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ORIGINAL ARTICLE

The body distribution of scabies skin lesions

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Abstract

Background: The clinical diagnosis of scabies relies on the assessment of signs and symptoms and an improved understanding of the distribution of skin lesions may lead to improved diagnostic performance.

Objectives: To investigate the detailed body distribution of scabies lesions and to explore the accuracy of simplified, focused examination approaches.

Methods: We did a prospective, cross-sectional study in the Western Province of Solomon Islands (2019). Consenting individuals of all ages were eligible. The entire skin surface was examined, and the presence and number of typical scabies lesions were recorded at 98 topographic body sites, corresponding to 5 regions and 16 subregions. We compared the distribution at sites, regions and subregions overall, and by age and sex. We also calculated the expected sensitivity of examination of limited body areas. Choropleth maps were generated to provide detailed descriptions of the distribution of lesions.

Results: A total of 467 individuals were enrolled (median age: 9 years [range: 0–86]; female: 54.6%) of whom 269 (57.6%) participants had typical scabies lesions. The most common sites for scabies lesions were the dorsal fingers (65.7% of participants with scabies lesions), dorsal finger web spaces (62.1%) and dorsal hands (61.7%). Of those less than 2 years old with scabies, eight (30.8%) had lesions at the head and neck region compared to 10.8% of those aged 2–5. Genital lesions were more common in males than females (27.3% vs. 7%, relative risk 3.9, 95% confidence interval: 1.2–2.1). Simplified, focused examinations were estimated have very high sensitivity (hands and wrists only: 93.3%; exposed arms and legs: 99.3%) compared to whole-body examinations.

Conclusion: We report highly detailed descriptions of the body distribution of scabies lesions, including differences by age and sex. These data are valuable for training and diagnosis and support the use of simplified, focused examinations for scabies mapping.

[Correction added on 14 November 2022, after first online publication: Ethics statement has been added to the end of the article.]

KEYWORDS
dermatology, diagnosis, infestations, neglected tropical diseases, scabies

INTRODUCTION

Scabies is a skin condition caused by the ectoparasitic mite *Sarcoptes scabiei* var. *hominis*. The global prevalence of scabies has been estimated at approximately 200 million,[1] although the accuracy of these estimates is limited by a paucity of studies and variance in diagnostic methods.[2,3] Improving the standardisation and accuracy of scabies diagnosis is important for clinical practice, individual patient management and public health strategies. There are currently no objective diagnostic tests available for use in the field. Consensus diagnostic criteria were developed by the International Alliance for the Control of Scabies (IACS) to improve diagnostic standardisation and were published in 2020.[4,5] The 2020 IACS criteria classify scabies diagnosis as either Confirmed Scabies (direct visualisation of mite or mite products), Clinical Scabies (specific dermatological signs and history features) or Suspected Scabies (less specific, more sensitive features). In most high-prevalence settings, techniques to diagnose Confirmed Scabies are not available.[6] In addition, confirmatory techniques such as skin scrapings are not sensitive, are operator dependent and require specialised training. Therefore, scabies diagnosis in most settings remains reliant on clinical assessment of presenting symptoms and signs.[7]

The skin manifestations of common scabies are most commonly small papules, although larger nodules, burrows, vesicles and pustular lesions can also be seen.[5] Lesions are caused by direct, localised mite activity and by hypersensitivity reactions to mite products.[8] The distribution of lesions on the skin surface is a principal feature defining the clinical presentation of scabies. The 2020 IACS criteria include definitions for the typical distribution of scabies lesions.[5] Although these definitions were based on available evidence and the consensus of international experts, validation is needed across a range of settings.[9]

Scabies lesions do not appear uniformly across the body surface. Lesions are commonly found in some areas including the fingers, hands, web spaces, wrists, arms, axilla, feet, ankles, legs, groin, buttocks, female breast and male genitals.[10–12] Previous studies have described variation in the distribution of lesions among different populations, age groups and sexes.[13–15] However, these studies have reported limited and inconsistent detail using large body regions. Few studies include examination of unexposed areas such as genitals and breasts. Additionally, although scabies lesions are sometimes described as presenting symmetrically on both sides of the body, there are limited data to support this.

A simplified, abbreviated approach to examination, whereby only a limited area of the skin is examined, has been proposed for scabies mapping and prevalence surveys, in an attempt to reduce the logistical challenges for privacy in field settings.[16] One retrospective study and one prospective study found that a simplified examination had high sensitivity for diagnosis.[17,18] However, further evidence to support the use of focused examinations is required.[6]

Therefore, the aim of this study was to investigate and generate a detailed description of, the body distribution of skin lesions in individuals with scabies. We also aimed to investigate differences in distribution by sex and age, and to evaluate the diagnostic accuracy of focused skin examination.

METHODS

Design and setting

This prospective, cross-sectional study was conducted in seven rural villages in the Western Province of Solomon Islands in May and June 2019. The Solomon Islands is an archipelagic nation located in the southwest Pacific Ocean. The Western Province of Solomon Islands has a population of approximately 100,000. The prevalence of scabies in this region was reported to be 15% in 2019.[19,20]

Participants

Participants were enrolled in parallel to the baseline recruitment of the regimens of ivermectin for scabies elimination (RISE) trial, which compared scabies community control strategies.[21] Following community engagement, individuals of all ages were invited to participate. As it was not feasible to examine the whole community, we enrolled consecutive participants who could be practically examined during the study period. We aimed to enrol at least 200 participants with scabies lesions.

Written, informed consent was obtained from all participants. Consent was obtained from parents or guardians for those aged less than 18 years. All participants were offered treatment for scabies (oral ivermectin or topical permethrin), regardless of examination findings, as part of the RISE trial.

Examination

Participants were examined in a separate, private area. A doctor with 2 years of training, including specific training and experience in diagnosing scabies, conducted the examinations. Although some participants had been previously examined by a RISE study nurse, the doctor and participants were both blinded to the findings of the previous assessment.

The doctor examined the entire skin surface. The numbers of scabies lesions at each of 98 cutaneous sites were counted and recorded onto a data form (Supporting Information: Figure S1), using pragmatic categories (0, 1, 2, 3, 4, 5, 6–10, 11–20, 21–50, >50). Only lesions with typical morphology for scabies were recorded, defined according to 2020 IACS criteria consensus definitions.[5] Participants were given the option of declining examination of any of the skin sites. Where this occurred, it was noted on the data form. Age and sex data were collected. Clinical history including itch and contact history was not collected as the focus was only on lesion distribution.

Statistical analysis

Lesion distribution was analysed by calculating the proportion of individuals with scabies who had typical scabies lesions at each site. The 98 numbered sites were grouped into larger, clinically relevant areas to form five regions and 16 subregions (Supporting Information: Table S1). The distribution was analysed at each of the levels (sites, subregions and regions). A body site was considered 'involved' if there were lesions at either side of the body (left or right), where relevant. To calculate the median lesion number per body site, the median number of each category was used for analysis. Severity was determined by total lesion number (very mild: 1–2 lesions; mild: 3–10 lesions; moderate: 11–50 lesions and severe: >50 lesions).[20]

We defined 'exposed' body areas as those which can be commonly examined without the removal of clothing (head and neck, arm from above elbow to fingers, legs from above knees to toes), and all other areas as 'unexposed' (Supporting Information: Table S1), similar to previous studies.[17] We calculated the expected sensitivity of focused examination of limited body areas compared to examination of the entire body.

We used relative risk (RR) to compare the proportion of individuals with lesions at specific areas between males and females, between participants of different age (less than 2 years, 2–5 years, 6–10 years and greater than 10 years) and between different aspects of the body surface (left and right, anterior and posterior). We used the K-sample equality of medians test to compare median lesion numbers between sex and age groups. Data were analysed using Stata (version 14.2, StataCorp.).

Choropleth maps

Choropleth maps, as used in geographical mapping, represent the variability of numerical data in spatially related regions by using colour templates to represent data scales.[22] Although other colour and mapping techniques have been used to describe skin lesion distribution previously,[15,23,24] choropleth maps have not been previously developed for scabies. We generated maps to visually represent the proportion of individuals with scabies lesions with lesions at each of the 98 individual sites and to compare the distribution of lesions between males and females and between participants of different age categories.

Ethics

The study was approved by the Royal Children's Hospital Melbourne Human Research Ethics Committee (38099A) and the Solomon Islands Health Research and Ethics Review Board (HRE005/18).

RESULTS

Four hundred sixty-seven individuals were enrolled and examined. The median age was 9 years (interquartile range [IQR]: 5–23; range: 0–86) and 255 (54.6%) were female (Supporting Information: Table S2). Typical scabies lesions were found in 269 participants (57.6%, Table 1).

Individual sites

Scabies lesions were most commonly found on the dorsal fingers (65.7% of participants with scabies lesions), dorsal finger web spaces (62.1%) and hand dorsum (61.7%, Figure 1 and Supporting Information: Table S3). The buttocks (40.9%) and dorsum of the feet (36.4%) were also commonly involved. Scabies lesions were least commonly observed on the plantar toes, toe web spaces, scalp and the back of the neck (all <2%).

There was a marked difference in distribution between the anterior and posterior surfaces of somebody sites. For example, the dorsal finger web spaces were much more commonly involved than the palmar web spaces (62.1% vs. 4.1%). Similarly, the dorsal toe web spaces were more

TABLE 1 Characteristics of participants with scabies.

Participants with scabies	*n*	Number of lesions					
		Very mild (1–2), *n* (%)	Mild (3–10) *n* (%)	Moderate (11–49) *n* (%)	Severe (>50) *n* (%)	Median (IQR)	*p* value*
Sex							
Female	144	3 (2.1)	46 (31.9)	72 (50.0)	23 (16.0)	13 (7, 30)	<0.001
Male	125	0 (0)	16 (12.8)	80 (64.0)	29 (23.2)	27 (16, 48)	<0.001
Age (years)							
<2	26	0 (0)	2 (7.7)	10 (38.5)	14 (53.8)	59 (30, 94)	<0.001
2–5	65	0 (0)	13 (20.0)	40 (61.5)	12 (18.5)	22 (12, 43)	<0.001
6–10	101	0 (0)	26 (25.7)	59 (58.4)	16 (15.8)	21 (10, 35)	<0.001
11–20	38	0 (0)	6 (15.8)	27 (71.1)	5 (13.2)	13.5 (11, 25)	<0.001
>20	39	3 (7.7)	15 (38.5)	16 (41.0)	5 (12.8)	13 (5, 25)	<0.001
Total	269	3 (1.1)	62 (23.0)	152 (56.5)	52 (19.3)	20 (11, 40)	-

*p value refers to the comparison of all medians, determined by the K-sample equality of medians test, and calculated separately for sex and age.

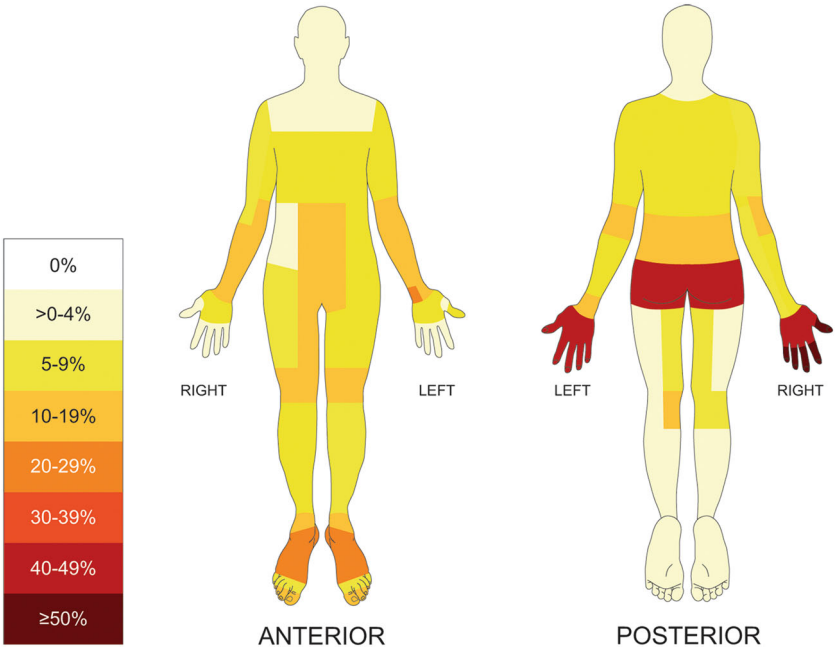

FIGURE 1 Choropleth maps showing percentage of participants with scabies lesions who had lesions at each individual site

commonly involved than the plantar toe web spaces (13.4% vs. 1.1%) and the volar wrists were more commonly involved than the dorsal aspects (43.5% vs. 27.1%).

Subregions

The hands (dorsum hands, palmar hands and digits) were most commonly involved subregion (88.5%), followed by the elbow and forearm (61.0%), wrists (56.9%), knees and lower legs (46.6%) and buttocks (40.9%, Table 2). The least commonly affected subregions were the scalp (1.5%), face (4.5%) and neck (3%).

Regions

The arms were by far the most commonly involved region (97.0%, Supporting Information: Table S4). The legs (66.3%), groin (45.3%) and torso (34.3%) were also commonly involved the head and neck were infrequently involved (6.3%, Supporting Information: Table S4).

TABLE 2 The proportion of individuals with scabies lesions at each subregion, overall and by age and sex.

		Sex			Age									
	Overall[a]	Female	Male		<2 years		2–5 years		6–10 years		11–20 years		>20 years	
Subregion	*n* (%)	*n* (%)	*n* (%)	RR[b] (95% CI)	*n* (%)	RR (95% CI)	*n* (%)	RR (95% CI)	*n* (%)	RR (95% CI)	*n* (%)	RR (95% CI)	*n* (%)	RR
Scalp	4/269 (1.5)	2/144 (1.4)	2/125 (1.6)	1.2 (0.2–8.1)	1/26 (3.8)	3.9 (0.3–60.0)	2/65 (3.1)	3.1 (0.3–33.6)	1/101 (1.0)	ref	0/38 (0)	-	0/39 (0)	-
Face	12/269 (4.5)	6/144 (4.2)	6/125 (4.8)	1.2 (0.4–3.5)	6/26 (23.1)	8.8 (1.1–68.6)	4/65 (6.2)	2.3 (0.3–20.2)	1/101 (1.0)	0.4 (0.0–5.9)	1/38 (2.6)	ref	0/39 (0)	-
Neck	8/269 (3.0)	4/144 (2.8)	4/125 (3.2)	1.2 (0.3–4.5)	3/26 (11.5)	4.3 (0.5–39.9)	3/65 (4.6)	1.8 (0.2–16.3)	1/101 (1.0)	0.4 (0.0–5.9)	1/38 (2.6)	ref	0/39 (0)	-
Chest	34/269 (12.6)	17/144 (11.8)	17/125 (13.6)	1.2 (0.6–2.2)	4/26 (15.4)	1.2 (0.4–4.0)	10/65 (15.4)	1.2 (0.4–3.3)	13/101 (12.9)	1.0 (0.4–2.6)	2/38 (5.3)	0.4 (0.1–2.0)	5/39 (12.8)	Ref
Back	47/269 (17.5)	19/144 (13.2)	28/125 (22.4)	1.7 (0.9–2.9)	14/26 (53.8)	4.2 (1.7–10.3)	12/65 (21.5)	1.4 (0.5–3.8)	16/101 (15.8)	1.2 (0.5–3.1)	1/38 (2.6)	0.2 (0.0–1.7)	5/39 (12.8)	Ref
Abdomen	63/268 (23.5)	25/144 (17.4)	38/124 (30.6)	1.8 (1.1–2.8)	10/26 (38.5)	3 (1.1–7.8)	19/65 (29.2)	2.3 (0.9–5.6)	21/100 (21.0)	1.6 (0.7–4.0)	8/38 (21.1)	1.6 (0.6–4.6)	5/39 (12.8)	Ref
Upper arm and axilla	68/268 (25.4)	32/144 (22.2)	36/124 (29.0)	1.3 (0.9–2.0)	10/26 (38.5)	2.1 (0.9–4.9)	16/65 (24.6)	1.4 (0.6–3.0)	31/100 (31.0)	1.7 (0.8–3.6)	4/38 (10.5)	0.6 (0.2–1.8)	7/39 (17.9)	Ref
Elbow and Forearm	163/267 (61.0)	75/142 (52.8)	88/125 (70.4)	1.3 (1.1–1.6)	15/25 (60.0)	1.0 (0.7–1.5)	42/65 (64.6)	1.1 (0.8–1.5)	63/101 (62.4)	1.1 (0.8–1.4)	20/37 (54.1)	0.9 (0.6–1.4)	23/39 (59.0)	Ref
Hands	238/269 (88.5)	122/144 (84.7)	116/125 (92.8)	1.1 (1.0–1.2)	21/26 (80.8)	1.2 (0.9–1.5)	59/65 (90.8)	1.3 (1.0–1.6)	93/101 (92.1)	1.3 (1.1–1.7)	38/38 (100)	1.4 (1.1–1.7)	27/39 (69.2)	Ref
Wrists	153/269 (56.9)	67/144 (46.5)	86/125 (68.8)	1.5 (1.2–1.8)	11/26 (42.3)	0.8 (0.5–1.4)	34/65 (52.3)	1.0 (0.7–1.5)	67/101 (66.6)	1.3 (0.9–1.8)	21/38 (55.3)	1.1 (0.7–1.6)	20/39 (51.3)	Ref
Genitals	43/264 (16.3)	10/143 (7.0)	33/121 (27.3)	3.9 (2.0–7.5)	3/26 (11.5)	0.9 (0.2–3.4)	12/65 (21.5)	1.4 (0.5–3.7)	18/99 (18.2)	2 (0.8–5.0)	5/36 (13.9)	1.1 (0.3–3.3)	5/38 (13.2)	Ref
Buttocks	110/269 (40.9)	47/144 (32.6)	63/125 (50.4)	1.5 (1.2–2.1)	18/26 (69.2)	3 (1.6–5.6)	30/65 (46.2)	2 (1.1–3.8)	46/101 (45.5)	2.0 (1.1–3.6)	7/38 (18.4)	0.8 (0.3–1.9)	9/39 (23.1)	Ref
Upper leg	52/266 (19.5)	26/142 (18.3)	26/124 (21.0)	1.1 (0.7–1.8)	12/26 (46.2)	4.5 (1.6–12.4)	14/64 (21.9)	2.1 (0.8–6.0)	18/99 (18.2)	1.8 (0.6–4.9)	4/38 (10.5)	1.0 (0.3–3.8)	4/39 (10.3)	Ref
Knees and lower leg	125/268 (46.6)	58/144 (40.3)	67/125 (54.0)	1.3 (1.0–1.7)	22/26 (84.6)	3 (1.7–5.1)	33/65 (50.8)	1.8 (1.0–3.1)	45/100 (45.0)	1.6 (0.9–2.7)	14/38 (36.8)	1.3 (0.7-–2.5)	11/39 (28.2)	Ref
Ankles	87/267 (32.6)	45/143 (31.5)	42/124 (33.9)	1.1 (0.8–1.5)	16/25 (64.0)	5.0 (2.1–12.0)	23/65 (35.4)	2.8 (1.1–6.7)	33/100 (33.0)	2.6 (1.1–6.1)	10/38 (26.3)	2.0 (0.8–5.4)	5/39 (12.8)	Ref
Feet	111/268 (41.4)	54/144 (37.5)	57/124 (46)	1.5 (0.9–1.6)	19/26 (73.1)	9.5 (3.1–29.0)	34/65 (52.3)	6.8 (2.2–20.7)	37/100 (37.0)	4.8 (1.6–14.7)	18/38 (47.4)	6.2 (2.0–19.2)	3/39 (7.7)	Ref

Abbreviations: CI, confidence interval; RR, relative risk.

[a]The denominator for each subregion varies by participants consenting to the examination of that subregion.

[b]RR = females as reference.

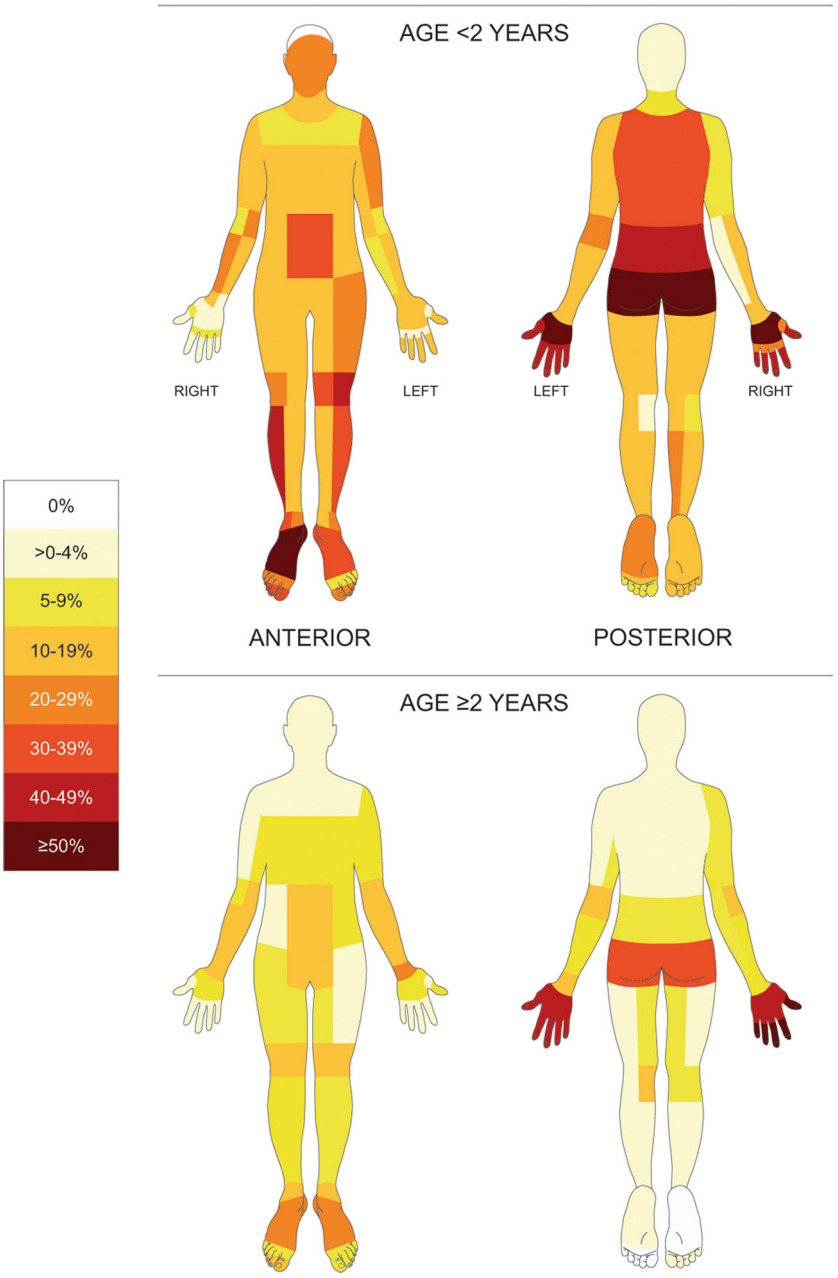

FIGURE 2 Choropleth maps of scabies lesion distribution by age group

Distribution by age group

Individuals aged less than 2 years had a distinct widespread pattern of lesion distribution (Figure 2). All participants aged less than two had more than one body region involved and 76.9% had three or more body regions involved compared to 47% of those aged 2%–20% and 23.7% of those older than 20 (Supporting Information: Table S5). Individuals aged less than two also had a higher median number of lesions (59) compared to other age groups (2–5 years: 22 lesions, 6–10 years: 21, >10 years: 13, $p \leq 0.001$, Table 1). Of those less than 2 years old with scabies, 8 (30.8%) had lesions at the head and neck region compared to 10.8% of those aged 2%–5% and 1.4% of older participants (Supporting Information: Table S4). Individuals aged less than two were also more likely to have lesions on the face, compared to those aged 11–20, and more likely to have lesions at the back, abdomen, buttocks, upper and lower legs, ankles and feet subregions, when compared to individuals aged over 20 years (Table 2).

When compared to those aged over 20 years, individuals aged 2–5 years were more likely to have lesions at the buttocks, ankles and feet (Table 2). Children aged 6–10 years were more likely to have lesions on the hands, buttocks, ankles and feet than participants aged over 20 years (Table 2).

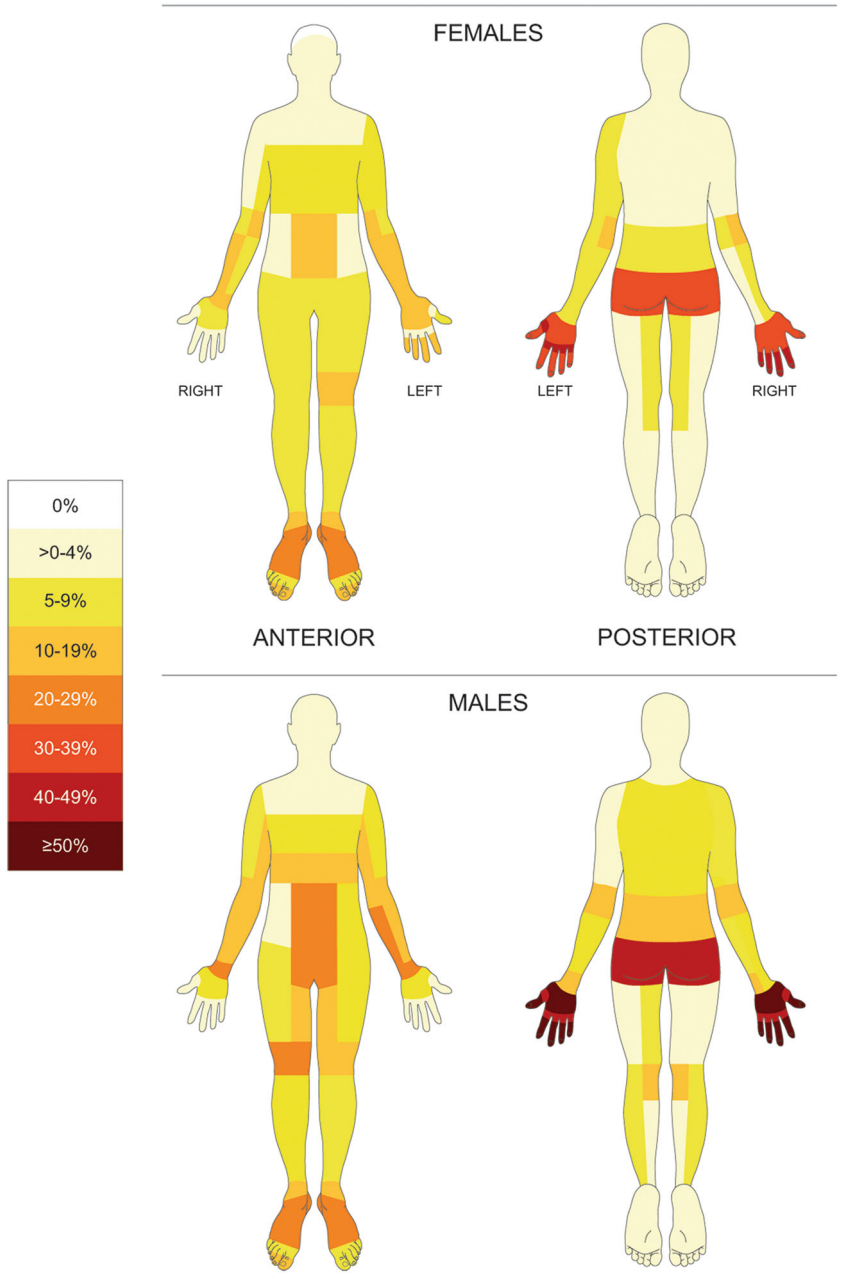

FIGURE 3 Choropleth maps of scabies lesion distribution by sex

Distribution by sex

There was a difference in the pattern and distribution of lesions between males and females (Figure 3). Males were more likely to have moderate or severe scabies (66.0% vs. 87.2%, RR: 1.3, 95% CI: 1.2–1.5, Table 1) and a higher median number of lesions (27 vs. 13, $p = < 0.001$). Males were more likely to have lesions in the genital subregion (27.3% vs. 7%, RR: 3.9, 95% CI: 2.0–7.5, Table 2 and Supporting Information: Table S7) and also supported by more frequent involvement of the groin region (RR: 1.6, 95% CI: 1.3–2.2, Supporting Information: Table S4).

Lesion symmetry

Most participants with scabies lesions ($n = 225$, 84.2%) had lesions on both the left and right sides of the body (Supporting Information: Table S6). At the subregion level, lesions were commonly present bilaterally on the hands (64.7% of those with lesions in this subregion), upper leg (57.7%) lower leg (53.6%) and feet (52.3%, Supporting Information: Table S6). Subregions, where fewer participants had lesions on both sides, included the upper arm (32.4%), wrist (36.6%) and ankles (34.5%).

TABLE 3 Sensitivity of focused examinations compared to whole body examination, overall and by age.

Focused examination areas	Sensitivity			
	Overall (95% CI)	<2 years (95% CI)	2–20 years (95% CI)	>20 years (95% CI)
Hands and wrists	93.3 (89.6–96.0)	88.5 (69.8–97.6)	96.6 (93.1–98.6)	79.5 (63.5–90.7)
Exposed arms	96.7 (93.7–98.5)	96.2 (80.4–99.9)	97.5 (94.4–99.2)	92.3 (79.1–98.4)
Exposed legs	64.2 (58.1–69.9)	92.3 (74.9–99.1)	66.5 (59.6–73)	33.3 (19.1–50.2)
Exposed arms and legs	99.3 (97.3–99.9)	96.2 (80.4–99.9)	100 (98.2–100)	97.4 (86.5–99.9)
Exposed arms, legs, head and neck	99.3 (97.3–99.9)	96.2 (80.4–99.9)	100 (98.2–100)	97.4 (86.5–99.9)
Exposed arms, legs, head, neck, abdomen and back	99.6 (97.9–100)	100 (86.8–100)	100 (98.2-100)	97.4 (86.5–99.9)

Sensitivity of limited examination

Only two individuals (0.7%) had lesions in unexposed areas that did not also have lesions in exposed areas. The most sensitive approach to focused examination was the examination of the exposed arms and legs, head and neck, abdomen and back (sensitivity 99.6% compared to examination of the whole body, Table 3). Limiting examination to the exposed arms and legs (excluding the abdomen and back) only led to a minor decrease in sensitivity (99.3%). There was a lower sensitivity for limiting the examination to just the hands and wrists (93.3%), just the exposed arms (96.7%) or just the exposed legs (64.2%). Including examination of the head and neck did not lead to improvements in sensitivity.

DISCUSSION

This systematic and detailed description of the body distribution of scabies lesions from 269 participants with scabies lesions provides important evidence for the clinical diagnosis of scabies. Our findings are generally supportive of the typical body distribution of scabies lesions, as defined in the 2020 IACS Criteria.[5]

We found that the most common sites of scabies lesions were the hand dorsum, dorsal fingers and finger web spaces. The hands were the most commonly involved subregion, with lesions seen in almost 90% of individuals in our study, consistent with previous reports.[14,17,23,25,26] The finger web spaces (62% of participants) are a highly characteristic site for scabies lesions.[10,12,13,27–29] Our data also support previous reports that scabies lesions are uncommon on the face, neck or sole of the foot.[13,25,30]

This study provides new and increased detail about the distribution of scabies. For example, our results show that the dorsal aspect of the finger web spaces is much more commonly involved than the palmar web spaces. One previous study showed an increased frequency of involvement of the dorsal hand compared to the palmar hand.[18] Similarly, where previous studies have reported the arms to be common sites for lesions,[14,23,31] our study and choropleth figures reveal this in greater detail, including the preponderance for lesions on the medial and anterior arm.[14,25,32]

The distribution of scabies lesions was notably different by age. Participants aged less than 2 years had a more generalized distribution with more body sites involved than older participants. These findings are consistent with a study from Brazil that showed an inverse correlation between the number of body sites affected and age.[13] Participants aged less than 2 years also had a higher median number of lesions and considerably higher proportion had lesions on the head and neck (30%) compared to other age groups (less than 2% in those aged over 6 years). Scalp, neck and face lesions have previously been reported to be common in young children,[13,14,30] and uncommon in older age groups. Our findings support the 2020 IACS criteria recommendations regarding the typical distribution of scabies lesions in individuals aged less than 2 years.[5]

We also found differences in the distribution between males and females. Male participants in our study were

significantly more likely to have genital lesions than females (27% vs. 7%), with a higher proportion of genital involvement in all age groups except those aged less than 2 years. Males were also more likely to have abdominal lesions, buttock lesions and a higher overall lesion count. Scabies genital lesions affecting males are frequently reported,[33,34] but this is, to our knowledge, the first prospective study comparing the frequency of male and female genital lesions.

The detailed description of scabies distribution produced by this study, including the use of choropleth maps to display these data, may assist with the clinical diagnosis of scabies, including expected differences in this distribution between age groups and between males and females. These findings could be incorporated into training packages and may lead to improvements in diagnostic accuracy.[35]

The reasons scabies lesions favour certain locations are incompletely understood. In addition to burrows, which are a specific but uncommon lesion type, lesions are caused by hypersensitivity responses to mite products, and possibly to temporary excavations made by immature mites.[8,36] Lesions do not always correlate directly with the location of mites or mite products.[37] Research of *S. scabiei* var *canis* mites, which affect dogs and foxes, suggests mites may favour locations depending on the tissue lipid composition.[8,38]

Our data suggest that abbreviated, focused skin examination is likely to have very high sensitivity, approaching that of a whole-body examination. Such examinations may be particularly useful for prevalence mapping surveys, reducing the need for exposure and removal of clothes, enabling a more rapid assessment.[6] Based on our findings, focused examination of the arms and legs would be highly accurate (sensitivity 99%). This approach would be practical to implement, particularly in warm climates where these areas are commonly unclothed. An even more limited examination such as only the hands and wrists (sensitivity 93%) or only the arms (sensitivity 97%) could also be considered. These sensitivities are slightly higher than previous estimates of limited examinations which ranged from 92% to 93%.[17,18] Focused examination may miss a small number of cases in infants and young children (sensitivity 88% for hands and wrists, 96% for arms). While a reduced sensitivity in infants may not significantly alter community prevalence estimates during mapping, these results underline the importance of whole-body examination for the individual clinical diagnosis of scabies in those aged less than 2 years.

This study has several limitations. First, it was conducted in a tropical setting with a very high prevalence of scabies and therefore the results may not be generalisable to other populations. In particular, the distribution of scabies may be different in temperate climates, in low-prevalence areas, and among particular groups such as elderly, bedridden individuals or immunosuppressed individuals where distribution is more frequently atypical.[15,39–43] Second, the assessment was conducted by a single examiner using clinical assessment of typical scabies lesions, without confirmation of scabies diagnosis using dermoscopy or microscopy. Third, the age distribution of enrolled individuals was not representative of the general community with younger age groups overrepresented and males aged 20–40 underrepresented. The strengths of the study include the large sample size of individuals with scabies lesions, the prospective examination of the entire skin surface and detailed documentation of lesion numbers across 98 clinically relevant sites. Additionally, the use of choropleth maps is a novel methodology which could be adapted for other dermatological conditions.

This study provides novel and highly detailed data on the body distribution of scabies lesions. The hands were most commonly involved. There were substantial differences in the distribution of scabies lesions by age and sex. The results support the recommendations of the 2020 IACS criteria for the typical distribution of scabies. These data will be useful for training and may contribute to improvements in clinical diagnosis. The results also provide evidence to support the use of focused examinations when the individual-level diagnosis is not required, such as for prevalence mapping. Future research priorities include developing new, objective diagnostic methods for scabies and evaluation of the implementation of focused examination during prevalence surveys.

AUTHOR CONTRIBUTIONS

Daniel Engelman and Millicent H. Osti conceived the study. Daniel Engelman, Millicent H. Osti, Andrew C. Steer and Margot J. Whitfeld designed the study. Millicent H. Osti collected data in the field, assisted by Sean Dauer, Michael Marks and Susanna Lake under the local leadership of Oliver Sokana and Dickson Boara. Millicent H. Osti performed the analysis, created the choropleth maps and prepared the initial manuscript draft, supervised by Daniel Engelman. Oliver Sokana, Dickson Boar, Titus Nasi, Margot J. Whitfeld, Michael Marks, John M. Kaldor, Lucia Romani, Andrew C. Steer and Daniel Engelman are investigators of the RISE trial. All authors were involved in revising the manuscript and approved the final version.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Written, informed consent was obtained from all participants. Consent was obtained from parents or guardians for those aged less than 18 years. The study was approved by the Royal Children's Hospital Melbourne Human Research Ethics Committee (38099A) and the Solomon Islands Health Research and Ethics Review Board (HRE005/18).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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