Costs of primary healthcare visits and hospitalizations for scabies and related bacterial skin infections in Fiji, 2018-2019

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# Abstract

Scabies and related bacterial skin and soft tissue infections (SSTIs) are highly prevalent in many tropical, low- and middle-income settings. These skin conditions contribute to higher healthcare costs and burdens on healthcare systems. The Big Skin Health Intervention Fiji Trial (“Big SHIFT”) carried out surveillance for scabies and related SSTIs from July 2018 to June 2019 in the Northern Division of Fiji, an area with high prevalence of scabies, prior to a division-wide ivermectin-based mass drug administration campaign. Using data from Big SHIFT, we sought to estimate the annual direct medical costs of **scabies and related SSTIs** for the Northern Division and extrapolate these costs to the national level. We also assessed **non-scabies-related SSTIs**. We categorized SSTIs as being potentially scabies-related or not scabies related, based on a previous study. The analysis used a health system perspective, with the main resource use categories of health services (clinic visits and bed days), medications, and diagnostics. We extrapolated the total annual number of cases and direct medical costs for all divisions in Fiji based upon previous scabies prevalence data across all divisions. The average cost per outpatient case for scabies was US$12.4, and for scabies-related SSTI was **US$X**. The average cost per hospital admission for scabies-related SSTI case was US$449, and for non-scabies-related SSTI was US$763. The estimated annual direct medical costs of scabies and related SSTIs in Fiji was FJ$7.1 million (US$3.1 million), with cost per capita of FJ$ 8.0 (US$ 3.6). Scabies and SSTIs lead to a heavy economic burden in Fiji and prevention would reduce these healthcare costs.

# Introduction

Scabies is a contagious and itchy skin infestation caused by the mite *Sarcoptes scabiei* var*. hominis* that can lead to secondary bacterial skin and soft-tissue infections (SSTIs). Scabies promotes bacterial SSTIs by causing breaches in the skin. SSTIs range in severity from impetigo and other uncomplicated infections which can be generally treated in primary healthcare (PHC) settings ([1](#_ENREF_1)), while necrotizing fasciitis and other complicated SSTIs usually require hospital admission ([2](#_ENREF_2)). In 2017, The World Health Organization (WHO) recognized scabies as a neglected tropical disease (NTD) following recommendation from the Strategic and Technical Advisory Group for NTDs ([3](#_ENREF_3)). In 2019, the Global Burden of Disease study estimated that the global prevalence of scabies was 2.4% (185 million) **(**[4](#_ENREF_4)**).**

The Pacific region has a high scabies burden, comprising eight out of the top ten countries with the highest age-standardized disability-adjusted life-years (DALYs) due to scabies ([5](#_ENREF_5)). In the Skin Health Intervention Fiji Trial (SHIFT) conducted between 2012–2013 , scabies prevalence was measured at 36.4% and impetigo prevalence at 23.4% among residents of three islands of Fiji ([6](#_ENREF_6)). In Fiji, scabies is often initially treated with traditional medicines, and many individuals only seek medical care for prolonged disease or if secondary skin infection develops ([7](#_ENREF_7)). In addition, treatment adherence of the household contacts of affected individuals is often low, leading to ongoing disease and perpetuation of community transmission and further burden on the health system. In 2016, the Fiji Government annual Health Status Report reported that SSTIs caused 4.3% of mortality within the country ([8](#_ENREF_8)).

There is limited evidence globally regarding the cost of scabies and related SSTIs, although the apparent need for healthcare services suggests a high economic burden. A 2018 cost-of-illness analysis for treatment of crusted scabies among Aboriginal communities in the Northern Territory of Australia found health care costs per patient diagnosed with crusted scabies were over $AU 35,000. We found no cost-of-illness study on of scabies or related SSTIs from the Pacific. Quantifying these costs would contribute to a more accurate estimate of the global burden of scabies, further delineating the benefits of scabies control and informing future evaluation of scabies prevention programs. Therefore, we sought to estimate the annual direct medical costs of scabies and related SSTIs in Fiji.

Methods

## Study design and setting

The Northern Division is one of four primary administrative units of Fiji, and has a population of 131,914 people (2017 census) REF. Healthcare in Fiji comprises a government public healthcare system and a smaller private healthcare sector ([9](#_ENREF_9)). Government health facilities provide most healthcare services, which are free to the public or provided at very low out-of-pocket cost. Public health facilities charge user fees for some services, but these fees are modest and some groups such as children aged less than 15 years are exempted from these charges. In 2020, about FJ$300 million (US$XXX million) from the Fiji government’s revenue was allocated to health.

The Big Skin Health Intervention Fiji Trial (Big SHIFT) was a before-after intervention trial of ivermectin-based mass drug administration delivered to the whole population of the Northern Division of Fiji ([10](#_ENREF_10)). Before drug administration, Big SHIFT established a monthly reporting system at all public healthcare facilities for presentations of scabies and SSTIs over a 50-week period (from 16 July 2018 to 30 June 2019) ([1](#_ENREF_1)). Data on patients presenting to the outpatient departments at subdivisional hospitals, health centers and nursing stations were prospectively collected using a dedicated data collection tool. Data on scabies among children was also collected via the Integrated Management of Childhood Illness (IMCI) clinics. Staff at all primary healthcare facilities reported presentations of scabies and bacterial SSTIs (infected scabies, impetigo, cellulitis, abscess, and severe SSTIs) – we considered all these bacterial SSTIs to be potentially scabies related. We included all scabies and SSTI cases diagnosed in general outpatient departments, emergency departments, IMCI clinics, during school visits, and during community outreach. Staff collected data regarding treatment, such as the antibiotic prescribed, surgical procedures performed, referral to a larger health facility, and day admission in the health facility.

The trial also carried out prospective surveillance of SSTI admissions at the divisional hospital in Labasa over a 48-week period (between July 16 2018 and June 30 2019, with a 2-week break between 24 December 2018 and 6 January 2019) ([2](#_ENREF_2)). Cases of scabies and SSTIs were prospectively identified by reviewing admission registries and case notes of all newly admitted cases at the hospital daily. Informed consent was obtained from suitable patients to be included in the study. The microbiology laboratory records in the hospital were reviewed for skin swabs to identify potential cases for enrolment in our study ([11](#_ENREF_11)). Hospital admissions for SSTIs were categorized into two groups: those likely scabies-related (infected scabies, impetigo, abscess, cellulitis, pyomyositis, necrotizing fasciitis with pure growth of *Staphylococcus aureus* or *Streptococcus* *pyogenes*, and crusted scabies), and those unlikely to be scabies related (wound infections, surgical wound infections, and necrotizing fasciitis without pure growth of *S. aureus* or *S. pyogenes*) ([2](#_ENREF_2)).

## Costing procedure

We conducted a cost-of-illness study to estimate the cost per case of scabies and related SSTI from a health system perspective using baseline data from the Big SHIFT trial. We undertook a health system perspective because public provision of most outpatient and inpatient care is free in Fiji and user fees are insignificant to the overall health expenditure in government facilities ([9](#_ENREF_9)). The main resource use categories were health services clinic visits, diagnostic procedures, and medicines. Adopting a health systems perspective meant we did not consider costs of productivity losses from premature death, SSTI-related work/school absenteeism or other social impacts. The costs of all new cases of scabies and SSTIs were estimated with respect to their treatment in two settings: PHC (IMCI clinics, general outpatient clinics, emergency departments, school visits, and during community outreaches); and hospital admissions at Labasa Hospital, the main referral hospital in the Northern Division of Fiji.

We measured the frequency of healthcare service use for PHC visits and hospitalizations as the number of PHC presentations and hospital bed days, respectively. We assumed that patients admitted during PHC presentations only stayed at the facility for one night. Our hospital admissions dataset included the number of days spent in the intensive care unit (ICU) and the number of bed days in general wards. The data did not include follow-up visits and repeated presentations for the same condition. The number of diagnostic procedures was calculated as the sum of skin swabs, blood cultures and tissue cultures taken from patients admitted to the hospital.

To estimate the quantities of medications, we supplemented the utilization data collected in the trial with published treatment guidelines for scabies and SSTIs in Fiji ([12](#_ENREF_12), [13](#_ENREF_13)). For outpatient cases, we did not have the names of medications prescribed, but only the formulations. Therefore, using the guidelines, we considered patients treated with topical medications were given permethrin cream for scabies. We considered that to treat the whole family as recommended in the guidelines, one tube of the cream would be sufficient. Similarly, we used benzathine penicillin injection (single dose) and co-trimoxazole (five days dosage) for those given injection and oral medications, respectively, as recommended by Fiji guidelines for treatment of scabies-related SSTIs (cellulitis, abscess, and impetigo).REFERENCE

The hospital admissions dataset included the name of medication and number of days prescribed during admission and on discharge, but not the dosage. Therefore, we categorized patients into age groups (less than 5 years, 5 to 9 years, 10 to 14 years, and 15 years and above), and then calculated the dosage using the median weight of the average age for each age group based on WHO child growth standards ([14](#_ENREF_14)). For instance, a body weight of 11kg is used for a patient less than 5 years old because that is the median weight of a 2 year 6 months old child ([14](#_ENREF_14)). If the child was prescribed cloxacillin injection (dosage 50mg/kg up to 2000mg daily every six hours), we assumed the dose was 550mg and the daily dose was 2200mg. Each vial of cloxacillin contains 500mg, so five vials (2500mg) would be sufficient for one day. Finally, where the dosage calculated was greater than the recommended adult dose, the adult dose was used instead. Table S1 details the daily quantities of oral and injection medications used in the costing exercise.

Each unit of resource utilized by each individual patient was multiplied by unit prices (Table 1) to estimate the cost of each resource utilized by the individual patient. The unit costs of a hospital bed-day, ICU bed-day, and laboratory tests were obtained from a 2012 costing study of selected health facilities in Fiji ([15](#_ENREF_15)) and WHO-CHOICE estimates for healthcare service costs per bed-day (for hospitalized patients) or per outpatient visit at tertiary level hospitals in Fiji ([16](#_ENREF_16), [17](#_ENREF_17)). The WHO-CHOICE estimates include personnel (healthcare providers and support staff salary), capital, and patient food costs but exclude the cost of drugs and diagnostic tests ([17](#_ENREF_17)). The Fiji study reported cost estimates of various healthcare services in two hospitals (Lautoka Hospital and Colonial War Memorial Hospital (CWMH) and Nausori PHC in Fiji. We used the same unit costs for patients admitted during PHC presentations because the unit costs for Nausori PHC were higher than that of the two hospitals in the costing study ([15](#_ENREF_15)).

We used unit cost of outpatient visits in Nausori PHC as the base case for PHC presentations in our study. We had three estimates available for the cost per bed day (Lautoka, CWMH, and WHO-CHOICE), so we used the median of the three values (CWMH) as the base case for those admitted to general wards. We had two estimates for cost per bed day in ICU (Lautoka and CWMH), so we used the average of the two values as the base case for those in ICU. Also, we had two estimates for cost per laboratory test (Lautoka and CWMH), so we used the average of the two values as the base case for every test. Cost of surgical procedures were not estimated separately because it was captured in the unit cost of hospital bed-days based on the Irava costing study. Lastly, unit costs of medicines were largely based on procurement prices collected at CWMH Pharmacy, and supplemented with Fijian Competition and Consumer Commission (FCCC) information ([18](#_ENREF_18)), or the third edition of ‘Fiji Essential Medicines List’ published in 2013, where unit costs were unavailable ([13](#_ENREF_13)).

Table 1. Unit costs (in 2020 Fiji dollars) used in the costing study.

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Base case**  **(low—high)** | **Source and notes** |
| Cost per outpatient visit | 25.2  (12.7—63.1) | Base case is the estimate for Nausori PHC facility, reported in Irava ([15](#_ENREF_15)). Low value is the estimate from WHO-CHOICE for a PHC facility with beds ([17](#_ENREF_17)). High value is for Lautoka hospital in Irava ([15](#_ENREF_15)). |
| Cost per hospital bed-day (ward) | 122.1  (94.0—132.9) | Base case is the estimate for CWMH reported in Irava costing study ([15](#_ENREF_15)). Low value is the estimate from WHO-CHOICE for a tertiary hospital ([17](#_ENREF_17)). High value is for Lautoka hospital, reported in Irava ([15](#_ENREF_15)). |
| Cost per hospital bed-day (ICU) | 547.8  (259.1—836.6) | Low and high values use estimates for CWMH and Lautoka hospital, reported in Irava ([15](#_ENREF_15)). Base case is average of the two values. |
| Cost per laboratory test | 28.3  (24.6—32.1) | Low and high values use estimates for CWMH and Lautoka hospital, reported in Irava ([15](#_ENREF_15)). Base case is average of the two values. |
| Cost of medicines | see S2 Table | FCCC prices (Quarter 1 2020) and Fiji essential medicines list, 3rd edition. |

CWMH, Colonial War Memorial Hospital; FCCC, Fijian Competition and Consumer Commission; ICU, intensive care unit; PHC, primary healthcare; WHO, World Health Organization; CHOICE, choosing Interventions that are cost-effective.

## Cost analysis

### Direct medical costs per case

The cost of each resource utilized by an individual patient was added to obtain the average direct medical cost of treatment of one case, separately by principal diagnoses. Principal diagnoses for hospital admitted cases were categorized into two groups: potentially scabies-related admissions, and unlikely scabies-related admissions ([2](#_ENREF_2)).

Costs are reported in 2020 Fijian dollars (FJ$) and United States dollars (US$). Costs obtained in previous years were adjusted to 2020 prices using the gross domestic product implicit price deflator following best practice guidance ([19](#_ENREF_19)). Costs obtained in previous years and different currencies were converted to FJ$ using the exchange rate in that year ([20](#_ENREF_20)), before adjusting to 2020 prices. We assumed scabies as an acute disease and we did not account for any healthcare costs accruing beyond one year, and therefore did not apply any discounting ([21](#_ENREF_21)).

### Total annual direct medical costs

We estimated the total annual direct medical costs of scabies and related SSTIs in the Northern Division, and then extrapolated this total cost to the other primary administrative units in Fiji to estimate the overall annual economic burden of scabies and related SSTIs at a national level. We did the same for admissions for non scabies-related SSTIs also.

We first converted incidence rates for scabies and SSTI presentations into a risk of infections over one year, using the following formulae:

Then, we calculated the risk ratio (RR) of scabies- or non scabies-related infections for each of the four categories using the odds ratio (OR) of scabies infestation between the Northern division and other Fiji divisions, assuming the same ratio holds for SSTIs. A study by Romani ([22](#_ENREF_22)) indicated that scabies was most prevalent among residents of the Northern division compared with other regions (adjusted OR, 1.3).

From this risk ratio, we calculated the risk of infections for all other divisions in Fiji:

Finally, we multiplied the risk of infection with the population for Northern division of Fiji (131,914) and other Fiji divisions (752,973) based on 2017 Fiji population census data and summing up the values.

The total number of cases was then multiplied by the respective average per-case direct medical cost (separately for scabies PHC presentations, SSTI PHC presentations, scabies-related admissions, and non scabies-related admissions). The total scabies-related cost was calculated by adding costs of scabies and SSTI presentations to costs of potentially scabies-related admissions. Likewise, the non-scabies-related cost was calculated by adding costs of SSTI presentations to costs of unlikely scabies-related admissions. The total direct medical cost was calculated by adding the costs of all presentations and all admissions.

### Sensitivity analysis

A one-way sensitivity analysis was conducted to examine how sensitive the cost estimates were to variations in unit cost given the underlying uncertainty in some of the key unit cost input estimates. Patients presenting to outpatient settings were seen in various settings (general outpatient departments, emergency departments, IMCI clinics, during school visits, and during community outreaches). Therefore, we used WHO-CHOICE health center with beds as lower value (all were seen in PHCs or clinics) and Lautoka hospital (assuming all were seen in subdivisional or divisional hospital) as higher value. WHO-CHOICE estimates for cost per hospital bed day were lower than those in the 2012 Fiji costing study, so we used the WHO-CHOICE estimates as the lower value and higher of the two hospitals in the costing study (Lautoka hospital) as the higher estimate to examine potential variations in hospital bed-day unit cost. For ICU, our base case used an average of estimates in Irava ([15](#_ENREF_15)), so we used the lesser of the two values (Lautoka Hospital) as the low value and the greater (CWMH) as the high value. For laboratory tests, used wide (±50%) variation to reflect reasonable uncertainty. The results of the sensitivity analysis were reported in a tornado chart.

All analyses were conducted using R version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria).

## Ethics statement

The study was performed as part of the Big SHIFT trial investigating the effects of ivermectin-based mass drug administration for the control of scabies and SSTIs (ACTRN12618000461291). Ethical approval for Big SHIFT was granted by the Fiji National Health Research Ethics Review Committee (2018.38.NOR) and the Royal Children’s Hospital Human Research Ethics Committee in Melbourne, Australia (38020).

# Results

## Patient characteristics

Over a 50-week period between July 2018 and June 2019, 3,643 patients presented with scabies to PHC, and 10,093 presented with SSTI (Table 1) . Over 80% of PHC presentations were patients of iTaukei ethnicity. At the time of presentation, the median age was 5 years for scabies patients and 15 years for SSTI patients. 108 patients required admission to the health facility.

In the 48-week hospital surveillance period, 569 patients were admitted to hospitals with scabies-related SSTIs, and 179 with non scabies-related SSTIs (total 788, Table 1). Clinical data were available for 748 patients who provided consent for BigSHIFT to obtain demographic and clinical data. I DON’T LIKE REPEATING DATA THAT IS ALREADY IN TABLES INTO THE TEXT – THE READER CAN READ THE TABLES!

Table 2. Characteristics of primary health care and hospitalized patients with skin and soft tissue infections between July 2018 and June 2019 in Northern Division, Fiji (PHC: primary health care; SSTI: skin and soft tissue infection).

| **Characteristic** | **PHC presentations** | | **Hospital admissions** | |
| --- | --- | --- | --- | --- |
|  | Scabies, N=3,643 | SSTIs, N=10,093 | Potentially scabies-related SSTIs, N=569 | Unlikely scabies-related SSTIs, N=179 |
| Sex, no. (%) |  |  |  |  |
| Male | 1,914 (53%) | 5,560 (55%) | 299 (53%) | 105 (59%) |
| Female | 1,706 (47%) | 4,481 (45%) | 270 (47%) | 74 (41%) |
| Age in years, median (IQR) | 5 (1, 9) | 15 (3, 36) | 33 (9, 55) | 35 (21, 54) |
| Age category in years, no. (%) |  |  |  |  |
| 0-4 | 2,009 (55%) | 3,182 (32%) | 110 (19%) | 12 (6.7%) |
| 5-14 | 1,228 (34%) | 1,907 (19%) | 68 (12%) | 21 (12%) |
| 15+ | 384 (11%) | 4,814 (49%) | 391 (69%) | 146 (82%) |
| Ethnicity, no. (%) |  |  |  |  |
| I-Taukei | 3,080 (86%) | 8,160 (82%) | 384 (67%) | 124 (69%) |
| Others | 482 (14%) | 1,782 (18%) | 185 (33%) | 55 (31%) |
| Residence, no. (%) |  |  |  |  |
| Urban | 1,723 (47%) | 5,227 (52%) | NA | NA |
| Rural | 1,920 (53%) | 4,866 (48%) | NA | NA |
| Bed days, median (IQR) | NA | NA | 5 (3, 8) | 7 (4, 15) |

Percentages may not total 100 due to rounding. IQR, interquartile range; NA, not available; PHC, primary healthcare; SSTIs, skin and soft tissue infections.

## Health service utilization and costs

### Primary health care patients

The average cost per outpatient case of scabies was US$XX.X and for SSTI was US$XX.X (Table 3, Table S3). Topical medications were prescribed for 2,972 (81.6%) patients presenting with scabies (Table S4). Oral antibiotics were prescribed for 1,508 (41.4%) of scabies patients and 84.3% of patients presenting with SSTIs. Intramuscular antibiotics were prescribed for 26.8% of scabies patients and 50.8% of SSTI patients.

Table 3. Mean (standard deviation) costs per patient in 2020 Fiji dollars by resource use category of scabies- and non-scabies-related SSTIs in Northern Division, Fiji

| **Characteristic** | **PHC presentations** | | **Hospital admissions** | |
| --- | --- | --- | --- | --- |
|  | Scabies, N=3,643 | SSTIs, N=10,093 | Potentially scabies-related SSTIs, N=569 | Unlikely scabies-related SSTIs, N=179 |
| Health services | 25.3 (3.5) | 26.4 (12.4) | 911 (999) | 1,547 (1,792) |
| Medications | 1.6 (0.9) | 1.6 (0.9) | 42 (54) | 82 (153) |
| Diagnostic tests | 0.0 (0.0) | 0.0 (0.0) | 22 (17) | 26 (12) |
| Mean total costs | 26.9 (3.6) | 28.0 (12.3) | 974 (1,036) | 1,655 (1,872) |

Values in parenthesis are standard deviations. PHC, primary healthcare; SSTIs, skin and soft tissue infections.

### Hospital admissions

The mean length of hospital stay for patients scabies-related SSTIs was 6.9 days (non scabies-related SSTI was 11.6 days; overall 8.0 days). Admission to ICU was required for 3.9% of scabies-related SSTI (5.6% for non scabies-related SSTI). All admitted patients required antibiotics, with flucloxacillin and cloxacillin being the most frequently prescribed oral and injectable antibiotic, respectively. Injectable antibiotics were prescribed for a mean duration of 4.9 days scabies-related SSTI. Oral antibiotics were prescribed for a mean duration of 8.6 days. Surgery was required for 64.2% of patients (commonly incision and drainage, dressing and debridement). Laboratory tests (including blood cultures, tissue cultures, and skin swabs) were conducted among 72% (CORRECT???) of patients with scabies-related SSTI.

The average cost per hospital admitted case of scabies-related SSTI was FJ$974 (FJ$1,655 for non scabies-related SSTI, Table 3). The average ward bed day cost for scabies-related SSTI was FJ$821, and ICU bed-day cost was FJ$90 per patient.. Approximately 93% of direct medical costs were for hospital bed days. No costs were recorded for surgical procedures (including amputation), because these are assumed to be incorporated in the cost per bed day, based on the unit cost estimate from the Irava 2010 costing study ([15](#_ENREF_15))

## Total annual healthcare costs for Fiji

Extrapolating the data from the Northern Division to the rest of Fiji, the estimated annual number of PHC presentations for scabies and SSTIs was 75,685, and the estimated number of hospital admissions for scabies-related SSTIs was XXXX (equivalent to about XX,XXX hospital bed days) across all Fiji divisions (Table 4). The estimated annual direct medical costs of scabies and related SSTIs in Fiji between 2018 and 2019 was FJ$3.8 million (FJ$3.2 million for non-scabies infestations; total $7.0 million). One-way sensitivity analysis indicated that variations in the cost per outpatient visit had the biggest influence on the total cost of scabies and SSTIs in Fiji (Figure 1). In all sensitivity analyses, the lowest annual cost was at least FJ$6.1 million.

Table 4. Estimated total annual number of cases, hospitalizations, and costs (in 2020 Fiji dollars) of scabies- and non-scabies-related SSTIs, extrapolated to all four divisions in Fiji based on 2017 census figures.

| Component | Scabies and scabies-related SSTIs | Non-scabies related SSTIs | Scabies and all SSTIs |
| --- | --- | --- | --- |
| Number of PHC presentations | 20,311 | 55,374 | 75,685 |
| Number of hospital admissions | 3,330 | 1,048 | 4,378 |
| Cost of PHC presentations only | 545,962 | 1,552,275 | 2,098,237 |
| Cost of hospital admissions only | 3,244,966 | 1,734,721 | 4,979,687 |
| Total cost for PHC and hospital | 3,790,928 | 3,286,996 | 7,077,924 |
| Cost per capita (person) | 4.3 | 3.7 | 8.0 |

PHC, primary healthcare; SSTI, skin and soft tissue infection

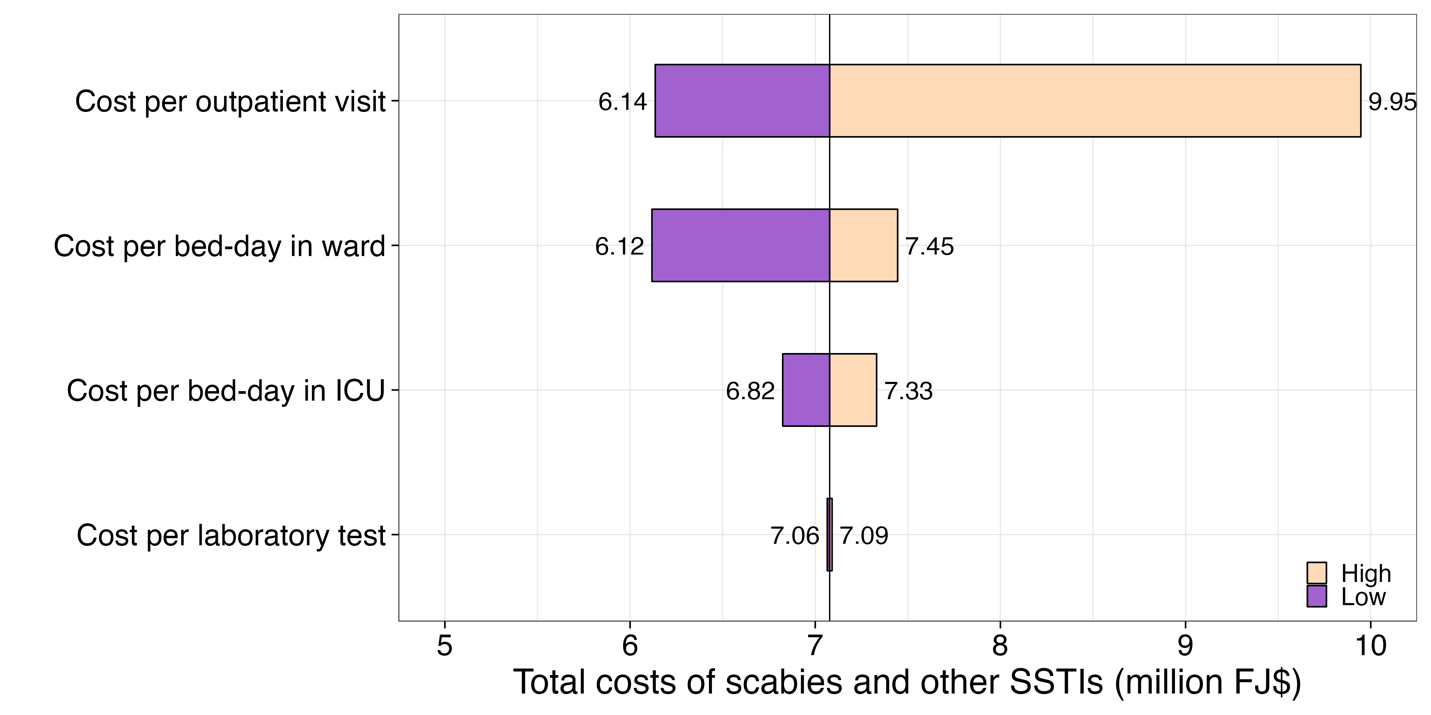


Figure 1. Total costs (in 2020 FJ$) of scabies (purple) and non-scabies (pink) skin and soft-tissue infections IS THIS THE SENSITIVITY ANALYSIS?

# Discussion

Our study provides a first estimate of the healthcare resource use and costs of treating scabies and related SSTIs in a highly prevalent setting prior to a mass drug administration programme. We used before-intervention data from the BigSHIFT trial and extrapolated these costs to the entire country. The trial provided rich information on PHC presentation and hospital admissions for scabies and related SSTIs. The estimated annual direct medical costs of scabies and related SSTIs in Fiji was FJ$ 7.1 million (approximately US$ 1.8 million), equivalent to 2.4% of government revenues allocated to health in 2020. Scabies and related SSTIs therefore lead to a heavy economic burden in Fiji, raising the potential benefit of prevention programs.

The average costs in this study were generally lower than other estimates which were carried out in high income countries. The average cost per patient with scabies and related SSTIs for hospital admitted cases in our study was US$736, compared to an estimated per-patient cost of US$10,499 for hospital treatment of pediatric scabies and pyoderma in an Australian study in 2019 ([23](#_ENREF_23)). In our study, the average cost of treatment of a case of scabies in an outpatient setting was US$126.9 compared to the average cost of treating a case of scabies in outpatient care in the United States was US$216 in 2019 ([24](#_ENREF_24)), where the cost estimate was based on claims for a privately insured population. WHO-CHOICE estimates show that healthcare services in USA and Australia are generally more expensive when compared to Fiji, so this is a possible explanation for the difference.

The main resource use category contributing to costs was hospital bed days. The mean length of stay in our study for scabies related SSTI was (6.9 days), higher than the mean of 4.5 reported in an Australian paediatric study ([25](#_ENREF_25)). It is plausible that delayed detection and normalization of skin infections contribute to complications of scabies. In countries endemic for scabies like Fiji, patients may not seek treatment of scabies unless it creates a significant disturbance to their quality of life ([26](#_ENREF_26)). The average cost of medicines for treatment of outpatient scabies in our study was $1.6 (2019 USD), which was similar to the estimated cost of medicines for treatment of outpatient pneumonia in Fiji ([27](#_ENREF_27)); in that study, the average cost of medicines ranged from $1.3 for Nausori PHC to $2.6 for CWMH (in 2020 USD values).

We assumed that bacterial SSTI presentations to PHC (infected scabies, impetigo, abscess and cellulitis) and a range of bacterial SSTI requiring hospital admission (infected scabies, impetigo, abscess, cellulitis, pyomyositis, necrotizing fasciitis) were wholly related to scabies. It is likely that these assumptions over-estimated the attribution of bacterial skin infection to scabies, and therefore over-inflated the economic burden of scabies-related skin infection. This attribution may be direct (an individual has scabies and their scabies lesions become infected with bacteria) or indirect (the burden of scabies in the community promotes higher rates of bacterial skin infection within that community and so transmission and exposure to these bacteria is vastly increased). While there are few data to guide the attribution of bacterial skin infection to scabies in highly endemic settings, two lines of evidence suggest that impetigo is highly associated with scabies in Fiji and other Pacific island countries. First, the population attributable risk of impetigo to scabies has ranged from X to X% in studies in Fiji and the Solomon Islands. Second, substantial reductions in scabies prevalence (~90%) after ivermectin-based mass drug administration have resulted in reductions of 67-75% in impetigo prevalence (without dedicated impetigo treatment).

A strength of our study is that we analysed PHC data obtained from a trial that was conducted among the entire population of the Northern Division of Fiji, including among children and the elderly. However, hospital surveillance was only possible at Labasa Hospital, the main referral center for the division. The Northern Division is made up of four subdivsions, and Labasa Hospital is located in Macuata subdivision; about 74% of all admissions to Labasa hospital were among residents of Macuata subdivision, and so it is likely that we missed admissions at subdivisional hospitals, thereby underestimating the overall burden. Furthermore, we may have also underestimated the burden by: 1) missing SSTI cases that were not recognized by clinicians because clinicians are known to normalize scabies in endemic setings (REF); 2) missing cases that were recognized and treated but not included in patient records; and 3) missing cases in the community because individuals chose traditional medical remedies for scabies treatment ([7](#_ENREF_7)).

Our analysis used a health system approach, utilizing micro-costing that involved direct quantification and costing of each resource use item. However, we did not consider resource use for of managing recurrent SSTI cases, or for containing institutional outbreaks. Furthermore, we did not consider non-medical costs such as transportation. Indirect costs were not available to us from the BigSHIFT study, which precluded adopting a societal perspective. It is known that scabies and SSTI cause a range of societal impacts ranging from school and work absence to impacts from stigma.

Notwithstanding the limitations above, our study contributes to a sparse literature on the direct medical costs of scabies and related SSTIs in high prevalence settings. We found that scabies imposes a substantial economic loss to the government in relation to costs and healthcare resource utilization. Investment in scabies prevention and control may reduce the direct and indirect cost of scabies treatment in the longer term. Our findings are likely to be relevant to other countries in the Pacific, where the burden of scabies and the costs of treatment may be similar to that of Fiji. Further research is needed to explicitly model the net economic burden of scabies and the cost effectiveness of public health control interventions for scabies such as mass drug administration.

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Supplementary Tables

S1 Table. Daily quantities and unit costs (in Fijian dollar) of oral and injection medications

| Medication name | Strength | Pack size | Cost per pack | Unit cost | Cost year | Source |
| --- | --- | --- | --- | --- | --- | --- |
| Injection cloxacillin 500mg | 500mg | 1 | 0.76 | 0.76 | 2013 | Fiji essential medicines list 2013 |
| Injection gentamicin 80mg/2mL | 80mg/2mL | 1 | 0.12 | 0.12 | 2013 | Fiji essential medicines list 2013 |
| Injection penicillin procaine 4 million IU | 4 million IU | 1 | 1.41 | 1.41 | 2013 | Fiji essential medicines list 2013 |
| Injection metronidazole 500mg/100mL | 500mg/100mL | 1 | 1.80 | 1.80 | 2013 | Fiji essential medicines list 2013 |
| Injection erythromycin 1000mg | 1000mg | 1 | 10.17 | 10.17 | 2013 | Fiji essential medicines list 2013 |
| Injection ceftriaxone 1000mg | 1000mg | 1 | 2.47 | 2.47 | 2013 | Fiji essential medicines list 2013 |
| Injection ciprofloxacin 100mg/50mL | 100mg/50mL | 1 | 6.30 | 6.30 | 2013 | Fiji essential medicines list 2013 |
| Injection meropenem 1000mg | 1000mg | 1 | 40.00 | 40.00 | 2020 | ~~Assumed price (awaiting info)~~ |
| Injection septrim 480mg/5mL | 480mg/5mL | 1 | 1.80 | 1.80 | 2013 | ~~Assumed price (awaiting info)~~ |
| Injection penicillin G 4 million IU | 2.4 million IU | 1 | 0.95 | 0.95 | 2013 | Essential medicines list 2013 |
| Oral flucloxacillin 500mg | 500mg | 500 | 76.35 | 0.15 | 2020 | FCCC Fiji authorization 2020 |
| Oral penicillin 250mg | 250mg | 50 | 5.23 | 0.10 | 2020 | FCCC Fiji authorization 2020 |
| Oral amoxycillin 500mg | 500mg | 500 | 59.36 | 0.12 | 2020 | FCCC Fiji authorization 2020 |
| Oral metronidazole 200mg | 200mg | 500 | 14.28 | 0.03 | 2020 | FCCC Fiji authorization 2020 |
| Oral erythromycin 250mg | 250mg | 1,000 | 192.65 | 0.19 | 2020 | FCCC Fiji authorization 2020 |
| Oral doxycycline 100mg | 100mg | 1,000 | 192.65 | 0.19 | 2020 | Assumed price of erythromycin |
| Oral cephalexin 500mg | 500mg | 500 | 76.35 | 0.15 | 2020 | Assumed price of flucloxacillin |
| Oral septrim 480mg | 480mg | 1,000 | 33.75 | 0.03 | 2020 | FCCC Fiji authorization 2020 |
| Oral suspension flucloxacillin 125mg/5mL (100mL) | 125mg/5mL (100mL) | 1 | 2.35 | 2.35 | 2020 | FCCC Fiji authorization 2020 |
| Oral suspension penicillin 125mg/5mL (100mL) | 125mg/5mL (100mL) | 1 | 2.99 | 2.99 | 2020 | FCCC Fiji authorization 2020 |
| Oral suspension amoxycillin 125mg/5mL (100mL) | 125mg/5mL (100mL) | 1 | 1.71 | 1.71 | 2020 | FCCC Fiji authorization 2020 |
| Oral suspension metronidazole 200mg/5mL (100mL) | 200mg/5mL (100mL) | 1 | 1.05 | 1.05 | 2020 | Assumed price of septrim |
| Oral suspension erythromycin 125mg/5mL (100mL) | 125mg/5mL (100mL) | 1 | 2.46 | 2.46 | 2020 | FCCC Fiji authorization 2020 |
| Oral suspension doxycycline |  |  |  |  | 2020 | No such formulation |
| Oral suspension cephalexin 125mg/5mL (100mL) | 125mg/5mL (100mL) | 1 | 2.35 | 2.35 | 2020 | Assumed price of flucloxacillin |
| Oral suspension septrim 240mg/5mL (100mL) | 240mg/5mL (100mL) | 1 | 1.05 | 1.05 | 2020 | FCCC Fiji authorization 2020 |

S2 Table. Recommended doses for oral and injection medications in Fiji Antibiotics Guidelines

| Medication name | Dosing guide |
| --- | --- |
| Injection cloxacillin | 2000mg (child:50mg/kg up to 2g ) 6 hourly |
| Injection gentamicin | 3.2mg/kg up to 320mg daily |
| Injection penicillin | 1.5 million units (child: 50,000 units/kg up to 1.5 million units) daily |
| Injection metronidazole | 500mg (child: 12.5mg/kg up to 500mg) 12-hourly |
| Injection erythromycin | 500mg (child: 25 mg/kg up to 500mg) 6-hourly |
| Injection ceftriaxone | 2000mg (child: 50 mg/kg up to 2g) daily |
| Injection ciprofloxacin | 400mg (child:10mg/kg up to 400mg) 12-hourly |
| Injection meropenem | 1000mg (child: 20mg/kg up to 1g) 8-hourly |
| Suspension flucloxacillin | 500mg (child 12.5mg/kg up to 500mg) 6-hourly |
| Oral capsules flucloxacillin | 500mg (child 12.5mg/kg up to 500mg) 6-hourly |
| Suspension penicillin | 500mg (child: 12.5 mg/kg up to 500 mg) orally, 6-hourly |
| Oral tablets penicillin | 500mg (child: 12.5 mg/kg up to 500 mg) orally, 6-hourly |
| Suspension amoxycillin | 1000mg (child: 25mg/kg up to 1 g) 8-hourly |
| Oral capsules amoxycillin | 1000mg (child: 25mg/kg up to 1 g) 8-hourly |
| Suspension metronidazole | 400mg (10mg/kg up to 400mg ) 12-hourly |
| Oral tablets metronidazole | 400mg (10mg/kg up to 400mg ) 12-hourly |
| Suspension erythromycin | 500mg (child:10mg/kg up to 500mg) 6-hourly |
| Oral tablets erythromycin | 500mg (child:10mg/kg up to 500mg) 6-hourly |
| Oral capsules doxycycline | 100mg (child 8 years+: 2mg/kg up to 100mg) 12-hourly |
| Suspension cephalexin | 500mg (child: 12.5mg/kg up to 500mg) 6-hourly |
| Oral capsules cephalexin | 500mg (child: 12.5mg/kg up to 500mg) 6-hourly |
| Suspension septrim | 960mg (child: 24mg/kg up to 960mg) 12-hourly |
| Oral tablets septrim | 960mg (child: 24mg/kg up to 960mg) 12-hourly |

S3 Table. Healthcare resource utilization and costs (in 2020 Fiji dollars) of primary healthcare presentations for scabies- and non-scabies-related SSTIs in Northern Division, Fiji.

|  | Proportion of patients (%) | | Mean ± SD cost per patient ($) | |
| --- | --- | --- | --- | --- |
| **Characteristic** | Scabies | Non-scabies | Scabies | Non-scabies |
| Clinic visits | 100.0 | 100.0 | 25.2 ± 0.0 | 25.2 ± 0.0 |
| Bed days | 0.1 | 1.0 | 0.1 ± 3.5 | 1.3 ± 12.4 |
| Medications, topical | 81.6 | 1.4 | 0.7 ± 0.4 | 0.0 ± 0.1 |
| Medications, oral | 41.4 | 84.3 | 0.4 ± 0.5 | 0.7 ± 0.3 |
| Medications, injection | 26.8 | 50.8 | 0.5 ± 0.8 | 0.9 ± 0.9 |
| Procedure, surgical | 0.0 | 0.5 | 0.0 ± 0.0 | 0.0 ± 0.0 |
| Total per patient |  |  | 26.9 ± 3.6 | 28.0 ± 12.3 |

S4 Table. Healthcare resource utilization and mean costs (in 2020 Fiji dollars) of hospital admissions with scabies- and non-scabies-related SSTIs in Northern Division, Fiji

|  | Proportion of patients (%) | | Mean ± SD cost per patient ($) | |
| --- | --- | --- | --- | --- |
| **Characteristic** | Potentially scabies-related | Unlikely scabies-related | Potentially scabies-related | Unlikely scabies-related |
| Bed days, general ward | 100.0 | 100.0 | 821.4 ± 759.9 | 1,372.7 ± 1,502.1 |
| Bed days, intensive care | 3.9 | 5.6 | 89.5 ± 525.1 | 174.4 ± 836.3 |
| Medications, oral | 92.6 | 92.2 | 7.6 ± 25.1 | 6.3 ± 12.2 |
| Medications, injection | 97.7 | 95.0 | 34.4 ± 42.4 | 76.1 ± 153.2 |
| Procedure, surgical | 63.3 | 67.0 | 0.0 ± 0.0 | 0.0 ± 0.0 |
| Procedure, amputation | 1.1 | 6.7 | 0.0 ± 0.0 | 0.0 ± 0.0 |
| Diagnostics, blood culture | 16.2 | 15.0 | 4.6 ± 10.5 | 4.2 ± 10.2 |
| Diagnostics, tissue culture | 1.1 | 0.6 | 0.3 ± 2.9 | 0.2 ± 2.1 |
| Diagnostics, skin swab | 65.1 | 83.8 | 18.4 ± 13.5 | 23.7 ± 10.5 |
| Total per patient |  |  | 974.5 ± 1,035.5 | 1,655.3 ± 1,872.2 |