Prevalence of Staphylococcus Aureus colonisation and skin conditions in Otago school children

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INTRODUCTION

The incidence of hospitalisation for serious skin infections in children in New Zealand almost doubled between 1990 to 2007, making this an important health priority.[1] *Cunliffe* reported that 'without some knowledge of the incidence of a pathogenic micro-organism in the healthy body it is difficult to assess the significance of the organism when found in diseased tissues',[2] and so in order to understand the drivers behind this increased rate of hospitalisation, further investigation is needed in the healthy population. Direct or indirect contact with S. aureus may be followed by a period of asymptomatic colonisation, which may then lead to tissue invasion or contamination of damaged tissue.[3] It is unclear whether the high admission rates in NZ purely reflect a high community prevalence of low-grade infection or carriage, or alternatively are due to a higher proportion of infections that require hospitalisation.[4] However, to date very little evidence has been gathered regarding the prevalence of Staphylococcus aureus carriage and occurrence of low-grade skin infection by S. aureus, and we found no evidence of such research in South Island communities.

BRIEF REVIEW OF STAPHYLOCOCCUS AUREUS EPIDEMIOLOGY IN LITERATURE

International studies show an average nasal carriage prevalence of 27%, derived from a wide variety of healthy populations.[5] Only one known study has been carried out in New Zealand concerning the carriage rates of S. aureus in healthy individuals, estimating 18% (95% CI 14-22) nasal carriage amongst adults.[3] S. aureus prospers in the vestibulum nasi region, compared to other carriage sites,[6] and despite antibiotic treatment to eradicate S. aureus from the body, nasal carriage tends to persist.[7] Carriers remain reservoirs for its spread in the community.[8] A study in Tairawhiti (Gisborne, NZ) showed there were 14 primary care cases of skin condition for every one hospitalisation,[4] it seems reasonable to assume a larger burden of low-severity infections which remain hidden from primary care.

The aim of this study was to measure the prevalence of S. aureus carriage, and to contribute to current understanding of the burden of skin conditions, in Otago school children.

METHODS

Sample selection:

Sample collection was carried out in November 2013 at an intermediate school in Otago with a role of 283 students. All students currently enrolled in the school were eligible to participate provided the informed consent of both students and caregivers was given. Questionnaires were sent to homes, using tracked number identification to maintain anonymity.

Data collection:

The questionnaire included;

- Demographic information
- History of skin conditions ever/in the last year/currently (eczema, dermatitis, trauma, or any other condition that might predispose to infection)[6]
- Barriers and access to health care (including time, work, cost, attitudes)
- Psychosocial impacts of skin conditions (experiences of bullying, teasing, pain, or time off school as a result of skin infection)
- Space to draw and comment on sites of previous skin conditions
- Barriers and access to health care (including time, work, cost, attitudes)

Specimen Collection:

Children were swabbed by one of the investigators (HL). A sterile swab was rubbed across the antecubital fossa. Nasal swabs were taken from the nasal ostium in both nostrils. Labelled samples were stored in ice, and transported in Amie's medium, to be processed within 5 hours.

Specimen Processing:

Samples were cultured in mannitol salt enrichment broth by incubating aerobically for 24 hours at 35±2°C. Turbid broths were streaked onto mannitol salt agar (MSA). MSA plates were incubated over 24 hours, and observed for colour change. Plates that were not positive after one day were re-incubated for a further 24 hours. Positive isolates were stored at 4°C overnight. Positive MSA colonies showing yellow colour change were identified using standard microbiological tests (gram stain, tube and slide coagulase, DNAse production). Samples with conflicting results were

identified by MALDI-TOF (matrix-assisted laser desorption/ionisation time of flight mass spectrometry).

Analysis:

Questionnaire data were managed and analysed using Epi Info 7. Categories were as in Table 1. Low income groups were $0-20,000, $20-35,000 and $35-70,000. The middle income group was those in the $70-100,000 bracket, and the high income group was $100,000 or more. "Skin conditions in the last year" included all reported cases of skin conditions from any category now or in the last year. The outcome used in the main analysis was total carriage (either nasal or elbow is positive). The proportion of participants with different characteristics, experience of skin conditions, and colonisation were tabulated and confidence intervals calculated using Epi-Info 7. The prevalence of colonisation in different groups was tabulated and RR and associated confidence intervals calculated.

Ethics Approval:

Prior to beginning the study we obtained consent from the school Board of Trustees, and approval from the Otago University Ethics Committee (reference 12/280).

RESULTS

From a school of 280 pupils, 59 (21%) returned the questionnaire and consent forms, 3 of which were illegible. Two students were absent on the swab dates, resulting in a final sample of 54 (19%) pupils.

Table 1 shows participant characteristics. Female students' parents were 50% more likely than males' to return the questionnaire and give consent for the swab procedure (23% compared to 15.3%). Maori and Pacific students were both underrepresented in the sample.

Table 2 shows the parents' reports of participants' skin conditions; 11.1% reported ever being diagnosed with cellulitis at some point. The highest frequency skin condition reported was "itchy lumps or spots" with 26 students ever experiencing this (48%, CI 34.3-62.2). This was followed by "dry, flaky or scaly patches" with 15 reports.

The most commonly mentioned sites of infection were the face/head, antecubital and popliteal fossae, each reported 6 times. 5/54 (9.3%) children reported ever being teased for a skin condition.

As shown in Table 3, the total prevalence of S. aureus carriage was 28/54 (51.9%, 95% CI 37.8-65.7), based on a positive result at either site. Colonisation prevalence in the nasal vestibule was much higher at 25/54 (46.4%, 95% CI 32.6-60.4) when compared with elbow-colonised students, 8/54 (14.8%, 95% CI 6.6-27.1) (Table 4). One student was found to be colonised with nasal MRSA.

Table 4 shows the results of the analysis of carriage prevalence by characteristics of the students. Boys were more than twice as likely as girls to carry S. aureus.

Table 5 shows parent reports of skin conditions by colonisation status (total colonisation). Colonised children were 2.3 (95% CI 1.1-5.1) times as likely to have been taken to a doctor, although 0.7 (95% CI 0.4-1.6) times as likely to have been bought non-prescription medicines compared with non-colonised participants. Children in the colonised group were 2.8 (95% CI 0.6-12.6) times as likely to have taken time off school due to a skin condition.

DISCUSSION

Key Findings:

Just over half (51.9%, 95%CI 37.8-65.7) of our sample of Oamaru school children were colonised with S. aureus. This is higher than other estimates of child colonisation[5,7] and than New Zealand estimates of colonisation in adults,[3] although the latter is consistent with other studies showing that children have higher carriage rates than adults.[2] A very high colonisation prevalence such as we found could be due to the frequent close contact

Variable	Sample population n (%)
Age of student	
11	12 (22.2)
12	26 (48.2)
13	16 (29.6)
Gender of student	
Male	22 (40.7)
Female	32 (59.3)
Ethnicity of student (non-exclusive)	
New Zealand European	52 (96.3)
Maori	1 (1.9)
Pacific	0 (0.0)
Other	4 (7.4)
Family income (NZD)	
Low income	21 (39.0)
Middle income	14 (25.9)
High income	16 (29.6)
Not specified	3 (5.6)
Occupants per bedroom	
≤1	20 (37.0)
1.1 - ≤1.5	30 (55.6)
1.6 - ≤2	4 (7.4)
Highest held qualification of household members	
None	1 (1.9)
School Qualification	20 (37.1)
Post-school Qualification	31 (57.4)
Parent-rated home hygiene practices of family	
Very Good/Excellent Hygiene	35 (64.9)
Fair/Good Hygiene	18 (33.4)
Average Hygiene	0 (0)
Poor Hygiene	0 (0)

Table 1. Characteristics of responders to skin infection questionnaire

Condition	Now n (%, 95% CI)	In the last year n (%, 95% CI)	Ever n (%, 95% CI)
Sore red lumps or spots	6 (11.1, 4.2-22.6)	8 (14.8, 6.6-27.1)	9 (16.7, 7.9-29.3)
Itchy lumps or spots	12 (22.2, 12.0-35.6)	13 (24.1, 13.5-37.6)	26 (48.2, 34.3-62.2)
Boils	0 (0)	1 (1.9, 0.05-9.9)	9 (16.7, 7.9-29.3)
Dry, flaky or scaly patches	5 (9.26, 3.1-20.3)	6 (11.1, 4.2-22.6)	15 (27.8, 16.5-41.6)
Red, swollen areas	2 (3.7, 0.5-12.8)	3 (5.6, 1.2-15.4)	8 (14.8, 6.6-27.1)
Crusty, oozing areas	2 (3.7, 0.5-12.8)	4 (7.4, 2.1-17.9)	14 (25.9, 15.0-39.7)
Eczema*	0 (0)	1 (1.9, 0.05-9.9)	6 (11.1, 4.2-22.6)
Dermatitis*	2 (3.7, 0.5-12.8)	5 (9.26, 3.1-20.3)	7 (13.0, 5.4-24.9)
Cellulitis*	0 (0)	0 (0)	6 (11.1, 4.2-22.6)
Skin Abscess	0 (0)	0 (0)	5 (9.26, 3.1-20.3)
Students reporting at least one of the above skin conditions	21	30	44

* Diagnosed by a doctor

Table 2. Self-reported experience of skin conditions from questionnaire

among school children, allowing exchange of microflora.[9]

We also found that males in the sample were more likely to be colonised, consistent with other studies.[3,5] Students colonised at either nose or elbow were 2.32 (95% CI 1.06-5.07) times as likely to have visited a doctor due to a skin condition in the past. While none of our participants were classed as living in crowded homes (>2 occupants per bedroom)[14], we did find increasing colonisation prevalence with increasing occupants per bedroom, consistent with overcrowding being a well-documented risk factor for skin infection.[12,13] Since 14% of Otago children live in crowded homes,[14] if our sample had included children living in crowded homes, we would expect them to have higher prevalence of carriage.

Strengths:

This small study was designed to provide estimates of S. aureus colonisation that could be used in the design of larger prevalence studies. Standard methods of swabbing[10,11] were used by a single investigator, ensuring consistency, and standard culture techniques were used.

Limitations:

Our small sample size means we lack power to detect statistically significant relationships with many demographic and health variables. The response rate was low, and participating families were relatively wealthy, potentially biassing our estimate of the prevalence of colonisation, although we did not show significant differences in colonisation by income category.

Because of time restrictions we were not able to measure carriage over time, so our results may overestimate carriage due to inclusion of intermittent carriers.

Anectodatal feedback suggested that the paperwork required for ensuring informed consent hindered the involvement of some parents, particularly those who did not read English. Time restrictions meant we were unable to employ translators to improve community involvement from all areas; this was an important omission in the design of this study.

FUTURE FOCUS

Reducing New Zealand's high rate of morbidity due to serious skin infections should be a priority. Studies such as this, of the normal skin microlora in a community setting, are important to inform our understanding the mechanisms behind skin pathology and infection, including carriage and transmission. In New Zealand there is a need for larger, more community-comprehensive studies. This study provides a good basis for informing the design of such a study, which should measure difference in carriage prevalence in different regions of New Zealand. Further studies should be designed and presented in a way that is more accessible to all parents and children and, if possible, translated into languages which are prominently spoken in the community involved.

Sample site	n (%, 95% CI)
Nasal colonised	25 (46.4, 32.6-60.4)
Inner elbow colonised	8 (14.8, 6.6-27.1)
Exclusive colonisation at inner elbow	3 (5.6, 1.2-15.4)
Exclusive Nasal colonisation	20 (37.0, 24.3-51.3)
Total Carriage (either site positive)	28 (51.9,37.8-65.7)
Nasal MRSA	1 (1.9, 0.05-9.9)
Inner elbow MRSA	0 (0, 0-7.9)

Table 3. Positive results for Staphylococcus aureus colonisation

Characteristic	Prevalence of colonisation n (%, 95% CI)*	Relative risk (95% CI)
Gender of student		
Female colonised	11/32 (34.4, 18.6-53.2)	1.0
Male colonised	17/22 (77.3, 54.6-92.2)	2.3 (1.3-3.8)
Family income		
Low Income (below median)	14/21 (66.7, 43.0-85.4)	1.0
Middle Income (median)	5/14 (35.7, 12.8-64.9)	0.5 (0.3-1.1)
High Income (above median)	8/16 (50.0, 24.7-75.4)	0.8 (0.4-1.3)
Occupants per bedroom		
≤ 1	7/20 (35, 15,.4-59.2)	1.0
≥1-1.5	18/30 (60, 40.6-77.4)	1.7 (0.9-3.3)
≥1.5-2	3/4 (75, 19.4-99.4)	2.1 (0.9-4.9)
Highest-held parent qualification		
High School Qualification or below	9/21 (42.9, 21.8-66.0)	1.0
Post-School Qualification	17/31 (54.8, 36.0-72.7)	1.2 (0.7-2.2)
Self-reported hygiene practices		
Very Good/Excellent Hygiene	15/35 (42.9, 26.3-60.7)	1.0
Fair/Good Hygiene	12/18 (66.7, 41.0-86.7)	1.6 (0.9-2.6)
History of any skin condition in the last year		
No reported skin condition	13/24 (54.2,32.8-74.5)	1.0
Self-reported skin condition (boils/lumps/dry, flaky, or swollen areas/itchy lumps/cellulitis/skin abscess/dermatitis etc.)	15/30 (50, 31.3-68.7)	0.9 (0.5-1.7)
History of prescribed medicines or antibiotics		
No prescription medications	23/49 (46.9, 32.5, 61.7)	1.0
Prescription MEDS/ABX for skin condition	5/5 (100)	2.1 (1.6-2.9)

*Not all categories include total 54 respondents due to non-response for some variables.

Table 4. Colonised prevalence by demographic and health characteristics

	Total n (% sample)	Non-colonised	Colonised	Relative risk colonised vs. non-colonised (95% CI)
Took child to doctor	21 (38.9)	6/26 (23.1, 9.0-43.7)	15/28 (53.6, 33.4-72.5)	2.32 (1.1-5.1)
Parent bought non-prescription medicines	18 (33.3)	10/26 (38.5, 20.2-59.4)	8/28 (28.6, 13.2-48.7)	0.7 (0.4-1.6)
Child took time of school due to condition	8 (14.8)	2/26 (21.4, 8.3-41.0)	6/28 (7.7, 1.0-25)	2.8 (0.6-12.6)
Skin condition significant pain	5 (9.3)	1/26 (3.9, 0.1-19.6)	4/28 (14.3, 4.0-32.7)	3.7 (0.4-12.5)
Child experienced teasing due to condition	5 (9.3)	2/26 (21.4, 8.3-41.0)	3/28 (10.7, 2.3-28.2)	1.4 (0.3-7.7)

Table 5. Parent-reported consequences of skin conditions

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