Costs of primary healthcare presentations and hospital admissions for scabies and related skin infections in Fiji, 2018-2019

Edifofon Akpan1\*, Li Jun Thean2,3, Rabindra Baskota1, Jyotishna Mani2, Maria Mow2, Mike Kama4, Meciusela Tuicakau4, Joseph Kado4,5,6, Lucia Romani7, Daniel Engelman2,3,8, Andrew Steer2,3,8, and Natalie Carvalho1

1 School of Population and Global Health, University of Melbourne, Melbourne, Australia  
2 Tropical Diseases Group, Murdoch Children’s Research Institute, Melbourne, Australia  
3 Department of Pediatrics, University of Melbourne, Melbourne, Australia

4 Ministry of Health and Medical Services, Suva, Fiji  
5 Wesfarmers Centre for Vaccines and Infectious Diseases, Telethon Kids Institute, Nedlands, Australia

6 Medical School, University of Western Australia, Nedlands, Australia

7 Kirby Institute, University of New South Wales, Sydney, Australia

8 Melbourne Children’s Global Health, The Royal Children’s Hospital, Melbourne, Australia

\* Corresponding author email: [e.akpan@unimelb.edu.au](mailto:e.akpan@unimelb.edu.au)

# 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 (MDA) campaign. Using data from Big SHIFT, we sought to estimate the annual direct healthcare 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 primary healthcare (PHC) visits, bed days, medicines, and diagnostics. We extrapolated the total annual number of cases and direct healthcare costs for all divisions in Fiji based upon previous scabies and impetigo prevalence data across all divisions. The average cost per PHC presentation for scabies was US$17.7, and for scabies-related SSTI was $18.3. The average cost per hospital admission for scabies-related SSTI case was $439. The estimated annual healthcare costs of scabies and related SSTIs in Fiji was US$3.0 million, with cost per capita of $3.3. Scabies and related 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 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 (or US$ 24,600) [[9](#_ENREF_9)]. We found no cost-of-illness study on 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 healthcare costs of scabies and related SSTIs in Fiji.

# Methods

## Study setting and design

Fiji is an island country located in the South Pacific Ocean with a census population of 884,887 people in 2017 [[10](#_ENREF_10)]. Healthcare in Fiji comprises a government public healthcare system and a smaller private healthcare sector [[11](#_ENREF_11)]. 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 2019, about US$144 million from the Fiji government’s revenue was allocated to health **[**[12](#_ENREF_12)**]**. The Northern Division is one of four primary administrative units of Fiji (2017 census population, 131,914) [[10](#_ENREF_10)]. The division has the highest prevalence of scabies (28.5%) and impetigo (23.7%) among all Fiji divisions.

The Big Skin Health Intervention Fiji Trial (Big SHIFT) was a before-after intervention trial of ivermectin-based MDA delivered to the whole population of the Northern Division of Fiji [[13](#_ENREF_13)]. Before MDA, Big SHIFT established a monthly reporting system for presentations of scabies and SSTIs at all public PHC facilities over a 50-week period (from 16 July 2018 to 30 June 2019) [[1](#_ENREF_1)]. Additionally, data on patients presenting to the outpatient departments at subdivisional hospitals, emergency departments, health centers and nursing stations, and Integrated Management of Childhood Illness (IMCI) clinics were prospectively collected using a dedicated data collection tool. We also included cases diagnosed during school visits and community outreaches. Staff at these PHC settings reported presentations of scabies and bacterial SSTIs (infected scabies, impetigo, cellulitis, abscess, and severe SSTIs we considered all these SSTIs to be potentially scabies related). Staff collected data regarding treatment, such as the medication 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 16 July 2018 and 30 June 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 all patients that were 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 [[14](#_ENREF_14)]. 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)].

## Estimating annual case numbers

We extrapolated case numbers to all Fiji divisions using the expected annual number of cases in the Northern Division, and the risk ratio (RR) of scabies infestation between the Northern Division and other divisions. The expected annual number of cases in the Northern Division was derived by multiplying the annual risk of cases by the population size.

Where is the risk of cases in the Northern Division, is the incidence rate of cases, is the follow-up time (50 weeks for presentations and 48 weeks for admissions), and is the annual number of cases.

A study by Romani [[15](#_ENREF_15)] indicated that scabies and impetigo cases were prevalent in the Northern division compared with other Fiji divisions, with an adjusted odds ratio (OR) of 1.3 for each disease. We assumed that the OR for impetigo holds for other scabies-related SSTIs. We converted the OR to risk ratio (RR) and multiplied it by the risk in the Northern Division to derive the risk other Fiji divisions.

To obtain the expected annual cases in other Fiji divisions, we multiplied the annual risk of cases above with the population size for all other Fiji divisions (752,973 based on 2017 census) [[10](#_ENREF_10)]. Lastly, we summed up the number of cases for the Northern and the number for other divisions to get the total annual number of cases in all Fiji divisions.

## Estimation of healthcare costs

We estimated the cost per case (presentation or admission) as well as the total annual costs using extrapolated number of cases in Fiji to estimate the economic burden at a national level. Costs were calculated from a health system perspective - including the direct costs of clinic visits, hospital admissions, diagnostic tests, and medicines. We used this 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 [[11](#_ENREF_11)]. In line with our costing perspective, we did not consider costs of productivity losses from premature death, SSTI-related work/school absenteeism, or other social impacts.

### Resource use

The main resource use categories were health services (presentations and admissions); diagnostic procedures; and medicines (oral, injection, and topical). We measured clinic visits using the number of presentations in a PHC setting (one clinic visit per presentation). Our data did not include follow-up visits and repeated presentations as the BigSHIFT study did not collect this information. We measured hospital admissions using the number of bed days for admissions to general wards and intensive care unit (ICU). We had no data on the length of stay for patients admitted in PHC facilities, so we assumed PHC admissions were for one night only. 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 medicines, we supplemented the utilization data collected in the trial with relevant antibiotics and treatment guidelines for scabies and SSTIs in Fiji [[16](#_ENREF_16), [17](#_ENREF_17)]. For PHC presentations, we did not have the names of medicines prescribed, but only the dosage form. Therefore, we considered that patients treated with topical medicines were given permethrin cream [[16](#_ENREF_16)]. We used the average household size in Fiji, 4.2 in 2021 [[18](#_ENREF_18)], to quantify the number of tubes that would be sufficient to treat the whole family as recommended in the guidelines. For those prescribed an injection, we used benzathine penicillin (for impetigo) or cloxacillin (for cellulitis, abscess, or severe SSTI) as recommended by Fiji antibiotics guidelines [[16](#_ENREF_16)]. Similarly, those prescribed oral medicines had co-trimoxazole (for impetigo) or flucloxacillin (for the other SSTIs).

The hospitalizations 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 [[19](#_ENREF_19)]. For instance, 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 recommended doses and daily quantities of medicines used in the costing exercise.

### Unit costs

The unit costs per diagnostic test, presentation, and admission were obtained from a Fiji costing study [[20](#_ENREF_20)] . The study estimated the costs of various healthcare services in three facilities - Lautoka (LTK) hospital, Colonial War Memorial (CWM) hospital, and Nausori PHC. We used the average cost per laboratory test as unit cost of diagnostic tests in our study. We used the cost per outpatient visits in Nausori PHC as unit cost for presentations. The study estimated the costs per bed day for the two hospitals, so we used the lower values to obtain conservative estimates. Accordingly, we used the cost per bed day in CWM hospital as unit cost for PHC and hospital ward admissions. Likewise, we used the cost per ICU bed day in LTK hospital as unit cost for hospital ICU admissions. Cost of surgical procedures were not estimated separately because it was captured in the unit cost of admissions. Lastly, unit costs of medicines were largely based on procurement prices collected at CWMH Pharmacy, and supplemented with other sources, where unavailable (see Table S1).

### Cost analysis

We multiplied the resource quantities by their respective unit cost to derive the cost per case, separately for scabies presentations, scabies-related SSTI presentations, and scabies-related SSTI admissions. These costs were then multiplied by the extrapolated number of cases in Fiji to yield the annual costs for each category. The annual costs of presentations and all admissions were added to yield the total annual costs.

Table 1. Unit costs (in 2020 US$ dollars) used in this study.

|  |  |  |
| --- | --- | --- |
| Parameter | Base case  (low—high) | Source and notes |
| Cost per diagnostic test | 13.0  (11.3—14.8) | Low value from costing study (CWM hospital); high value from costing study (LTK hospital); Base case is average of the two values. |
| Cost per presentation | 11.6  (5.9—29.1) | Base case from costing study (Nausori PHC); low value from WHO-CHOICE (PHC with bed); and high value from costing study (LTK hospital). |
| Cost per bed day in a hospital ICU | 252.4  (119.4—385.5) | Base case from costing study (LTK hospital); Low value uses the cost per bed day in hospital ward; high value from costing study (CWM hospital); |
| Cost per bed day in hospital ward | 56.3  (43.3—61.2) | Base case from costing study (CWM hospital); low value from WHO-CHOICE (tertiary hospital); and high value from costing study (LTK hospital). |
| Cost per bed day in a PHC ward | 56.3  (43.3—61.2) | Same as hospital ward |
| Cost of oral, injectable, and topical medicines | varies | see S1 Table |

CWM, Colonial War Memorial; ICU, intensive care unit; LTK, Lautoka; PHC, primary healthcare; WHO-CHOICE, World Health Organization CHOosing Interventions that are Cost-Effective.

A one-way sensitivity analysis was conducted to examine how sensitive the cost estimates were to variations in unit costs. The WHO-CHOICE project estimated the cost for inpatient and outpatient health service delivery [[21](#_ENREF_21)]. WHO-CHOICE unit costs for PHC visits/presentation and ward admission were lower than our base case values, so we used the former as “low” value and got our “high” values from the costing study (see Table 1). For ICU, used an average of ICU bed day estimates from two hospitals in the Fiji costing study [[20](#_ENREF_20)] in the base case, so these two estimates served as our low/high value for sensitivity analysis. For laboratory tests, we used wide (±50%) variation to reflect reasonable uncertainty. The results of the sensitivity analysis were reported in a tornado chart.

Costs were reported in 2020 United States dollars (US$). Costs obtained in other years and/or different currencies converted to Fijian dollar using the average exchange rate in that year [[22](#_ENREF_22)], adjusted to 2020 prices using GDP deflator [[23](#_ENREF_23)], and converted back to US$ using 2020 exchange rates. We assumed scabies to be an acute disease, so we only considered healthcare costs that occurred within one year, and therefore did not apply any discounting for future costs [[24](#_ENREF_24)]. 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 MDA for the control of scabies and SSTIs (trial ID: ACTRN12618000461291). Ethical approval for Big SHIFT was granted by the Fiji National Health Research Ethics Review Committee (reference: 2018.38.NOR) and the Royal Children’s Hospital Human Research Ethics Committee in Melbourne, Australia (reference: 38020). The trial obtained written informed consent from all participants or from their parent or legal guardian if they were below 18 years or lack the capacity to provide properly informed consent.

# Results

## Characteristics of presentations and admissions

The expected annual number of PHC presentations in the Northern Division was 3,747 for scabies and 11,292 for related SSTI presentations (Table 1). Over 80% of PHC presentations were patients of iTaukei ethnicity. The median age was lower for patients presenting with scabies, compared with scabies-related SSTIs presentations or admissions. 617 cases of scabies-related SSTI admissions are expected annually in the Northern Division. The average length of stay (bed days) of these admissions was about 7 days. The estimated annual number of non-scabies-related SSTIs was 617 (S2 Table).

## Healthcare resource use and costs per case

The average cost per presentation was US$17.7 for scabies and US$18.3 for scabies-related SSTIs (Table 3). Approximately two-thirds of costs of scabies and related SSTI presentations were for clinic visits. Patients presenting with scabies were likely to be prescribed topical medication (81.6% of scabies patients; average costs of $4.0); those presenting with related SSTI were likely to be require oral medicines (83.2% of related SSTI patients; average costs, $2.1). Additionally, those presenting with scabies were less likely than those with related SSTIs to require admission (0.1% vs 1.0%) or referral (0.6% vs 1.3%). Table S3 in the supplementary appendix contains the proportion of presentations and admissions requiring each resource use category.

Table 2. Estimated annual number of PHC presentations and admissions with scabies and scabies-related skin and soft tissue infections in Northern Division, Fiji.

| Characteristic | Scabies presentations | Scabies-related SSTI presentations | Scabies-related SSTI admissions |
| --- | --- | --- | --- |
| Annual total | 3747 | 11292 | 617 |
| Sex, n. (%) |  |  |  |
| Male | 1969 (53%) | 6179 (55%) | 324 (53%) |
| Female | 1755 (47%) | 5052 (45%) | 293 (47%) |
| Age, median (IQR) | 5 (1, 9) | 12 (3, 33) | 33 (9, 55) |
| Age category, n. (%) |  |  |  |
| 0-4 | 2066 (55%) | 3844 (35%) | 119 (19%) |
| 5-14 | 1263 (34%) | 2307 (21%) | 74 (12%) |
| 15+ | 395 (11%) | 4995 (45%) | 424 (69%) |
| Ethnicity, n. (%) |  |  |  |
| I-Taukei | 3168 (86%) | 9194 (83%) | 316 (67%) |
| Others | 496 (14%) | 1916 (17%) | 201 (33%) |
| Residence, n. (%) |  |  |  |
| Urban | 1772 (47%) | 5737 (51%) | NA |
| Rural | 1975 (53%) | 5555 (49%) | NA |
| Bed days, mean (SD)1 | 1.0 | 1.0 | 6.9 (6.5) |

Notes: Numbers may not add up to totals due to missing values for some characterisitics. SD, standard deviation; NA, not available; PHC, primary healthcare; SSTI, skin and soft tissue infection.

1 The duration of PHC admissions were assumed to be one night, since there was no available data on length of stay for PHC-admitted patients.

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

| Characteristic | Scabies presentations | Scabies-related SSTI presentations | Scabies-related SSTI admissions |
| --- | --- | --- | --- |
| Clinic visits | 11.6 (0.0) | 11.6 (0.0) | NA |
| Ward bed days | <0.1 (1.6) | 0.5 (5.5) | 378.5 (350.2) |
| ICU bed days | NA | NA | 41.3 (242.0) |
| Topical medicines | 4.0 (1.9) | 0.4 (1.3) | NA |
| Oral medicines | 0.7 (1.3) | 2.1 (1.9) | 1.2 (2.8) |
| Injection medicines | 0.2 (0.6) | 1.2 (1.5) | 8.3 (10.8) |
| Diagnostic tests | 0.0 (0.0) | 0.0 (0.0) | 9.9 (7.7) |
| Mean total costs | 17.7 (3.5) | 18.3 (6.9) | 439.2 (468.3) |

Values in parenthesis are standard deviations. NA, not applicable; PHC, primary healthcare; SSTIs, skin and soft tissue infections.

The average cost per hospital admitted case of scabies-related SSTI was $439 ($756 for non-scabies-related SSTI, S4 Table). Approximately 86% of admission costs were for hospital bed days. The average ward bed day cost for related SSTI admissions was $821. Admission costs are directly related to the mean length of hospital stay, which was higher among admissions for non-scabies-related SSTI (11.6 days; S2 Table) than for non-scabies-related SSTI (6.9 days; Table 2). The average ICU bed-day cost was $1,067 among those that required an ICU (3.9% of hospital admissions), or $41 among all admissions. Surgical procedures were required for 63.2% of scabies-related SSTI cases (commonly incision and drainage, dressing, and debridement). No costs were recorded for these procedures, because these are assumed to be incorporated in the cost per bed day [[20](#_ENREF_20)]. Injectable medicines were prescribed for a mean duration of about 4.9 days for scabies-related SSTI (oral medicines, about 8.6 days).

## Total annual cases and healthcare costs

Extrapolating the data from the Northern Division to the rest of Fiji, the estimated annual number of PHC presentations for scabies and SSTIs was 82,183 (Table 4). The estimated number of hospital admissions for scabies-related SSTIs was 3,330 (equivalent to about 23,000 hospital bed days). The estimated annual healthcare costs of scabies and related SSTIs in Fiji was US$3.0 million (excluding US$780,000 for non-scabies-related SSTI admissions). One-way sensitivity analysis indicated that variations in the cost per PHC 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 US$2.5 million.

Table 4. Estimated annual number of cases and healthcare costs of scabies and related SSTIs, extrapolated to all four divisions in Fiji based on 2017 census figures.

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Number of cases | Total annual cost ($) | Cost per capita ($) |
| Scabies presentations (a) | 20,311 | 359,790 | 0.41 |
| Scabies-related SSTI presentations (b) | 61,873 | 1,131,421 | 1.28 |
| Scabies-related SSTI admissions (c) | 3,330 | 1,462,236 | 1.65 |
| All scabies and related SSTI presentations (a+b) | 82,183 | 1,491,211 | 1.69 |
| All scabies and related SSTI cases (a+b+c) | 85,513 | 2,953,447 | 3.34 |

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

Figure 1. One-way sensitivity analysis on the impact of changing the base case parameter values to low and high values on the total annual healthcare costs (in 2020 US$) of scabies and related SSTIs in Fiji.

Total annual cost is indicated by the black reference line ($2.95 million). See Table 1 for the ranges used for this sensitivity analysis. ICU, intensive care unit; PHC, primary healthcare; SSTI, skin and soft tissue infection.

# 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 an MDA program. We used before-intervention data from the Big SHIFT trial and extrapolated these costs to the entire country. The trial provided rich information on PHC presentations and hospital admissions for scabies and related SSTIs. The estimated annual direct healthcare costs of scabies and related SSTIs in Fiji was $3.0 million, equivalent to 2.4% of government revenues allocated to health in 2019. Scabies and related SSTIs therefore lead to a heavy economic burden in Fiji, raising the potential benefit of prevention programs.

The main resource use category contributing to costs was hospital bed days. The estimated 23,000 bed days in our study represents 7.1% of admissions for all divisional hospitals in Fiji in 2017 (3.6% of divisional and specialist hospital admissions). The mean length of stay in our study (6.9 days) was higher than the mean of 4.5 reported in an Australian pediatric 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 per scabies-related SSTI admission ($439), was much lower than an estimated per-patient cost of US$10,499 for hospital treatment of pediatric scabies and pyoderma in an Australian study in 2019 [[27](#_ENREF_27)]. The average cost of medicines for treatment of scabies PHC presentations in our study was $4.0, more than double the estimated cost of medicines for treatment of outpatient pneumonia in Fiji [[28](#_ENREF_28)]; in that study, the average cost of medicines ranged from $1.3 for Nausori PHC to $2.6 for CWMH (in 2020 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 SSTIs 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 41 to 93% in studies in Fiji and the Solomon Islands [[15](#_ENREF_15), [29](#_ENREF_29)]. Second, substantial reductions in scabies prevalence (~90%) after ivermectin-based MDA have resulted in reductions of 67-75% in impetigo prevalence (without dedicated impetigo treatment) [[30](#_ENREF_30), [31](#_ENREF_31)].

A strength of our study is that we analyzed 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 centre for the division. The Northern Division is made up of four subdivisions, and Labasa Hospital is 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 missing SSTI cases that were not recognized by clinicians because clinicians are known to normalize scabies in endemic settings [[32](#_ENREF_32)]; missing cases that were recognized and treated but not included in patient records; and 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 managing recurrent SSTI cases, or for containing institutional outbreaks. Furthermore, we did not consider non-healthcare costs such as transportation. Indirect costs were not available to us from the Big SHIFT 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 [[7](#_ENREF_7), [26](#_ENREF_26)].

Notwithstanding the limitations above, our study contributes to a sparse literature on the direct healthcare 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 MDA.

# References

1. Thean LJ, Romani L, Engelman D, Jenney A, Wand H, Mani J, et al. Prospective Surveillance of Primary Healthcare Presentations for Scabies and Bacterial Skin Infections in Fiji, 2018–2019. American Journal of Tropical Medicine and Hygiene. 2021;105(1):230-7. <https://doi.org/10.4269/ajtmh.20-1459>. PMID: 34029210.

2. Thean LJ, Jenney A, Engelman D, Romani L, Wand H, Mudaliar J, et al. 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. 2020;14(12):e0008887. Epub 20201209. <https://doi.org/10.1371/journal.pntd.0008887>. PMID: 33296378.

3. World Health Organization. Report of the tenth meeting of the WHO strategic and technical advisory group for neglected tropical diseases. Geneva: 2017 [cited 9 Dec 2023]. Available from: <https://www.who.int/publications/m/item/tenth-report-of-the-strategic-and-technical-advisory-group-for-neglected-tropical-diseases-(stag-ntds>).

4. GBD 2019 Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. The Lancet. 2020;396(10258):1204-22. <https://doi.org/10.1016/S0140-6736(20)30925-9>. PMID: 33069326.

5. Karimkhani C, Colombara DV, Drucker AM, Norton SA, Hay R, Engelman D, et al. The global burden of scabies: a cross-sectional analysis from the Global Burden of Disease Study 2015. The Lancet Infectious Diseases. 2017;17(12):1247-54. <https://doi.org/10.1016/s1473-3099(17)30483-8>. PMID: 28941561.

6. Romani L, Whitfeld MJ, Koroivueta J, Kama M, Wand H, Tikoduadua L, et al. The Epidemiology of Scabies and Impetigo in Relation to Demographic and Residential Characteristics: Baseline Findings from the Skin Health Intervention Fiji Trial. American Journal of Tropical Medicine and Hygiene. 2017;97(3):845-50. Epub 20170719. <https://doi.org/10.4269/ajtmh.16-0753>. PMID: 28722612.

7. Mitchell E, Bell S, Thean LJ, Sahukhan A, Kama M, Koroivueti A, et al. Community perspectives on scabies, impetigo and mass drug administration in Fiji: A qualitative study. PLOS Neglected Tropical Diseases. 2020;14(12):e0008825. Epub 20201204. <https://doi.org/10.1371/journal.pntd.0008825>. PMID: 33275592.

8. Ministry of Health and Medical Services [Fiji]. Health Status Report 2017. Suva, Fiji: Ministry of Health and Medical Services, 2018 [cited 20 Dec 2023]. Available from: <https://www.health.gov.fj/wp-content/uploads/2020/03/HSR-2017-.pdf>.

9. Campbell M, van der Linden N, Gardner K, Dickinson H, Agostino J, Dowden M, et al. Health care cost of crusted scabies in Aboriginal communities in the Northern Territory, Australia. PLoS Negl Trop Dis. 2022;16(3):e0010288. Epub 20220328. <https://doi.org/10.1371/journal.pntd.0010288>. PMID: 35344551.

10. Fiji Bureau of Statistics. 2017 Population and Housing Census - Release 3. Suva, Fiji: Fiji Bureau of Statistics, 2018 [cited 4 April 2024]. Available from: <https://www.statsfiji.gov.fj/index.php/census-2017>.

11. World Health Organization Regional Office for the Western Pacific. The Fiji Islands health system review. Manila: 2011 [cited 9 Dec 2023]. Report No.: 9789290615439. Available from: <https://apo.who.int/publications/i/item/9789290615439>.

12. Ministry of Health and Medical Services [Fiji]. Fiji Health Accounts 2014-2019: National Health Expenditure. Suva, Fiji: Government of Fiji, 2023 [cited 11 Apr 2024]. Available from: <https://www.health.gov.fj/wp-content/uploads/2023/12/Fiji-NHA-Report-2018-2019.pdf>.

13. Thean LJ, Romani L, Engelman D, Wand H, Jenney A, Mani J, et al. Prevention of bacterial complications of scabies using mass drug administration: A population-based, before-after trial in Fiji, 2018-2020. The Lancet Regional Health – Western Pacific. 2022;22(10433). <https://doi.org/10.1016/j.lanwpc.2022.100433>. PMID: 35345391.

14. Engelman D, Yoshizumi J, Hay RJ, Osti M, Micali G, Norton S, et al. The 2020 International Alliance for the Control of Scabies Consensus Criteria for the Diagnosis of Scabies. British Journal of Dermatology. 2020;183(5):808-20. <https://doi.org/10.1111/bjd.18943>. PMID: 32034956.

15. Romani L, Koroivueta J, Steer AC, Kama M, Kaldor JM, Wand H, et al. Scabies and Impetigo Prevalence and Risk Factors in Fiji: A National Survey. PLOS Neglected Tropical Diseases. 2015;9(3):e0003452. <https://doi.org/10.1371/journal.pntd.0003452>. PMID: 25738499.

16. Ministry of Health and Medical Services [Fiji]. Fiji Guidelines for Sore Throat and Skin Disease: Diagnostic and Treatment Guidelines. Government of Fiji, 2018 [cited 10 Dec 2023]. Available from: <https://www.health.gov.fj/wp-content/uploads/2019/08/Fiji-Guidelines-for-Sore-Throat-and-Skin-Disease.pdf>.

17. Ministry of Health and Medical Services [Fiji]. Antibiotic Guidelines. 4th edition. Government of Fiji, 2019 [cited 10 Dec 2023]. Available from: <https://www.health.gov.fj/wp-content/uploads/2020/12/Fiji-Antibiotic-Guidelines.pdf>.

18. Fiji Bureau of Statistics. Fiji Multiple Indicator Cluster Survey 2021, Survey Findings Report. Suva, Fiji: Fiji Bureau of Statistics, 2022 [cited 4 April 2024]. Available from: <https://www.statsfiji.gov.fj/index.php/census-2017>.

19. World Health Organization. Child growth standards: weight-for-age. Geneva: World Health Organization, 2006 [cited 3 March 2024]. Available from: <https://www.who.int/tools/child-growth-standards/standards/weight-for-age>.

20. Irava W, Pellny M, Khan I. Costing Study of Selected Health Facilities in Fiji. Ministry of Health and Medical Services [Fiji], 2012 [cited 10 Dec 2023]. Available from: <https://www.health.gov.fj/wp-content/uploads/2018/03/Costing-Study-of-Selected-Health-Facilities-in-Fiji.pdf>.

21. World Health Organization. WHO-CHOICE estimates of cost for inpatient and outpatient health service delivery. Geneva: World Health Organization, 2011 [cited 3 Dec 2023]. Available from: <https://www.who.int/publications/m/item/who-choice-estimates-of-cost-for-inpatient-and-outpatient-health-service-delivery>.

22. The World Bank. Official exchange rate (LCU per US$, period average): The World Bank; 2022 [cited 9 Dec 2023]. Available from: <https://data.worldbank.org/indicator/PA.NUS.FCRF>.

23. The World Bank. GDP deflator (base year varies by country) Online: The World Bank; 2022 [cited 9 Dec 2023]. Available from: <https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS>.

24. Chaiyakunapruk N, Kotirum S, Newall AT, Lambach P, Hutubessy RCW. Rationale and opportunities in estimating the economic burden of seasonal influenza across countries using a standardized WHO tool and manual. Influenza and Other Respiratory Viruses. 2018;12(1):13-21. Epub 20171116. <https://doi.org/10.1111/irv.12491>. PMID: 29143498.

25. Whitehall J, Kuzulugil D, Sheldrick K, Wood A. Burden of paediatric pyoderma and scabies in North West Queensland. Journal of Paediatrics and Child Health. 2013;49(2):141-3. Epub 20130125. <https://doi.org/10.1111/jpc.12095>. PMID: 23347222.

26. Worth C, Heukelbach J, Fengler G, Walter B, Liesenfeld O, Feldmeier H. Impaired quality of life in adults and children with scabies from an impoverished community in Brazil. International Journal of Dermatology. 2012;51(3):275-82. <https://doi.org/10.1111/j.1365-4632.2011.05017.x>. PMID: 22348561.

27. Thomas J, Carson CF, Peterson GM, Walton SF, Hammer KA, Naunton M, et al. Therapeutic Potential of Tea Tree Oil for Scabies. American Journal of Tropical Medicine and Hygiene. 2016;94(2):258-66. Epub 20160119. <https://doi.org/10.4269/ajtmh.14-0515>. PMID: 26787146.

28. Temple B, Griffiths UK, Mulholland EK, Ratu FT, Tikoduadua L, Russell FM. The cost of outpatient pneumonia in children <5 years of age in Fiji. Tropical Medicine & International Health. 2012;17(2):197-203. Epub 20111018. <https://doi.org/10.1111/j.1365-3156.2011.02897.x>. PMID: 22008519.

29. 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 Neglected Tropical Diseases. 2016;10(6):e0004803. Epub 20160627. <https://doi.org/10.1371/journal.pntd.0004803>. PMID: 27348119.

30. Romani L, Whitfeld MJ, Koroivueta J, Kama M, Wand H, Tikoduadua L, et al. Mass Drug Administration for Scabies Control in a Population with Endemic Disease. The New England Journal of Medicine. 2015;373(24):2305-13. <https://doi.org/10.1056/NEJMoa1500987>. PMID: 26650152.

31. Marks M, Toloka H, Baker C, Kositz C, Asugeni J, Puiahi E, et al. Randomized Trial of Community Treatment With Azithromycin and Ivermectin Mass Drug Administration for Control of Scabies and Impetigo. Clinical Infectious Diseases. 2018;68(6):927-33. <https://doi.org/10.1093/cid/ciy574>. PMID: 29985978.

32. 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. Epub 20170703. <https://doi.org/10.1371/journal.pntd.0005726>. PMID: 28671945.

33. Mow M, Thean LJ, Parnaby M, Mani J, Rafai E, Sahukhan A, et al. Costs of mass drug administration for scabies in Fiji. PLOS Neglected Tropical Diseases. 2022;16(2):e0010147. <https://doi.org/10.1371/journal.pntd.0010147>. PMID: 35113888.

# Supporting information

S1 Table. Unit costs (in US$) and guideline-recommended doses of medicines used in the study.

S2 Table. Estimated annual number of non-scabies-related skin and soft tissue infections in Northern Division, Fiji.

Notes: Numbers may not add up to totals due to missing values for some characterisitics. SD, standard deviation; NA, not available; SSTI, skin and soft tissue infection.

S3 Table. Healthcare resource utilization of PHC presentations for scabies and related SSTIs in Northern Division, Fiji.

ICU, intensive care unit; PHC, primary healthcare; SSTI, skin and soft tissue infection

S4 Table. Mean (standard deviation) costs per case in 2020 US dollars by resource use category of scabies- and non-scabies-related SSTIs in Northern Division, Fiji

Values in parenthesis are standard deviations. SSTIs, skin and soft tissue infections.