1	–	1	–	7	4.46%
Total	40	43	3	9	15	46	1	157	100.00%
Duration of ABx	1	2	3	5	6	7	Overseas		
>14 days IV ab	14	14	1	4	3	10	1	47	29.94%
> 5 but <14 days IV	12	11	2	2	4	13	–	44	28.03%
48 h–5 days IV	9	10	–	1	3	14	–	37	23.57%
24–48 h IV	–	1	–	1	3	2	–	7	4.46%
<24 h IV	–	3	–	–	2	5	–	10	6.37%
1 dose of IV only	3	1	–	–	–	–	–	4	2.55%
No IV Abx	2	3	-	1	–	–	–	6	3.82%
Unknown	–	–	–	–	–	2	–	2	1.27%
Total	40	43	3	9	15	46	1	157	100.00%
Trips to Theatre	1	2	3	5	6	7	Overseas		
0	4	3	–	–	2	7	–	16	
1	23	24	2	5	11	22	–	87	
2	8	12	1	1	1	10	1	34	
3	3	2	–	2	-	4	–	11	
4	2	–	–	1	1	2	–	6	
5	–	1	–	–	–	–	–	1	
6	–	–	–	–	–	1	–	1	
7	–	1	–	–	–	–	–	1	
Total	40	43	3	9	15	46	1	157	

Table 3 Microbiology by site and microbacterial subgroups

Classification of organisms	FMC *n* (%)	RDH *n* (%)	Total
Staphylococcus aureus			
Yes	24 (49%)	46 (43%)	70 (45%)
No	15 (31%)	46 (43%)	61 (39%)
No growth	10 (20%)	16 (15%)	26 (16%)
SENTRY class			
B-haemolytic strep*	5 (1%)	25 (19%)	30 (16%)
Coagulase Negative *S. aureus*	3 (6%)	2 (2%)	5 (3%)
Enterobacter spp	1 (2%)	1 (1%)	2 (1%)
Enterococcus	2 (4%)	0 (0%)	2 (1%)
Klebsiella	0 (0%)	1 (1%)	1 (1%)
MRSA	9 (17%)	27 (21%)	36 (20%)
MSSA	15 (28%)	19 (15%)	34 (18%)
Oral flora/Eikenella	2 (4%)	7 (5%)	9 (5%)
Corrodens			
Other*	6 (11%)	32 (24%)	38 (21%)
Pseudomonas	0 (0%)	1 (1%)	1 (1%)
No growth	10 (19%)	16 (12%)	26 (14%)
Monomicrobial	34 (69%)	56 (52%)	90 (57%)
Polymicrobial*	15 (31%) (Number of patients)	48 (44%) (Number of patients)	63 (40%) (Number of patients)

*Statistically significant difference found ($P < 0.05$) using 2 × 2 chi square test for independence between categorical variables.

surgeons from temperate cities such as Adelaide, Perth or Melbourne. This model is not unusual for surgeons across all specialties, who may choose to visit rural areas, and therefore it is important we prepare the workforce with data that may impact their practice, such as how rates of different bacteria vary from place to place.

Classification and grouping of bacteria in this study was developed based on existing literature examining bacteria most commonly seen in soft tissue infection.[7,8] Preliminary grouping was then reviewed by an infectious disease specialist to ensure common bacteria with slight nomenclature variations were not overlooked or

Table 4 Organisms found in polymicrobial infections

	FMC	RDH	Total
Proteus mirabilis	1	–	1
Streptococcus agalactiae	2	2	4
Streptococcus pyogenese ($P < 0.05$)	2	21*	23
Streptococcus dysgalactiae	1	–	1
Streptococcus mutans	1	–	1
Streptococcus sanguinis	1	–	1
Streptococcus aginosis	2	4	6
Streptococcus constellatus	–	1	1
Staphylococcus lugdunensis	2	1	3
Staphylococcus saprophyticus	-	1	1
Staphylococcus epidermidis	-	3	3
Staphylococcus capitis	-	1	1
Enterobacter cloacae complex	2	1	3
Pasteurella spec	1	2	3
Coliform	1	6	7
Enteric gram neg bacillis	1	–	1
Enteric flora	–	3	3
Cutaneous flora	–	22	22
Oropharanyngeal flora	–	10	10
Mixed anaerobes	–	15	15
Gemalla morbillorum	1	–	1
Haemophilis parainflienzae	1	–	1
Eikenella corrodens	1	3	4
Klebsiella varricola	1	–	1
Klebsiella pneumoniae	–	1	2
Klebsiella aeragenese	–	1	1
Coagulase Negative Staph Aureus	3	4	7
Candida albicans	1	1	
Anaerobic gram pos coccus	1	–	1
Photobacterium damselae	–	1	1
Corynebacterium species	–	1	1
Corynebacterium diaphtheriae	–	1	1
Escherichia coli	–	1	1
Basillus species	–	1	1
Pseudomonas aeraginosa	–	2	2
Enterococcus	2	–	2
MRSA	2	13	15
MSSA	7	14	21
Eikenella corrondens	–	2	2

*Variable with level of significance $p < 0.05$.

clustered inappropriately. A significant finding was the variety of bacteria seen in RDH. Although the bacteria grouping was comprehensive, 30% of bacteria seen in hand infection cases at the Northern territory hospital fell into the 'other' category, compared to only 12% at FMC. Similarly, RDH had a significant higher number of polymicrobial infections (48%) when compared to FMC (31%). This finding is important to hand surgeons who may spend short periods of time in the Northern Territory, in particular the importance of careful monitoring of microscopy and culture results to guide sensitive antibiotic treatment and ultimately improve patient outcomes. The Therapeutic Guidelines (a common resource used by Australian medical professionals) offers no tailoring to different climates, instead highlights the consideration of altered management in patients with increased risk of resistant organisms, particularly MRSA. While a useful principle, this is difficult to enact when rates of resistant organisms such as MRSA are not routinely recorded across different Australian locations.[4]

It is widely accepted that rural and remote Australians have higher rates of hospitalisations, deaths and injury as well as poor access to healthcare, as well as an overall lower socioeconomic status to their metropolitan counterparts.[14,15] Interestingly, there were no differences found across sites for length of stay in hospital or number of trips to theatre in this study, two of the markers that may suggest increased severity of infection. In fact, the metropolitan site FMC reported a significantly higher number of patients that received intravenous antibiotics for 14 days or longer. These results were surprising, with Turow et al. (2016) reiterating that rural Australians and specifically Indigenous Australians present with hand infections – on average – 2 days later than their non-Indigenous counterparts, with a nine-fold chance of readmission.[16] Identifying as an Aboriginal or Torres Strait Islander was not included in this study, so the impact of race between the different sites cannot be commented on in this study. Future studies may extend the data captured in this study, investigating factors such as delays in presentation and patient compliance to medical treatment both as an inpatient and following their admission to hospital. In regard to hand infection management, this would include antibiotic compliance as well as dressings and clinic reviews. Effective strategies to capture medical adherence in rural and remote communities are outside the scope of this paper but are important to consider in future studies focusing in this area. Furthermore, climate can vary significantly throughout the year in any given location, and a study that examines the contrast of data between the 'wet' and 'dry' season in the Northern Territory for example may also be a point of interest for future research.

Conclusion

This study compared the presentation, microbiology and treatment course of patients with hand infections across two sites that vary in remoteness and climate within Australia, and highlights that factors such as patient demographics and microbiology may vary significantly from region to region. As treating doctors at rural sites are often offering a 'fly in fly out' service, as is currently seen in the Plastic Surgery Unit at RDH, it is important to highlight and understand the significance of these differences.

Author contributions

Claire R. Baxter: Conceptualization; investigation; writing – original draft; writing – review and editing. **Nikki Burnett:** Conceptualization; data curation; methodology; writing – review and editing. **Mona Alatrash:** Conceptualization; data curation; investigation; methodology; project administration. **James Sires:** Conceptualization; data curation; investigation; methodology; writing – review and editing. **Phillipa van Essen:** Conceptualization; investigation; writing – original draft; writing – review and editing. **Nicola R. Dean:** Conceptualization; data curation; formal analysis; supervision; writing – original draft; writing – review and editing.

Acknowledgement

Open access publishing facilitated by Flinders University, as part of the Wiley - Flinders University agreement via the Council of Australian University Librarians.

Conflicts of interest

This study received no formal funding and there are no financial conflicts of interest. NR Dean serves as a section editor for the ANZJournal of Surgery.

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