The Epidemiology of Scabies and Impetigo in Relation to Demographic and Residential Characteristics: Baseline Findings from the Skin Health Intervention Fiji Trial

Lucia Romani,¹ Margot J. Whitfield,² Josefa Koroivueta,³ Mike Kama,³ Handan Wand,¹ Lisi Tikoduadua,³ Meciusela Tuicakau,³ Aminiasi Koroï,³ Raijeli Ritova,³ Ross Andrews,⁴ John M. Kaldor,¹ and Andrew C. Steer^{5,6*}

¹Kirby Institute, University of New South Wales, Sydney, Australia; ²Department of Dermatology, St. Vincent's Hospital, Sydney, Australia;

³Ministry of Health, Suva, Fiji; ⁴Menzies School of Health Research, Charles Darwin University, Darwin, Australia; ⁵Centre for International Child Health, University of Melbourne, Australia; ⁶Murdoch Children's Research Institute, Melbourne, Australia

Abstract. Scabies and associated impetigo are under-recognized causes of morbidity in many developing countries. To strengthen the evidence base for scabies control we undertook a trial of mass treatment for scabies. We report on the occurrence and predictors of scabies and impetigo in participants at baseline. Participants were recruited in six island communities and were examined for the presence of scabies and impetigo. In addition to descriptive analyses, logistic regression models were fit to assess the association between demographic variables and outcome of interest. The study enrolled 2051 participants. Scabies prevalence was 36.4% (95% confidence interval [CI] 34.3–38.5), highest in children 5–9 years (55.7%). Impetigo prevalence was 23.4% (95% CI 21.5–25.2) highest in children aged 10–14 (39.0%). People with scabies were 2.8× more likely to have impetigo. The population attributable risk of scabies as a cause of impetigo was 36.3% and 71.0% in children aged less than five years. Households with four or more people sharing the same room were more likely to have scabies and impetigo (odds ratios [OR] 1.6, 95% CI 1.2–2.2 and OR 2.3, 95% CI 1.6–3.2 respectively) compared to households with rooms occupied by a single individual. This study confirms the high burden of scabies and impetigo in Fiji and the association between these two conditions, particularly in young children. Overcrowding, young age, and clinical distribution of lesion are important risk factors for scabies and impetigo. Further studies are needed to investigate whether the decline of endemic scabies would translate into a definite reduction of the burden of associated complications.

INTRODUCTION

Scabies is a skin disease caused by infestation with a microscopic mite (*Sarcoptes scabiei* var *hominis*), which causes severe itchiness, sleep disturbance, and social stigmatization.¹ An estimated 100 million people have scabies, most in tropical countries,² with the Pacific region particularly affected.^{3–7} The disease is transmitted via close personal contact with an infected person and it is commonly spread within households and institutions.⁸

Impetigo, a common bacterial infection of the skin, often arises in people with scabies due to scratching of the lesions,^{6,9–12} and can in turn lead to complications associated with group A streptococcal infection such as septicemia, glomerulonephritis, and rheumatic heart disease, particularly in tropical settings.^{4,7,13,14} Unlike industrialized countries, where scabies and impetigo are regarded as nuisance diseases, in many resource-poor settings these diseases are endemic and reach prevalences as high as 25% in the general population and up to 50% in children.⁵

In countries where scabies is endemic, treatment that focusses on people with clinical scabies is often ineffective due to recurring reinfestation, even when extended to their household or family contacts. Mass drug administration (MDA), involving repeat administration of topical or oral treatments to whole communities, has been used for two decades to treat several neglected tropical diseases around the world and it is now emerging as a safe and effective strategy for the control of scabies.^{3,9,10,15–17} The evidence base for MDA in scabies control was recently strengthened by a trial that we undertook in Fiji, called the Skin Health

Intervention Fiji Trial (SHIFT).³ The SHIFT trial also provided an opportunity to gain insight into some of the factors associated with scabies in endemic settings, and anatomical distribution of scabies and impetigo. Few studies conducted in developing countries including Brazil, Bangladesh, Cambodia, and Pakistan investigated the complex relation between high prevalence of scabies and its socioeconomic factors.^{12,18–23} Despite emerging data on scabies and impetigo prevalence in Fiji and internationally, limited information is available on risk factors associated with scabies, particularly in community and household settings. This paper reports on the clinical characteristics of SHIFT participants seen at baseline, with a particular focus on the occurrence of scabies and impetigo in relation anatomical sites and participants' living circumstances.

MATERIAL AND METHODS

Setting and study population. Fiji is located in the South Pacific region, with a population estimated at 909,389 in 2015 living on more than 300 islands, and made up of two main ethnicities, iTaukei (indigenous) Fijians (57%) and Indo-Fijians (38%).²⁴ It is the second most populous country in the Pacific region, after Papua New Guinea. Fiji is ranked 90 out of 188 countries in the United Nations Human Development Index, with a gross domestic product per capita of U.S. dollars 4,532 in 2014.^{25,26}

Participants of this study were recruited as part of the SHIFT trial, which took place during 2012–2013 in Fiji.³ After consultation with authorities, we identified six island communities in the Eastern Division of the country. These islands were selected on the basis of relative isolation, population size, and cultural and demographic similarities.²⁴ All selected sites were rural coastline villages with approximately one-third of the households having access to piped water. Nearly, 60% of

* Address correspondence to Andrew C. Steer, Centre for International Child Health, Royal Children's Hospital Flemington Road, Parkville Victoria 3052, Australia. E-mail: andrew.steer@rch.org.au

residents live below the minimum wage of FJD 2.30 per hour and families' main income mostly comes from fishing and agriculture.²⁴ Typically, residents live in traditional huts made of wood and straw, or in houses made of cement or corrugated iron. Travels between villages are only possible by foot or boats; there are no vehicles or paved roads on any of the six islands. Residents of these islands typically dress in shorts, long skirts and sarongs, and tee-shirts or sleeveless tops. The majority of young children are either naked or wear only shorts. The average daytime temperatures in warmer months are between 30°C and 32°C with high and persistent humidity. Literacy level is high at 93% across the country but no detailed information is available for the Eastern Division or the study islands.²⁴

Study procedures and case definitions. SHIFT study procedures have been described elsewhere.³ All residents of the six island communities selected were eligible and invited to participate. Prior to the study, residents were identified from the 2012 population list provided by the study nurse, and those present on the island were invited to participate by letter to the community, followed by a visit to the community from the local district nurse. Meetings were held in each selected community by a local nurse who explained the concept to residents. Subsequently, the nurse was accompanied by members of the study team who were able to answer questions and concerns the community may have had. Written consent was obtained by all residents willing to participate. Those who were illiterate or with impaired vision were provided assistance to complete the questionnaire by a member of the local study team. Informed consent for children 12 years or under was provided by parents or guardians, whereas for adolescents aged 13–17 consent was obtained by both a guardian and the participant. Those who consented provided demographic details and underwent a complete skin examination by a trained study nurse. Questions were asked in English, Fiji's official language, and translated into indigenous Fijian by trained local staff when requested by participants. At baseline, sociodemographic information and a brief medical history were collected from all participants by the study team. This included information on how many people lived in the house, the number of rooms shared and the length of residence on the island. We calculated the density of individuals per room to assess the association between scabies and the number of people sharing the same room. Participants were asked questions regarding previous diagnosis and treatment of scabies and other skin conditions. All clinical results were made available to each participant and to the local community care nurses. Study participants diagnosed with scabies or other skin conditions were provided detailed information about the condition and referred for treatment to the local nursing station. On selected islands, participants were offered treatment with oral or topical agents regardless of scabies status, and further follow-up took place as part of an investigation of MDA, as reported elsewhere.³

Scabies at baseline was defined as pruritic inflammatory papules with a typical anatomical distribution, such as hands, wrists, webs of the fingers, and ankles, following the Integrated Management of Childhood Illnesses guidelines.^{13,27} Examination was performed on all exposed areas of the skin. Genitals and perianal regions were only examined if participants described symptomatic itching in these regions and consented for examination. Skin examinations were

conducted in a separate, private space. Scabies severity was based on number of lesions and classified as mild, moderate, or severe (1–10, 11–49, or more than 50 lesions) using a previously validated methodology.^{3,4,13} The topographic distribution of scabies lesions was recorded using 10 predefined body regions. Infected scabies was defined as scabies plus pus-filled or crusted papules. If crusted scabies was suspected, a skin scraping was taken for microscope examination to detect mites, and a photograph sent to the team's clinical advisors. Impetigo was defined as a papular, pustular, or ulcerative lesion surrounded by erythema. Severity was counted and classified as per scabies lesion methods described earlier. Body distribution of impetigo lesions followed the methodology of scabies.

Statistical analysis and sample size. For the purposes of analyses reported here, the study population was made up of all those who were enrolled at the baseline visit of the SHIFT trial. Participant characteristics were summarized by demographic categories (age, sex, and household density). Prevalence of scabies and impetigo were calculated for the whole population and by each of the demographic categories. Adjusted odds ratios (ORs) for scabies and impetigo were calculated using logistic regression models for age, gender, and number of people sleeping in the same room. Information on density of individuals per room was analyzed both at individual and household level. Intraclass correlation coefficients (ICCs) were estimated to determine the variation of infestation rate within and between households to assess clustering effects for both scabies and impetigo.²⁸ In addition, the population attributable risk (PAR) was calculated to estimate the percentage of impetigo attributed to scabies, overall and specific to body site and age.²⁹ All statistical analyses were conducted using STATA 14.0 (College Station, TX).

Ethical approvals. SHIFT was registered with the Australian and New Zealand Trials Registry (ACTRN 12613000474752), and approved by the Fijian National Research Ethics Committee (201247) and the Royal Children's Hospital Human Research Ethics Committee (32099).

RESULTS

Study population. Overall, 2,051 people consented to the study (Table 1), representing more than 85% of the population recorded on resident register, which was 99.7% indigenous Fijian (iTaukei). Participants were distributed across six island communities, in 29 villages and 527 households. The age and gender of participants were similar to those reported in the most recent national population census.²⁴ Most participants (51.2%) reported that they had never left their island of residence.

Prevalence and correlates of scabies. Scabies was observed in 746 participants (36.4%, 95% confidence interval [CI] 34.3–38.5) of the surveyed population (Table 1). Prevalence was highest in children aged 5–9 years (55.7%, OR 3.7, 95% CI 2.8–4.9; Table 1) when compared with those aged 35 years and over. Scabies was more common in females (39.2% versus 33.7%, OR 1.3, 95% CI 1.1–1.5). When adjusted for age, gender, and number of people per room, the results increased marginally and followed the same pattern.

Among participants with scabies, lesions were most often observed on the upper limbs (82.6%; Table 2). Although scabies lesions were present on the lower limbs less frequently in

TABLE 1
Scabies and impetigo prevalence by age, gender and household density

Factor	Sample (%)	Scabies		Impetigo	
	N	n (%)	Unadjusted OR (95% CI)	n (%)	Unadjusted OR (95% CI)
Total	2,051	746 (36.4)		479 (23.4)	
Age					
< 5 years	257 (12.5)	122 (47.5)	2.7 (2.0–3.6)	80 (31.1)	3.0 (2.1–4.2)
5–9 years	341 (16.6)	190 (55.7)	3.7 (2.8–4.9)	131 (38.4)	4.1 (3.0–5.6)
10–14 years	277 (13.5)	132 (47.7)	2.7 (2.0–3.6)	108 (39.0)	4.2 (3.0–0.8)
15–24 years	168 (8.2)	52 (31.0)	1.3 (0.9–1.9)	29 (17.3)	1.4 (0.9–2.2)
25–34 years	280 (13.7)	67 (23.9)	0.9 (0.7–1.3)	35 (12.5)	0.9 (0.6–1.4)
≥ 35 years	782 (35.5)	183 (25.1)	1	96 (13.2)	1
Gender					
Female	987 (48.1)	387 (39.2)	1.3 (1.1–1.5)	204 (20.7)	0.8 (0.6–0.9)
Male	1,064 (51.9)	359 (33.7)	1	275 (25.8)	1
No. of people per room					
< 2 people	287 (14.0)	79 (27.5)	1	40 (13.9)	1
2–3 people	759 (37.0)	283 (37.3)	1.5 (1.2–2.1)	170 (22.4)	1.8 (1.2–2.6)
≥ 4 people	1,005 (26.3)	384 (38.2)	1.6 (1.2–2.2)	269 (26.8)	2.3 (1.6–3.2)

CI = confidence interval; OR = odds ratio.

the sample overall (43.4%), this distribution was the most common in those aged less than 5 years (77.1%, $P < 0.001$). The distribution of scabies lesions was similar in both genders, with the exception of the perineum and buttocks areas, where scabies was more observed in females ($P = 0.006$).

Among participants with scabies, most had mild disease (Table 3). Children aged less than 5 years had more severe disease than other age groups ($P = 0.002$). The distribution of lesions was similar between males and females ($P = 0.006$). There was one diagnosis of crusted scabies.

Prevalence and correlates of impetigo. Impetigo was observed in 23.4% (95% CI 21.5–25.2) of participants (Table 1). Impetigo followed a similar age distribution to that of scabies, being most common in school-aged children. The most affected age group was the 10–14 years (39.0%, OR 4.2, 95% CI 3.0–5.8), followed by the 5–9 age group with 38.4%; Table 1). Unlike scabies, impetigo was more prevalent in males (25.8%) than in females (20.7%, OR 0.8, 95% CI 0.6–0.9). When adjusted for age, gender, and number of people per room, the results did not change.

Impetigo lesions were most frequently observed on the lower limbs (69.7%; Table 2). This trend was consistent across age groups, although more common in school-aged children (Table 2). Impetigo lesions on the face, scalp, and neck were

more commonly observed in those aged less than 5 years (21.3%) than in all other age groups ($P < 0.001$). The distribution of impetigo lesions was similar in both males and females ($P = 0.006$).

Most participants had mild disease (76.5%; Table 3), with children aged less than 14 years, and males, more likely to have moderate or severe disease, compared with older age groups ($P = 0.149$).

The presence of impetigo was strongly associated with a diagnosis of scabies (relative risk, 2.6, 95% CI 2.2–3.0). Overall, more than one-third (36.3%) of impetigo cases were attributed to scabies (Table 4). The same measure was calculated by age group and body site. In the age stratified analysis, significant proportions of scabies were associated with impetigo cases among children aged less than 5 and 5–14 years of age (71% and 46%, respectively). Although not significant, approximately one-third of the impetigo cases were due to scabies in participants aged 15 and over. In the site specific analysis, scabies in torso and arms/hands were both attributed to approximately 50% of the impetigo cases (Table 4). In the youngest age group, scabies in limbs and torso were responsible for 45–52% of the impetigo cases, whereas just over quarter of the impetigo were attributed to the scabies in face scalp/neck (Table 4). Individuals with

TABLE 2
Distribution of participants with scabies and impetigo lesions by age group

Factor	Age				P value
	n (%) [*]	n (%) [*]	n (%) [*]	N (%) [*]	
	< 5 years (N = 122)	5–14 years (N = 322)	≥ 15 years (N = 302)	Overall (N = 746)	
Location of scabies lesions					
Face/scalp/neck	13 (10.7)	13 (4.0)	16 (5.3)	42 (5.6)	< 0.001
Arms/hands	88 (72.1)	283 (87.9)	245 (81.1)	616 (82.6)	< 0.001
Torso†	25 (20.5)	30 (9.3)	79 (15.2)	134 (26.2)	0.027
Legs/feet	94 (77.1)	147 (45.7)	83 (27.5)	324 (43.4)	< 0.001
	< 5 years (N = 80)	5–14 years (N = 239)	≥ 15 years (N = 160)	Overall (N = 479)	
Location of impetigo lesions					
Face/scalp/neck	17 (21.3)	9 (3.8)	10 (6.3)	36 (7.5)	< 0.001
Arms/hands	19 (23.8)	77 (32.2)	49 (30.6)	145 (30.3)	< 0.001
Torso†	4 (5.0)	11 (4.6)	13 (8.1)	28 (5.8)	0.485
Legs/feet	51 (63.8)	183 (76.6)	100 (62.5)	334 (69.7)	< 0.001

^{*} As percentage of those in the category with scabies/impetigo.

† Includes perineum and buttocks areas.

TABLE 3
Severity of scabies and impetigo lesions by age-group*

	Age			
	n (%)	n (%)	n (%)	N (%)
	< 5 years (121)	5–14 years (320)	≥ 15 years (301)	Overall (742)
Severity of scabies lesions				
Mild (≤ 10 lesions)	61 (50.4)	198 (61.9)	192 (63.8)	451 (60.8)
Moderate (11–49 lesions)	39 (32.2)	81 (25.3)	91 (30.2)	211 (28.4)
Severe (≥ 50)	21 (17.4)	41 (12.8)	18 (6.0)	80 (10.8)
	< 5 years (N = 77)	5–14 years (N = 229)	≥ 15 years (N = 149)	Overall (N = 455)
Severity of impetigo lesions				
Mild (≤ 10 lesions)	52 (67.5)	173 (75.6)	123 (82.6)	348 (76.5)
Moderate (11–49 lesions)	15 (19.5)	34 (14.9)	17 (11.4)	66 (14.5)
Severe (≥ 50)	10 (13.0)	22 (9.6)	9 (6.0)	41 (9.0)

* $P = 0.002$ and $P = 0.149$.

severe scabies are at considerably higher risk of developing impetigo. The majority (62.5%) of participants with more severe scabies were diagnosed with impetigo lesions, whereas of those with mild or moderate scabies lesion, 35.3% were observed to have impetigo lesions.

Household level prevalence of scabies and impetigo.

The association between scabies and overcrowding was observed both at the individual and household levels (Tables 1 and 5). Participants were more likely to have scabies when four or more people were sharing the same room (38.2%, OR 1.6, 95% CI 1.2–2.2) compared with households with a single individual per room (27.5%; Table 1). However, the effect of room density was reduced and nonsignificant when adjusted for age (adjusted OR 1.2, 95% CI 0.8–1.7) in the same group.

Of all 527 households surveyed, only 177 (33.6%) were free of scabies. The majority of households with no scabies (56.8%) had only one or two residents living in the house, whereas only 7.6% of them were occupied by seven or more people (Table 5). Scabies prevalence was associated with the presence of younger children within a household, with prevalence decreasing as the median age increased. In households where inhabitants had a median age of less than 19 years, 37.3% had scabies at levels higher than 50% ($P < 0.001$). Conversely, the majority (44.1%) of households where no scabies was present had residents with a median age above 45 years. The ICC due to the clustering effect of household was estimated as 13% for scabies.

Similarly to scabies, participants were twice as likely to present with impetigo lesions when four or more people shared the same room (26.8%, OR 2.3, 95% CI 1.6–3.2) compared with households with a single individual sleeping in one room (13.9%; Table 1). However, the significant effect of

room density decreased when adjusted for age (adjusted OR 1.7, 95% CI 1.1–2.5) in the same group.

The same trend was observed in relation to prevalence of impetigo and number of people per household. Of all 527 households surveyed, more than half (52.0%) had residents affected with impetigo. The majority of households with no impetigo (75.7%) had only up to two residents living in the house, whereas only 14.1% of them were occupied by seven or more people (Table 5). Impetigo prevalence was associated with the presence of younger children within a household, with prevalence decreasing as the median age increased. In households where inhabitants had a median age less than 19 years, 32.5% had impetigo at levels higher than 33% ($P < 0.001$). Conversely, 38.2% of households where no impetigo was observed had residents with a median age above 45 years. The ICC due to the clustering effect of household was estimated as 5% for impetigo.

DISCUSSION

This study describes for the first time the occurrence of scabies and impetigo in relation to participants' clinical, demographic, and living characteristics in an endemic population of Fiji. The results of this study confirm that countries of the Pacific region, particularly Fiji, have a prevalence of scabies and impetigo at some of the highest levels recorded in the world, with more than one in two children affected and over one-third of the general population reporting scabies. The high prevalences of scabies and impetigo in these populations of the Eastern Division are consistent with those reported by other studies in Fiji, although considerably higher than figures described by a national prevalence study conducted several years before.⁴ It is possible that this is due to the high level of remoteness of these small islands, and therefore

TABLE 4

Population attributable risk of scabies as a risk factor for impetigo by body site and age*

Factor	Age			Overall
	< 5 years	5–14 years	≥ 15 years	
Location of lesions				
Face/scalp/neck	0.26	0.21	0.09	0.21
Arms/hands	0.52	0.35	0.41	0.45
Torso†	0.45	0.33	0.59	0.47
Legs/feet	0.47	0.15	0.21	0.26
Total	0.71	0.46	0.29*	0.36

* $P = 0.108$ (all other figures are statistically significant).

† Includes perineum and buttocks areas.

TABLE 5
Presence of scabies and impetigo by HH*

HH size	Number of households		
	Total number of HH	HH with no scabies (%)	HH with no impetigo (%)
< 3 people	185	105 (56.8)	140 (75.7)
3–4 people	84	29 (34.5)	40 (47.6)
5–6 people	166	36 (21.7)	60 (36.1)
> 6 people	92	7 (7.6)	13 (14.1)
Total	527	177 (33.6)	253 (48.0)

HH = household.

* $P < 0.001$.

more isolation and possible recurring lack of scabies treatment. Most participants (51.2%) reported that they had never left their island of residence; however, this may include people who were on the island since birth as well as residents who may have moved there more recently after marriage or retirement.

The occurrence and clinical manifestations of scabies showed a picture consistent with that previously observed in tropical developing countries, including Fiji.^{4,23,30} Children under 14 years of age were the most heavily affected by scabies, with more than 50% having the disease. However, no age group was free of scabies or impetigo, and they were present in both females and males. Besides having the highest prevalence of scabies, young children were also the group with the most severe manifestations of the disease, with one-fourth of children under five having moderate to severe lesions. There were differences between the topographic distribution of scabies and impetigo papules. Overall, the first was mostly seen in upper limbs, whereas the latter was more commonly observed in feet and lower limbs. These sites are more likely to be affected as they are generally not covered by clothing and are the only exposed body areas in these populations. In addition, children are often carried by carers on their arms, presumably making transmission to these body parts more likely due to prolonged contact. The presence of both diseases in the scalp and face followed a clinical manifestation typical of infants and was rarely seen in older age groups. A possible explanation is the proximity of this body part to the mother's breast or axillary areas while lactating.

This study documents that scabies is one of the main drivers of bacterial skin infection in Fiji based on its presence in association with impetigo, as suggested by previous research in Fiji.⁴ For the first time, this study explores the association of impetigo as a risk factor for scabies also by age group and body distribution, showing that the PAR, based on observed associations, is substantially stronger in younger children. For reasons that remain unclear there were also differences by location with lower PAR for the face/scalp/neck and neck in all age groups and for legs/feet in those more than 5 years of age. Substantial PARs suggest that strategies to control scabies in endemic areas would translate into significant reduction of associated bacterial infections, particularly in infants and younger children.

Clustering of infection by household is considered to be an important epidemiological predictor for scabies.²³ Crowding, defined as the number of individuals per household and number of individuals per room, was strongly associated with higher prevalence of scabies and impetigo. In addition, we noted a clear correlation between young age and severity of scabies and associated bacterial infection, both at individual and household level. Our analysis attempted to take account of the association between younger age and crowding but inclusion of age in the multivariate model did not modify the effect of crowding. The ICC due to household clustering were estimated as 13% and 5% for scabies and impetigo, respectively; however, accounting for this clustering effect did not change the associations between the demographic factors and the outcome variables (data not show).

This study has several limitations. First, the diagnosis of scabies and impetigo was only made clinically, without the use of a confirmatory microscopy, as this method was not practical in our study setting. However, the high prevalence reported in this study is consistent with findings from earlier

surveys in the Pacific region.³⁻⁵ In addition, the study nurse who performed all skin examinations has considerable experience in scabies diagnosis having worked in the national dermatology hospital for more than 20 years. We did not consistently examine breasts and genitals, areas where scabies is often common;^{27,31} however, we systematically asked participants whether itch, rash, or discomfort were present in these parts. Second, although Fiji has two main ethnicity groups, our study only measured scabies and impetigo prevalence in the indigenous iTaukei population. Previous studies in Fiji have documented that scabies and impetigo are most common in the iTaukei population.^{4,6,32} One of the explanations for this could possibly be due to a higher number of children per family and the tendency to live in houses with high density of people per room. Bacterial infections such as streptococcal and staphylococcal infections, pneumonia, and rheumatic heart disease have all been more frequently reported in the iTaukei population in Fiji.³³⁻³⁶ Although site-specific PAR was calculated to estimate the percentage of impetigo prevalence attributed to scabies, the association could have been analyzed in other ways. An example could be the examination of scabies lesions anywhere in the body as a predictor of impetigo in specific body sites. Finally, although we investigated the role of living circumstances as risk factors for scabies in these communities, we did not assess other socio-economic factors such as general hygiene, level of education, and income factors that could potentially be associated with the presence of scabies and bacterial infections. Although we do not have information on these determinants, we do have extensive local knowledge of these factors for each of the islands visited and we believe that these determinants are unlikely to vary substantially within very homogeneous village populations.

High prevalence of scabies and related bacterial infections have previously been documented in tropical countries and in disadvantaged populations, particularly in countries of the Pacific region.⁵ This study adds important data confirming the high prevalence of scabies and impetigo in Fiji. This burden of disease in resource poor communities highlights the need to undertake research to investigate the best strategies for public health control of scabies and impetigo at population level. Our data from the SHIFT study suggest that an effective public health control measure for scabies will also likely lead to a considerable reduction in the burden of impetigo. However, further studies are needed to investigate the effect of scabies control on serious secondary bacterial infections to determine whether the decline of endemic scabies would translate into a definite reduction of the burden of associated complications, such as invasive bacterial disease, poststreptococcal glomerulonephritis and potentially rheumatic heart disease.

Received September 16, 2016. Accepted for publication April 3, 2017.

Published online July 17, 2017.

Acknowledgments: We thank the communities who agreed to participate, and the generous support provided to the study by the Fiji Ministry of Health, including study team member Apenisa Seduadua. We also thank Hamish McManus for his help with calculations of the ICC.

Financial support: This study was funded by an Australian National Health and Medical Research Council project grant (1032310). Ivermectin was provided by Merck Sharp and Dohme, Australia.

Authors' addresses: Lucia Romani, Handan Wand, and John M. Kaldor, Kirby Institute, University of New South Wales, Sydney, Australia,

E-mails: lromani@kirby.unsw.edu.au, hwand@kirby.unsw.edu.au, and jkaldor@kirby.unsw.edu.au. Margot J. Whitfeld, Department of Dermatology, St. Vincent's Hospital, Sydney, Australia, E-mail: mwhtfeld@stlderm.com.au. Josefa Koroivueta, Mike Kama, Meciusea Tuicakau, and Aminiasi Koro, Ministry of Health, Suva, Fiji, E-mails: josefa.koroivueta@govnet.gov.fj, mnkama02@gmail.com, mtsatala@yahoo.com, and aminee.kay@gmail.com. Lisi Tikoduadua, Colonial War Memorial Hospital, Suva, Fiji, E-mail: liztiko@gmail.com. Ross Andrews, Menzies School of Health Research, Charles Darwin University, Darwin, Australia, E-mail: ross.andrews@menzies.edu.au. Andrew C. Steer, Murdoch Children's Research Institute, Melbourne, Australia, and Centre for International Child Health, University of Melbourne, Australia, E-mail: andrew.steer@rch.org.au.

REFERENCES

- Worth C, Heukelbach J, Fengler G, Walter B, Liesenfeld O, Feldmeier H, 2012. Impaired quality of life in adults and children with scabies from an impoverished community in Brazil. *Int J Dermatol* 51: 275–282.
- Vos T, et al., 2012. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 380: 2163–2196.
- Romani L, et al., 2015. Mass drug administration for scabies control in a population with endemic disease. *N Engl J Med* 373: 2305–2313.
- Romani L, Koroivueta J, Steer AC, Kama M, Kaldor JM, Wand H, Hamid M, Whitfeld MJ, 2015. Scabies and impetigo prevalence and risk factors in Fiji: a national survey. *PLoS Negl Trop Dis* 9: e0003452.
- Romani L, Steer AC, Whitfeld MJ, Kaldor JM, 2015. Prevalence of scabies and impetigo worldwide: a systematic review. *Lancet Infect Dis* 15: 960–967.
- Steer AC, Jenney AW, Kado J, Batzloff MR, La Vincente S, Waqatakirewa L, Mulholland EK, Carapetis JR, 2009. High burden of impetigo and scabies in a tropical country. *PLoS Negl Trop Dis* 3: e467.
- Thomas M, Woodfield G, Moses C, Amos G, 2005. Soil-transmitted helminth infection, skin infection, anaemia, and growth retardation in schoolchildren of Taveuni Island, Fiji. *N Z Med J* 118: U1492.
- Bouvresse S, Chosidow O, 2010. Scabies in healthcare settings. *Curr Opin Infect Dis* 23: 111–118.
- Taplin D, Porcelain SL, Meinking TL, Athey RL, Chen JA, Castillero PM, Sanchez R, 1991. Community control of scabies: a model based on use of permethrin cream. *Lancet* 337: 1016–1018.
- Lawrence G, Leafasia J, Sheridan J, Hills S, Wate J, Wate C, Montgomery J, Pandeya N, Purdie D, 2005. Control of scabies, skin sores and haematuria in children in the Solomon Islands: another role for ivermectin. *Bull World Health Organ* 83: 34–42.
- Wong LC, Amega B, Connors C, Barker R, Dulla ME, Ninnal A, Kolumboort L, Cumaiyi MM, Currie BJ, 2001. Outcome of an interventional program for scabies in an Indigenous community. *Med J Aust* 175: 367–370.
- Heukelbach J, Wilcke T, Winter B, Feldmeier H, 2005. Epidemiology and morbidity of scabies and pediculosis capitis in resource-poor communities in Brazil. *Br J Dermatol* 153: 150–156.
- Steer AC, Tikoduadua LV, Manalac EM, Colquhoun S, Carapetis JR, MacLennan C, 2009. Validation of an integrated management of childhood illness algorithm for managing common skin conditions in Fiji. *Bull World Health Organ* 87: 173–179.
- World Health Organization, 2005. *Epidemiology and Management of Common Skin Diseases in Children in Developing Countries*. Geneva, Switzerland: World Health Organization.
- Centers for Disease Control and Prevention (CDC), 2015. *Neglected Tropical Diseases: Global NTD Programs*. Available at: http://www.cdc.gov/globalhealth/ntd/global_program.html. Accessed May 5, 2015.
- World Health Organization, 2015. *Neglected Tropical Diseases*. Available at: http://www.who.int/neglected_diseases/diseases/en/. Accessed March 16, 2015.
- Mohammed KA, Deb RM, Stanton MC, Molyneux DH, 2012. Soil transmitted helminths and scabies in Zanzibar, Tanzania following mass drug administration for lymphatic filariasis: a rapid assessment methodology to assess impact. *Parasit Vectors* 5: 299.
- Jackson A, Heukelbach J, Filho AF, Junior Ede B, Feldmeier H, 2007. Clinical features and associated morbidity of scabies in a rural community in Alagoas, Brazil. *Trop Med Int Health* 12: 493–502.
- Karim SA, et al., 2007. Socio-demographic characteristics of children infested with scabies in densely populated communities of residential madrasahs (Islamic education institutes) in Dhaka, Bangladesh. *Public Health* 121: 923–934.
- Landwehr D, Keita SM, Ponnighaus JM, Tounkara C, 1998. Epidemiologic aspects of scabies in Mali, Malawi, and Cambodia. *Int J Dermatol* 37: 588–590.
- Raza N, Qadir SN, Agha H, 2009. Risk factors for scabies among male soldiers in Pakistan: case-control study. *East Mediterr Health J* 15: 1105–1110.
- Baillie R, Stevens M, McDonald E, Brewster D, Guthridge S, 2010. Exploring cross-sectional associations between common childhood illness, housing and social conditions in remote Australian Aboriginal communities. *BMC Public Health* 10: 147.
- Feldmeier H, Jackson A, Ariza L, Calheiros CM, Soares Vde L, Oliveira FA, Hengge UR, Heukelbach J, 2009. The epidemiology of scabies in an impoverished community in rural Brazil: presence and severity of disease are associated with poor living conditions and illiteracy. *J Am Acad Dermatol* 60: 436–443.
- Fiji Bureau of Statistics, 2007. *Census of Population and Housing: Labour Force, Employment and Unemployment*. Available at: <http://www.statsfiji.gov.fj/index.php/2007-census-of-population>. Accessed March 11, 2015.
- United Nations Development Programme, 2014. *Human Development Report, 2014. The Rise of the South: Human Progress in a Diverse World*. New York: United Nations Development Program.
- The World Bank, 2015. *Fiji Country Data*. Available at: <http://data.worldbank.org/country/fiji>. Accessed July 1, 2016.
- Walton SF, Currie BJ, 2007. Problems in diagnosing scabies, a global disease in human and animal populations. *Clin Microbiol Rev* 20: 268–279.
- Giraudeau B, 2006. Model mis-specification and overestimation of the intraclass correlation coefficient in cluster randomized trials. *Stat Med* 25: 957–964.
- Northridge ME, 1995. Public health methods—attributable risk as a link between causality and public health action. *Am J Public Health* 85: 1202–1204.
- Mason DS, Marks M, Sokana O, Solomon AW, Mabey DC, Romani L, Kaldor J, Steer AC, Engelman D, 2016. The prevalence of scabies and impetigo in the Solomon Islands: a population-based survey. *PLoS Negl Trop Dis* 10: e0004803.
- Chosidow O, 2006. Clinical practices. Scabies. *N Engl J Med* 354: 1718–1727.
- Haar K, Romani L, Filimone R, Kishore K, Tuicakau M, Koroivueta J, Kaldor JM, Wand H, Steer A, Whitfeld M, 2013. Scabies community prevalence and mass drug administration in two Fijian villages. *Int J Dermatol* 53: 739–745.
- Steer AC, Jenney AJ, Oppedisano F, Batzloff MR, Hartas J, Passmore J, Russell FM, Kado JH, Carapetis JR, 2008. High burden of invasive beta-haemolytic streptococcal infections in Fiji. *Epidemiol Infect* 136: 621–627.
- Jenney A, Holt D, Ritika R, Southwell P, Pravin S, Buadromo E, Carapetis J, Tong S, Steer A, 2014. The clinical and molecular epidemiology of *Staphylococcus aureus* infections in Fiji. *BMC Infect Dis* 14: 160.
- Singh PI, Carapetis JR, Buadromo EM, Samberkar PN, Steer AC, 2008. The high burden of rheumatic heart disease found on autopsy in Fiji. *Cardiol Young* 18: 62–69.
- Magree HC, Russell FM, Sa'aga R, Greenwood P, Tikoduadua L, Pryor J, Waqatakirewa L, Carapetis JR, Mulholland EK, 2005. Chest X-ray-confirmed pneumonia in children in Fiji. *Bull World Health Organ* 83: 427–433.