Hospital admissions for skin and soft tissue infections in a population with endemic scabies: A prospective study in Fiji, 2018–2019

Li Jun Thean1,2,* , Adam Jenney3, Daniel Engelman1,2,4, Lucia Romani5, Handan Wand6, Jyotishna Mudaliar1, Jyotishna Mudaliar1, Jessica Paka1, Tuliana Cua1, Sera Taole1, Aalisha Sahukhan6, Mike Kama6, Meciusela Tuicakau6, Joseph Kado6,7, Natalie Carvalho8, Margot Whitfeld9,10, John Kaldor5, Andrew C. Steer1,2,4

1 Tropical Diseases Group, Murdoch Children’s Research Institute, Melbourne, Victoria, Australia, 2 Department of Paediatrics, University of Melbourne, Melbourne, Victoria, Australia, 3 College of Medicine, Nursing and Health Sciences, Fiji National University, Suva, Fiji, 4 Melbourne Children’s Global Health, Melbourne Children’s Campus, The Royal Children’s Hospital, Melbourne, Victoria, Australia, 5 Kirby Institute, University of New South Wales, Sydney, New South Wales, Australia, 6 Ministry of Health and Medical Services, Suva, Fiji, 7 Wesfarmers Centre for Vaccines and Infectious Diseases, Telethon Kids Institute, Perth, Western Australia, Australia, 8 School of Population and Global Health, University of Melbourne, Melbourne, Victoria, Australia, 9 Department of Dermatology, St. Vincent’s Hospital, Sydney, New South Wales, Australia, 10 School of Medicine, University of New South Wales, Sydney, New South Wales, Australia

* lijun.thean@mcri.edu.au

Abstract

Scabies is an important predisposing factor for impetigo but its role in more serious skin and soft tissue infections (SSTIs) is not well understood. Information is limited on incidence of SSTIs in the presence of endemic scabies. We conducted a prospective study of hospital admissions for SSTIs in the Northern Division of Fiji (population: 131,914). Prospective surveillance for admissions with impetigo, abscess, cellulitis, wound infection, pyomyositis, necrotizing fasciitis, infected scabies, and crusted scabies was conducted at the Division’s referral hospital between 2018 to 2019. Information was collected on demographic characteristics, clinical features, microbiology, treatment and outcomes. Over the study period, 788 SSTI admissions were recorded corresponding to a population incidence 647 per 100,000 person-years (95%CI 571–660). Incidence was highest at the extremes of age with peak incidence in children aged <5 years (908 per 100,000) and those aged ≥65 years (1,127 per 100,000). Incidence was 1.7 times higher among the Indigenous Fijian population (753 per 100,000) compared to other ethnicities (442 per 100,000). Overall case fatality rate was 3.3%, and 10.8% for those aged ≥65 years. Scabies was diagnosed concurrently in 7.6% of all patients and in 24.6% of admitted children <5 years. There is a very high burden of hospital admissions for SSTIs in Fiji compared to high-income settings especially among the youngest, oldest and indigenous population which is concordant with scabies and impetigo distribution in this population. Our findings highlight the need for strategies to reduce the burden of SSTIs in Fiji and similar settings.
Scabies is causally linked to impetigo in endemic populations. In turn, impetigo can progress to more serious skin and soft tissue infections (SSTI). However, there are few data on the epidemiology of SSTIs in settings where scabies is endemic. We conducted a prospective study of the incidence of hospitalizations for SSTIs in 2018 and 2019 at the referral centre for the Northern Division of Fiji (population of 131,914) where community scabies prevalence is very high. We measured the incidence of admissions for abscesses, cellulitis, impetigo, wound infections, pyomyositis, necrotizing fasciitis and crusted scabies. We observed a high incidence of SSTI admissions (647 cases per 100,000 person-years) with high associated morbidity and case fatality in this population. We found a very high incidence in young children, the elderly and iTaukei (Indigenous Fijian) population which is concordant with the distribution of scabies and impetigo in the community. These findings highlight SSTIs as an important public health concern and provide further impetus to advance research into strategies that will alleviate this burden.

Introduction

Scabies is a pruritic skin disease caused by the mite Sarcoptes scabiei var. hominis with global prevalence estimated at 200 million in 2015. [1] Available studies have found high levels of prevalence in diverse, resource-limited settings including Pacific islands countries, parts of Latin America and some remote Aboriginal communities in Australia.[1] Scabies has a well described association with impetigo,[2–4] as breaches in skin from scratching facilitate acquisition of secondary bacterial infection, predominantly caused by Staphylococcus aureus and Group A Streptococcus (GAS).[5] A 2007 national survey in Fiji reported impetigo prevalence at 19.6% across all ages, and 34.2% in children aged 5 to 9 years.[2] Impetigo is understood to be a pathway by which more severe skin and soft tissue infections (SSTIs) and systemic infection can arise however the frequency of this progression is not well defined.

Thus, while skin and soft tissue infections are a key potential complication of scabies, little is known about their epidemiology, severity and outcomes in scabies endemic settings. According to a 2017 Global Burden of Disease Study update, a high proportion of the burden of skin and subcutaneous disease is caused by cellulitis and pyoderma, especially in Oceania and Africa, suggesting there is considerable morbidity and mortality from SSTIs in these settings.[6] The Fiji Ministry of Health and Medical Services 2016 Health Status Report stated that SSTIs were the fifth most common cause of mortality nationally.[7]

Clinical presentations of SSTIs range from superficial abscesses and cellulitis to life-threatening necrotizing fasciitis (also known as necrotizing soft tissue infections). In most populations where data are available, S. aureus and GAS are the most frequent causative pathogens, although attributable fractions vary by setting.[8–10] While most cases can be satisfactorily treated in primary care settings with standard antibiotics, a proportion require hospital admission.[11,12]

The incidence of SSTI admissions in high income countries such as the United States was reported as 219 per 100,000 person-years between 2005–2010. [12] A similar rate was found in non-Indigenous Australians at 290 per 100,000. However, this was substantially higher in the Indigenous population at 1,890 per 100,000,[13] suggesting an important role of environmental and socio-economic factors that may also be relevant in Pacific countries.[5] In a retrospective study of SSTI admissions to a public hospital in New Zealand, the incidence among children aged <14 years was 1352 per 100,000 among Pacific Islanders and 886 per 100,000.

Author summary

Scabies is causally linked to impetigo in endemic populations. In turn, impetigo can progress to more serious skin and soft tissue infections (SSTI). However, there are few data on the epidemiology of SSTIs in settings where scabies is endemic. We conducted a prospective study of the incidence of hospitalizations for SSTIs in 2018 and 2019 at the referral centre for the Northern Division of Fiji (population of 131,914) where community scabies prevalence is very high. We measured the incidence of admissions for abscesses, cellulitis, impetigo, wound infections, pyomyositis, necrotizing fasciitis and crusted scabies. We observed a high incidence of SSTI admissions (647 cases per 100,000 person-years) with high associated morbidity and case fatality in this population. We found a very high incidence in young children, the elderly and iTaukei (Indigenous Fijian) population which is concordant with the distribution of scabies and impetigo in the community. These findings highlight SSTIs as an important public health concern and provide further impetus to advance research into strategies that will alleviate this burden.
among Maori compared 229 per 100,000 among people of other ethnicities between 1990–
2007.[14] Little is known about the incidence of SSTI admissions in low-middle-income or
scabies endemic settings.

To better understand the occurrence of SSTIs in a setting with endemic scabies, we con-
ducted a prospective study of admissions for SSTIs in the Northern Division of Fiji. This study
was done as the baseline year of a before-after trial of ivermectin-based mass drug administra-
tion (MDA) for the control of scabies in this region (Trial ID: ACTRN12618000461291).

Methods
Ethics statement
Ethical approval was obtained from the Fiji National Health Research Ethics Review Committee
(reference number: 2018.38.NOR.) and the Royal Children’s Hospital Human Research Ethics
Committee in Melbourne, Australia (reference number: 38020). Written informed consent was
obtained from all participants or from their parent or legal guardian if they were aged less than
18 years. If a potential participant was assessed to lack the capacity to provide properly informed
consent, we sought consent from their primary carer or guardian. If consent was not obtained
for medical records review, the case was retained for incidence and mortality calculations.

Setting
Fiji is an archipelago nation in the South Pacific Ocean. Its population of approximately
885,000 people (2017), comprises two main ethnic groups, iTaukei or Indigenous Fijians
(56.8%) and Fijians of Indian Descent (37.5%).[15,16] Fiji is ranked 98 out of 189 countries on
the United Nations Development Programme Human Development Index 2019.[17]

The Northern Division, with a population of 131,914 people in 2017 [15] is one of four
administrative divisions of Fiji and is further divided into four subdivisions (Fig 1). The North-
ern Division was noted to have highest prevalence of scabies (28.5%) and impetigo (23.7%) by
a national survey conducted in 2007.[2] Most of the population (70.6%) of the Northern Divi-
sion live in rural areas. The study site was 195-bed Labasa Hospital, located in the divisional
capital and the referral centre for the division. The other three subdivisions are serviced by
smaller subdivisional hospitals.[18] Labasa Hospital is the only facility with specialist medical,
surgical, paediatric, obstetric and intensive care unit (ICU) services, and a microbiology labo-
ratory capable of processing specimens for bacterial culture.

Surveillance and inclusion criteria
Following consultation with the Fiji Ministry of Health and Medical Services and administra-
tive and ethical approvals, we established and implemented a protocol for prospective surveil-
lance of SSTI admissions at Labasa Hospital over a 48-week period between July 16th 2018 and
June 30th 2019, with a two week pause from 24th December 2018 to 6th January 2019.

Patients of all ages were recruited into the study. Potential study participants were identified
through several processes to ensure comprehensive and accurate enrolment by two study
nurses under the supervision of the study coordinator. First, ward-specific admission registries
and case notes of new admissions in all inpatient wards of the hospital were reviewed daily, to
identify possible cases. Patients discharged before contact could be made were followed up at
home and offered enrolment. Second, a verbal check was conducted daily with the nurse in
charge of each ward for any potential cases. Third, the hospital’s microbiology laboratory rec-
ords were reviewed daily for skin swabs or operative soft tissue samples received and related
back to the patient for potential enrolment.
Patients who met inclusion criteria were approached to give consent for review of their medical records. To be eligible, they had to have one of the following SSTIs: impetigo, abscess, cellulitis, wound infection (surgical and other), pyomyositis, necrotizing fasciitis, infected scabies, and crusted scabies. Diabetic foot infections were excluded. Eligibility was determined based on the working diagnoses of the treating clinicians as documented in the rounding books (a working ward book where diagnoses and plans for patients on each ward are documented daily), admission registries, case notes and on discharge, the hospital’s electronic record system Patient Information System (PATIS). Where necessary, clarification of diagnoses and treatment was sought from the treating clinicians. No study-specific assessments were implemented.

Detailed information from medical records regarding patient demographic, clinical and microbiological characteristics, management and outcomes were recorded after consent was obtained. Co-infestation with scabies as diagnosed by treating clinicians was noted. Surgical intervention was defined as a procedure performed in the operating theatre to treat the SSTI.
Microbiological data were obtained from the microbiology laboratory records. Data were entered onto the REDCap Mobile App and securely stored in an online server hosted by the Murdoch Children’s Research Institute.[19,20]

Microbiological methods

The microbiology laboratory at Labasa Hospital incubated blood culture bottles in an automated system (BacT/ALERT, bioMerieux, Craponne, France). Bacterial swabs were inoculated and incubated on solid media human/sheep blood agar, chocolate agar, MacConkey and cystine-lactose-electrolyte-deficient media. Identification of Gram-positive bacteria was performed through, Gram stain appearance and Oxoid Microbact (Thermo Fisher, Waltham, USA). S. aureus was identified through DNAse testing and GAS was identified through streptococcal latex agglutination test (Thermo Fisher) and bacitracin susceptibility. Antibiotic susceptibility was performed using the CLSI disk methods with Mueller-Hinton Media. Wound, skin and soft tissue specimens were incubated between 35–36°C in air. Respiratory specimens and subcultures from positive blood culture bottles were grown in CO₂ enriched conditions using the candle jar method.

Statistical analysis

Incidence was calculated using total population, age and sex data from the 2017 Fiji Bureau of Statistics census [15] and expressed per 100,000 census population per year with 95% confidence intervals (CI). As ethnicity data were unavailable from the 2017 census, denominators for ethnicity were calculated by applying Northern Division specific ethnicity proportions from 2007 census data to the 2017 population census data.[21] Non-overlapping CIs were interpreted as significant difference between the groups. We calculated incidence rate ratios (IRR) to compare population subgroups. We used Stata version 15 (StataCorp, College Station, Texas) for statistical calculations.

Patients diagnosed with more than one category of SSTI were assigned a principal diagnosis based on the most severe and most specific diagnosis, ranked according to a study-specific scale (S1 Fig). Principal diagnoses were categorized into two groups: 1) potentially scabies-related (cellulitis, abscess, impetigo, infected scabies, crusted scabies, pyomyositis necrotizing fasciitis with pure growth of S. aureus or GAS; and 2) unlikely scabies-related (wound infections, surgical wound infections and necrotizing fasciitis without pure growth of S. aureus or GAS). Sub-analysis for demographic groups was conducted for age, sex and ethnicity. Participant ethnicity was classified as either iTaukei or Other ethnicities (which included Fijians of Indian Descent and all other ethnicities). The outcomes that were assessed were: length of stay, need for amputation and survival.

Results

Incidence

During the 48-week study period there were 788 individual admissions of people with SSTIs who met inclusion criteria, corresponding to an annual incidence of 647.1 admissions per 100,000 people in the Northern Division (95% CI 602.9–693.8). Consent was obtained to collect more detailed demographic and clinical data for 748 admissions. Of these, 569 cases had principal diagnoses that were classified as potentially scabies-related (incidence of 467.3 per 100,000).

The overall annualized incidence of SSTI admissions was similar between males (684.2 per 100,000) and females (578.7 per 100,000 IRR 1.1, Table 1). Incidence was higher in the iTaukei
population (752.7 per 100,000) compared to other ethnicities combined (442.2 per 100,000), with an IRR of 1.7 (95% CI 1.5–2.0, Table 1). The IRR between iTaukei and other ethnicities was similar in the potentially scabies-related (IRR 1.7) and unlikely scabies-related (IRR 1.8) groups.

Incidence was highest in the youngest (<5 years) and oldest (55–64 years and ≥65 years) age groups, with incidence of 908, 958 and 1127 per 100,000 respectively (Table 1). The bimodal peaks in incidence among the youngest and oldest age groups were found in the group classified as potentially scabies-related but not in the unlikely scabies-related group (Fig 2).

A total of 556 admissions (74.3%) were among residents of Macuata Subdivision, where Labasa is located. Of these, 485 cases were direct admissions to Labasa Hospital, and 71 were referred from other health facilities. All-age incidence of admissions among residents of Macuata was 912.9 per 100,000 (95% CI 838.8–991.6). Based on the remaining 192 cases the combined incidence in the other three subdivisions was 315.5 per 100,000 (95% CI 272.5–363.3).

Clinical characteristics

Of the 748 cases for which detailed clinical data were available, 52 (7%) had 2 SSTI diagnoses and 2 (0.3%) had 3. The most common principal diagnosis was abscess (398 cases, incidence 326.9 per 100,000) followed by cellulitis (106 cases, 87.1 per 100,000, Table 2).

The distribution of most common diagnoses was similar between males and females, with the exception of non-surgical wound infection which was far more common in males (99.5 per 100,000) compared to females (15.1 per 100,000) with an IRR of 6.8 (95% CI 3.2–15.0, Table 2). Median age varied between diagnoses (S2 Fig), most notably for infected scabies (1.6 years, IQR 0.8–6.4) and necrotizing fasciitis (56.3 years, IQR 44.8–60.8). iTaukei patients had a higher incidence of admission for infected scabies compared to other ethnicities combined (IRR 10.1, 95% CI 2.5–87.6, Table 2).

| Demographic factor | n   | Incidence (95% CI) | IRR (95% CI) |
|--------------------|-----|--------------------|--------------|
| Sex                |     |                    |              |
| Male               | 404 | 648.2 (586.7–714.4) | 1.1 (1.0–1.3) |
| Female             | 344 | 578.7 (519.3–643.0) |              |
| Ethnicity          |     |                    |              |
| iTaukei            | 508 | 752.7 (688.9–820.8) | 1.7 (1.5–2.0) |
| Other              | 240 | 442.2 (338.1–501.7) |              |
| Age group (years)  |     |                    |              |
| 0–4                | 122 | 908.4 (754.9–1083.7)|              |
| 5–14               | 89  | 351.6 (282.4–432.5) | 0.4 (0.3–0.5) |
| 15–24              | 84  | 456.5 (364.3–564.9) | 0.5 (0.4–0.7) |
| 25–34              | 94  | 559.1 (452–683.8)   | 0.6 (0.5–0.8) |
| 35–44              | 79  | 493.7 (391–615)     | 0.5 (0.4–0.7) |
| 45–54              | 99  | 696.2 (566.1–847)   | 0.8 (0.6–1.0) |
| 55–64              | 98  | 958.5 (778.8–1167)  | 1.1 (0.8–1.4) |
| ≥65                | 83  | 1127.3 (898.8–1395.8)| 1.2 (0.9–1.7) |
| Total              | 748 | 614.3 (571.2–659.8) |              |

https://doi.org/10.1371/journal.pntd.0008887.t001
Fifty-seven patients (7.6%) were recorded as having scabies at the time of admission, including 7.6% of patients with cellulitis and 4.3% with skin abscesses. Scabies was most commonly recorded in younger children (24.6% of children aged < 5 years, S3 Fig). Scabies was more common among iTaukei (9.4%) patients compared to other ethnicities combined (2.5%, IRR 3.8, 95% CI 3.2–4.4). Scabies was diagnosed in 52 (9.1%) of potentially scabies-related SSTIs and 2 (1.1%) of other cases.

**Management.** Surgical intervention for SSTIs was performed in 478 patients (63.9%), including 87.5% of those with necrotizing fasciitis (Table 3). Eighteen patients (2.4%) required amputation of the affected extremity. Thirty-two patients (4.3%) were managed in the ICU (annual incidence 26.3 per 100,000), and 17 (2.3%) patients required mechanical ventilation.

Treatment with intravenous antibiotics was commenced in 726 cases (97.1%), with a median duration of 4 days (IQR 3–7), longest for necrotizing fasciitis (12.5 days; IQR 7–19, Table 3). Cloxacillin was the most frequently prescribed intravenous antibiotic (90.1% of cases), followed by gentamicin (70%). Of all 518 cases that were prescribed gentamicin, 515 (99.4%) were treated in combination with another intravenous antibiotic, the majority being with cloxacillin (499, 96.3%). Oral antibiotic treatment was commenced in 550 cases (73.5%), with a median duration of 3 days (IQR 2–5). A total of 4007 and 2432 days of intravenous and oral antibiotics were prescribed over the 48-week surveillance period respectively.

**Outcomes.** The median length of stay in hospital was 8 days (IQR 4–9). Of all principal diagnoses, cases with abscess had the shortest stay (median 4 days, IQR 3–6) and necrotizing fasciitis the longest (23 days, IQR 8–29.5, Table 3). Over the 48-week surveillance period, admissions for SSTIs utilised a total of 5989 inpatient bed days and 150 ICU bed days.

Among the 748 patients for whom consent was obtained to provide clinical data, there were 25 deaths during admission (case fatality rate, CFR, 3.3%) corresponding to an annualised...
death rate of 20.5 per 100,000 (95% CI 13.3–30.3, S1 Table). After inclusion of a further 11 patients who died before consent for detailed clinical data could be sought, there were 32 deaths (CFR 4.1%; incidence 26.3 per 100,000, 95% CI 18.0–37.1).
Necrotizing fasciitis had the highest CFR (5 deaths, 20.8%, Table 3). The CFR for those aged <14 years was 0.5%, while the CFR for those aged over 65 years was 10.8% (incidence 122.2 per 100,000, 95% CI 55.9–231.9, S1 Table). The CFR was higher in patients with microbiologically confirmed bacteraemia (14.5% compared to those without 2.2%, IRR of 6.6, 95% CI 5.1–8.5). The CFR for patients admitted to the ICU was 12.5% compared to 2.9% (IRR 4.3, 95% CI 1.1–12.6) in cases without ICU admission.

Microbiological findings

Superficial skin swabs were recorded as having been obtained from 520 patients (69.5% of consented cases). Of these, 409 (78.7%) yielded positive cultures, of which the majority were polymicrobial (221 swabs, 54%). Out of all swabs collected, S. aureus was isolated from 239 swabs (46%), including 11 (4.6% of all S. aureus isolated) that were methicillin-resistant, while GAS was isolated from 18 swabs (3.5%). Gram negative bacteria were isolated from 191 swabs (36.7%), most frequently Klebsiella pneumoniae (75 swabs, 14.4%, S2 Table).

Blood cultures were recorded as having been conducted on specimens from 431 patients (57.6%), with 64 returning positive (14.8%, S3 Table). S. aureus was isolated from blood cultures from 41 patients (9.5%), and GAS from 7 (1.6%). There was no significant variation with age in the incidence of SSTI admissions with S. aureus bacteraemia (S4 Table).

Table 3. Treatment and outcome for patients admitted with a skin and soft tissue infection (CI: confidence interval; IQR: interquartile range; ICU: intensive care unit; One patient with crusted scabies is not represented in this table).

|                | Abscess (N = 398) | Cellulitis (N = 106) | Surgical wound infection (N = 86) | Wound infection (N = 71) | Infected scabies (N = 27) | Pyomyositis (N = 27) | Necrotizing fasciitis (N = 24) | Impetigo (N = 8) | All cases (N = 748) |
|----------------|-------------------|----------------------|-------------------------------|-------------------------|-------------------------|------------------|-----------------------------|----------------|-------------------|
| **Surgery**    |                   |                      |                               |                         |                         |                  |                             |                |                   |
| n              | 316               | 18                   | 46                            | 53                      | 1                       | 22               | 21                          | 1              | 478               |
| %              | 79.4              | 17.0                 | 53.5                          | 74.7                    | 3.7                     | 81.5             | 87.5                        | 12.5           | 63.9              |
| 95% CI         | 75.1–83.3         | 10.4–25.5            | 42.4–64.3                     | 62.9–84.2               | 0.1–19                  | 61.9–93.7        | 67.6–97.3                   | 0.3–52.7       | 60.3–67.4         |
| **ICU admission** |                  |                      |                               |                         |                         |                  |                             |                |                   |
| n              | 11                | 1                    | 3                             | 4                       | 7                       | 0                | 3                           | 3              | 32                |
| %              | 2.8               | 0.9                  | 3.5                           | 5.6                     | 25.9                    | 0                | 12.5                        | 37.5           | 4.2               |
| 95% CI         | 1.4–4.9           | 0–5.1                | 0.1–9.9                       | 1.6–13.8                | 11.1–46.3               | -                | 2.7–32.4                    | 8.5–75.5       | 2.9–6             |
| **IV antibiotics (days)** |                |                      |                               |                         |                         |                  |                             |                |                   |
| median         | 3                 | 5                    | 5                             | 4                       | 6                       | 6                | 12.5                        | 9.5            | 4                 |
| IQR            | 2–5               | 3–7                  | 3–8                           | 3–7                     | 3–9                     | 4–12             | 7–19                        | 5–15           | 3–7               |
| **Admission (days)** |                |                      |                               |                         |                         |                  |                             |                |                   |
| median         | 4                 | 6                    | 7                             | 5                       | 7                       | 7                | 23                          | 16.5           | 5                 |
| IQR            | 3–6               | 4–9                  | 4–14                          | 4–9                     | 4–12                    | 5–15             | 8–29.5                      | 8–35           | 4–9               |
| **Amputation** |                   |                      |                               |                         |                         |                  |                             |                |                   |
| n              | 6                 | 0                    | 5                             | 5                       | 0                       | 0                | 2                           | 0              | 18                |
| %              | 1.5               | 0                    | 5.8                           | 7.0                     | 0                       | 0                | 8.3                         | 0              | 2.4               |
| 95% CI         | 0.6–3.3           | -                    | 1.9–13.1                      | 2.3–15.7                | -                       | -                | 1–27                        | -              | 1.4–3.8           |
| **Died**       |                   |                      |                               |                         |                         |                  |                             |                |                   |
| n              | 6                 | 5                    | 2                             | 6                       | 0                       | 0                | 5                           | 1              | 25                |
| %              | 1.5               | 4.7                  | 2.3                           | 8.5                     | 0                       | 0                | 20.8                        | 12.5           | 3.3               |
| 95% CI         | 0.6–3.3           | 1.6–10.7             | 0.3–8.2                       | 3.2–17.5                | -                       | -                | 7.1–42.2                    | 0.3–52.7       | 2.2–4.9           |

https://doi.org/10.1371/journal.pntd.0008887.t003
Discussion

We observed an incidence of 647 SSTI admissions per 100,000. This rate is very high compared to the few other available reports from other parts of the world.[12–14] Patients admitted with a SSTI experienced a high CFR, up to 10.8% in those aged ≥65 years. Admissions with SSTI also imposed a substantial burden on the health care system with inpatient bed days for SSTIs over the surveillance period accounting for 10% of the hospital's total bed capacity.

Incidence per capita was highest in young children and in the elderly, consistent with the age-prevalence relationship observed for both scabies and impetigo in Fiji[2] providing support for the hypothesis that these conditions are substantial contributors to SSTIs. This hypothesis is further supported by the finding in our study that SSTIs grouped as more likely to be scabies-related had a higher incidence in the young and the elderly, while those we grouped as unlikely to be scabies-related were evenly distributed across all ages. There may be other factors that explain this distribution however, such as higher GAS pharyngeal carriage in children resulting in increased bacterial transmission, [22,23] or predisposing comorbidities such as Type 2 diabetes mellitus in older age groups.[24]

While our finding of a very low proportion of S. aureus positive skin swabs being methicillin resistant (4.6%) is consistent with previous studies in Fiji, [25] this is a much lower proportion compared to other populations such as the United States (46%), Latin America (29.4%), Europe (22.8%) and China (20%).[11,26,27] The proportion of skin swabs that were positive for gram-negative bacteria is consistent with that described in other island populations with similar proportions of Klebsiella pneumoniae.[28]

The overall CFR of 4.3%, was substantially higher than that reported in high- and other middle-income settings; studies in the US and China have reported CFRs of 0.4% and 2.4% respectively [26,29]. The reason for this difference is unclear; one possible explanation is late admission, supported by the finding that the majority (63.9%) of patients underwent surgery, compared to 44% and 37.1% in the US and China respectively.[26,29] We observed that patients in our study required a median length of stay of 8 days, 97% required intravenous antibiotics, 63.9% surgery and 4.2% required admission to the ICU (incidence 26.3 per 100,000), reflecting the severity of disease presentations.[26,30]

Comprehensive skin health measures including health promotion, environmental optimisation, dissemination of treatment guidelines and even screening can be moderately effective in reducing prevalence of scabies and impetigo,[31] but there are no studies of the impact of these interventions on more complicated SSTIs. Ivermectin-based MDA for scabies control has been shown to substantially reduce scabies and impetigo prevalence in Pacific Island communities.[4,32] However, there is no current information on whether this leads to prevention of more complicated bacterial SSTIs or invasive infections. We collected these data in the context of a large before-after intervention trial, delivering two doses of ivermectin-based MDA to the entire Northern Division of Fiji. The trial aims to determine the impact of ivermectin-based MDA on infectious complications of scabies, in particular, bacterial SSTIs.[4,32]

There are a number of limitations to our study. First, it is possible that the true incidence of scabies in our recruited cases was underestimated, because of “normalisation” of scabies by clinicians in endemic settings where scabies is very common.[33] The reliance on hospital procedures for assessment and diagnosis may have led to under-reporting of cases admitted to hospital with an SSTI. Second, the incidence of SSTI admissions we report here for the Northern Division is a lower bound to the true number of SSTI cases that require hospitalization, because some SSTIs requiring hospitalization but lower levels of surgical or medical intervention are managed at the three small subdivisional hospitals. When we restricted our analysis to residents of Macuata and used the population of Macuata as the denominator, the incidence of
SSTI admissions from within Macuata was three times higher than the combined incidence from the other subdivisions.

Our study highlights the very high disease burden of SSTIs in Fiji, especially among the extremes of age and iTaukei population. It is likely that there is a similarly high burden of SSTIs in other tropical scabies-endemic countries, including those in the Pacific region, and further studies are needed to better understand the epidemiology and health impact of SSTIs in these settings. Our findings highlight the need for investigation into strategies to reduce the incidence and impact of SSTIs in Fiji and in other tropical countries where SSTIs are common, including MDA for scabies.

Supporting information

S1 Fig. Selection approach for principal diagnosis.
(TIF)

S2 Fig. Median age at admission by condition. The line within the boxplot indicates the median age at admission in years, the upper and lower borders of the box represent the interquartile range, the error bars represent minimum and maximum values and dots represent outliers.
(TIF)

S3 Fig. Percentage of skin and soft tissue admissions diagnosed with scabies by age group. The columns demonstrate the percentage of patients admitted with skin and soft tissue infection that were also diagnosed with scabies.
(TIF)

S1 Table. Case fatality rate and incidence of death by age group.
(PDF)

S2 Table. Breakdown of positive culture results for skin swabs.
(PDF)

S3 Table. Breakdown of positive blood culture results.
(PDF)

S4 Table. Incidence of Staphylococcus aureus bacteraemia among admissions with skin and soft tissue infections by age group.
(PDF)

S1 Data. Full data set.
(XLSX)

Acknowledgments

We would like to acknowledge the Fiji Ministry of Health and Medical Services including Clinical, Microbiology, Recording and Administrative staff of Labasa Hospital for their support in enabling our data collection. We acknowledge Prof. Ross Andrews from Menzies School of Health Research, for his contribution to the study design. We would also like to thank Avinesh Prasad from the Fiji Bureau of Statistics for his assistance in releasing census data. We acknowledge Suzanna Vidmar at the Murdoch Children’s Research Institute for her assistance with data cleaning. We are very grateful to the patients and their family members for allowing us to document their time in hospital.
Author Contributions

Conceptualization: Daniel Engelman, Lucia Romani, John Kaldor, Andrew C. Steer.

Data curation: Li Jun Thean, Jyotishna Mudaliar, Jessica Paka.

Formal analysis: Li Jun Thean, Andrew C. Steer.

Funding acquisition: Lucia Romani, Handan Wand, Mike Kama, Joseph Kado, Natalie Carvalho, Margot Whitfeld, Andrew C. Steer.

Investigation: Li Jun Thean, Jyotishna Mudaliar, Jessica Paka, Tuliana Cua, Sera Taole.

Project administration: Li Jun Thean, Jyotishna Mudaliar, Aalisha Sahukhan, Andrew C. Steer.

Supervision: Daniel Engelman, Lucia Romani, John Kaldor, Andrew C. Steer.

Writing – original draft: Li Jun Thean.

Writing – review & editing: Adam Jenney, Daniel Engelman, Handan Wand, Jyotishna Mudaliar, Aalisha Sahukhan, Mike Kama, Meciusela Tuicakau, Joseph Kado, Natalie Carvalho, Margot Whitfeld, John Kaldor, Andrew C. Steer.

References

1. Romani L, Steer AC, Whitfeld MJ, Kaldor JM. Prevalence of scabies and impetigo worldwide: a systematic review. Lancet Infect Dis. 2015; 15(8):960–7. https://doi.org/10.1016/S1473-3099(15)00132-2 PMID: 26088526.

2. Romani L, Koroviuvela J, Steer AC, Kama M, Kaldor JM, Wand H, et al. Scabies and impetigo prevalence and risk factors in Fiji: a national survey. PLoS Negl Trop Dis. 2015; 9(3):e0003452. https://doi.org/10.1371/journal.pntd.0003452 PMID: 25738499; PubMed Central PMCID: PMC4349858.

3. Mason DS, Marks M, Sokana O, Solomon AW, Mabey DC, Romani L, et al. The Prevalence of Scabies and Impetigo in the Solomon Islands: A Population-Based Survey. PLoS Negl Trop Dis. 2016; 10(6): e0004803. https://doi.org/10.1371/journal.pntd.0004803 PMID: 27348119; PubMed Central PMCID: PMC4922659.

4. Romani L, Whitfeld MJ, Koroviuvela J, Kama M, Wand H, Tikoduadua L, et al. Mass Drug Administration for Scabies Control in a Population with Endemic Disease. N Engl J Med. 2015; 373(24):2305–13. https://doi.org/10.1056/NEJMoa1500987 PMID: 26650152.

5. Bowen AC, Mahé A, Hay RJ, Andrews RM, Steer AC, Tong SYC, et al. The Global Epidemiology of Impetigo: A Systematic Review of the Population Prevalence of Impetigo and Pyoderma. PLoS ONE. 2015; 10(8):e0136789. https://doi.org/10.1371/journal.pone.0136789 PMID: 26317533.

6. Karimkhani C, Delavalle RP, Coffeng LE, Flohr C, Hay RJ, Langan SM, et al. Global Skin Disease Morbidity and Mortality: An Update From the Global Burden of Disease Study 2013. JAMA Dermatol. 2017; 153(5):406–12. https://doi.org/10.1001/jamadermatol.2016.5538 PMID: 28249066.

7. Fiji Ministry of Health and Medical Services. Health Status Report 2016. In: Health Information Research and Analysis, editor. 2016.

8. Tong SYC, Davis JS, Eichenberger E, Holland TL, Fowler VG. Staphylococcus aureus Infections: Epidemiology, Pathophysiology, Clinical Manifestations, and Management. Clin Microbiol Rev. 2015; 28 (3):603–61. https://doi.org/10.1128/CMR.00134-14 PMID: 26016486.

9. Carapetis JR, Steer AC, Mulholland EK, Weber M. The global burden of group A streptococcal diseases. Lancet Infect Dis. 2005; 5(11):685–94. Epub 2005/10/29. S1473-3099(05)70267-X [pii]. https://doi.org/10.1016/S1473-3099(05)70267-X PMID: 16253886.

10. Poulakou G, Lagou S, Tsiodras S. What’s new in the epidemiology of skin and soft tissue infections in 2018? Curr Opin Infect Dis. 2019; 32(2):77–86. https://doi.org/10.1097/QCO.0000000000000527 PMID: 30884027.

11. Linder KE, Nicolau DP, Nailor MD. Epidemiology, treatment, and economics of patients presenting to the emergency department for skin and soft tissue infections. Hosp Pract (1995). 2017; 45(1):9–15. https://doi.org/10.1080/21549831.2017.1279819 PMID: 28652987.

12. Miller L, Eisenberg D, Liu H, Chang C, Wang Y, Luthra R, et al. Incidence of skin and soft tissue infections in ambulatory and inpatient settings, 2005–2010. BMC Infect Dis. 2015; 15(362).
13. Harch SAJ, MacMorran E, Tong SYC, Holt DC, Wilson J, Athan E, et al. High burden of complicated skin and soft tissue infections in the Indigenous population of Central Australia due to dominant Panton Valentine leuococcinid clones ST93-MRSA and CC121-MSSA. BMC Infect Dis. 2017; 17(1):405. https://doi.org/10.1186/s12879-017-2460-3 PMID: 28592231.

14. O’Sullivan CE, Baker MG, Zhang J. Increasing hospitalizations for serious skin infections in New Zealand children, 1990–2007. Epidemiol. Infect. 2011; 139(11):1794–804. Epub 12/15. https://doi.org/10.1017/S0950268810002761 PMID: 21156094.

15. Fiji Islands Bureau of Statistics. 2017 Population and Housing Census Release 1. www.statsfijigov.fj; Fiji Bureau of Statistics; 2018.

16. Census 2007 Results: Population Size, Growth, Structure and Distribution [Internet]. 2008

17. The Human Development Reports Office. Human Development Report 2019. New York: United Nations Development Programme, 2019.

18. World Health Organization. Regional Office for the Western Pacific, Asia Pacific Observatory on Health Systems and Policies. The Fiji Islands health system review. Health Systems in Transition. 2011;1(1).

19. Harris PA, Taylor R, Minor BL, Elliott V, Fernandez M, O’Neal L, et al. The REDCap consortium—Building an international community of software platform partners. J Biomed Inform. 2019; 95:103208. https://doi.org/10.1016/j.jbi.2019.103208 PMID: 31078660.

20. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009; 42(2):377–81. https://doi.org/10.1016/j.jbi.2008.08.010 PMID: 18929666; PubMed Central PMCID: PMC2700030.

21. Fiji Islands Bureau of Statistics. 03_Relationship-Ethnicity-and-Religion-by_Province-of-Enumeration_data. Fiji-2007. Census 2007 General Tables. 2007.

22. Oliver J, Mallya Wadu E, Piersse N, Moreland NJ, Williamson DA, Baker MG. Group A Streptococcus pharyngitis and pharyngeal carriage: A meta-analysis. PLOS Neglected Tropical Diseases. 2018; 12(3):e0006335. https://doi.org/10.1371/journal.pntd.0006335 PMID: 29554121

23. Steer AC, Jenney AWJ, Kado J, Good MF, Batzloff M, Magor G, et al. Prospective Surveillance of Streptococcal Sore Throat in a Tropical Country. The Pediatric Infectious Disease Journal. 2009; 28(6):477–82. https://doi.org/10.1097/INF.0b013e318191b2af PMID: 19483515

24. Fiji Ministry of Health and Medical Services, World Health Organization. Fiji NCD Risk Factors STEPS REPORT 2011. 2011.

25. Jenney A, Holt D, Ritiika R, Southwell P, Pravin S, Buadromo E, et al. The clinical and molecular epidemiology of Staphylococcus aureus infections in Fiji. BMC Infect Dis. 2014; 14:160. Epub 2014/03/25. https://doi.org/10.1186/1471-2253-14-160 PMID: 24655406; PubMed Central PMCID: PMC3998116

26. Li X, Chen Y, Gao W, Ouyang W, Wei J, Wen Z. Epidemiology and Outcomes of Complicated Skin and Soft Tissue Infections among Inpatients in Southern China from 2008 to 2013. PLoS ONE. 2016; 11(2):e0149960. https://doi.org/10.1371/journal.pone.0149960 PMID: 26918456

27. Moet GJ, Jones RN, Biedenbach DJ, Stilwell MG, Fritsche TR. Contemporary causes of skin and soft tissue infections in North America, Latin America, and Europe: report from the SENTRY Antimicrobial Surveillance Program (1998–2004). Diagn Microbiol Infect Dis. 2007; 57(1):7–13. https://doi.org/10.1016/j.diagmicrobio.2006.05.009 PMID: 17059876.

28. Guerrier G, de Montera A-M, Mousset M, Steer A. Incidence of surgically drained cutaneous abscess in relation to climate in Mayotte, Comoros. Trop Doct. 2014; 44(2):77–81. Epub 12/09. https://doi.org/10.1177/0049475513515653 PMID: 24322764.

29. Lipsky BA, Moran GJ, Napolitano LM, Vo L, Nicholson S, Kim M. A prospective, multicenter, observational study of complicated skin and soft tissue infections in hospitalized patients: clinical characteristics, medical treatment, and outcomes. BMC Infect Dis. 2012; 12(1):227. https://doi.org/10.1186/1471-2334-12-227 PMID: 23009273

30. Secombe P, Planche Y, Athan E, Oliapalli J. Critical care burden of skin and soft tissue infection in Central Australia: More than skin deep. Aust J Rural Health. 2019; 27(6):550–6. https://doi.org/10.1111/ajr.12539 PMID: 31880053

31. May PJ, Tong SYC, Steer AC, Currie BJ, Andrews RM, Carapetis JR, et al. Treatment, prevention and public health management of impetigo, scabies, crusted scabies and fungal skin infections in endemic populations: a systematic review. Trop Med Int Health. 2019; 24(3):280–93. https://doi.org/10.1111/tmi.13198 PMID: 30582783

32. Romani L, Marks M, Sokana O, Nasi T, Kamoriki B, Cordell B, et al. Efficacy of mass drug administration with ivermectin for control of scabies and impetigo, with coadministration of azithromycin: a single-arm community intervention trial. Lancet Infect Dis. 2019; 19(5):510–8. https://doi.org/10.1016/S1473-3099(18)30790-4 PMID: 30956111
33. Yeoh DK, Anderson A, Cleland G, Bowen AC. Are scabies and impetigo "normalised"? A cross-sectional comparative study of hospitalised children in northern Australia assessing clinical recognition and treatment of skin infections. PLoS Negl Trop Dis. 2017; 11(7):e0005726. https://doi.org/10.1371/journal.pntd.0005726; PMID: 28671945; PubMed Central PMCID: PMC5510902.
Author/s:
Thean, LJ; Jenney, A; Engelman, D; Romani, L; Wand, H; Mudaliar, J; Paka, J; Cua, T; Taole, S; Sahukhan, A; Kama, M; Tuicakau, M; Kado, J; Carvalho, N; Whitfeld, M; Kaldor, J; Steer, AC

Title:
Hospital admissions for skin and soft tissue infections in a population with endemic scabies: A prospective study in Fiji, 2018-2019

Date:
2020-12-01

Citation:
Thean, L. J., Jenney, A., Engelman, D., Romani, L., Wand, H., Mudaliar, J., Paka, J., Cua, T., Taole, S., Sahukhan, A., Kama, M., Tuicakau, M., Kado, J., Carvalho, N., Whitfeld, M., Kaldor, J. & Steer, A. C. (2020). Hospital admissions for skin and soft tissue infections in a population with endemic scabies: A prospective study in Fiji, 2018-2019. PLOS NEGLECTED TROPICAL DISEASES, 14 (12), https://doi.org/10.1371/journal.pntd.0008887.

Persistent Link:
http://hdl.handle.net/11343/272282

File Description:
Published version

License:
CC BY