Article type: Original Research
Received
Accepted
Running head: Skin infections in Indigenous children
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Conflict of interest: none
*Authors' contributions: SN led the research project, designed the study, conducted the literature search, performed analysis of the findings and drafted the manuscript. RF provided critical revisions and edited the manuscript for submission. PM conceived of the study, contributed to the study design, provided critical revisions and edited the manuscript for submission. KT edited the manuscript for submission. ST significantly revised the draft version, provided new input and edited the text, figures and tables, and prepared the final submission.

Abbreviations:

APSGN	acute post-streptococcal glomerulonephritis
CA	community-associated
GAS	group A streptococcus
MRSA	methicillin-resistant *S. aureus*
RHD	rheumatic heart disease

Systematic literature review to identify methods for treating and preventing bacterial skin infections in Indigenous children

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Abstract

Background/Objectives: Bacterial skin infections in Indigenous children in Australia frequently lead them to access primary health care. This systematic review aims to identify and analyse available studies describing the treatment and prevention of bacterial skin infections in Indigenous children.

Methods: Electronic databases including Scopus, MEDLINE, CINAHL, ProQuest, Informit and Google Scholar were searched. Studies in English published between August 1994 and September 2016, with the subject of bacterial skin infections involving Indigenous children and conducted in Australia, New Zealand, the USA or Canada were selected.

Results: Initially 1474 articles were identified. After the application of inclusion and exclusion criteria, 10 articles remained. Strategies for the treatment and prevention of bacterial skin infections included

the management of active infections and lesions, improving environmental and personal hygiene, the installation of swimming pools and screening and treatment.

Conclusion: There is a need for more, rigorous, large-scale studies to develop evidence for appropriate, culturally acceptable methods to prevent and manage bacterial skin infections in Indigenous children in Australia. The problem is complex with multiple determinants. Until underlying socioeconomic conditions are addressed skin infections will continue to be a burden to communities.

Key words: skin infections, CA-MRSA, *Staphylococcus aureus*, *Streptococcus pyogenes*, pyoderma, Aboriginal and Torres Strait Islander, Indigenous, children

Introduction

Introduction

In Australia there is a disparity in health outcomes between Aboriginal and Torres Strait Islander (hereafter Indigenous) children and other Australian children. Factors contributing to this include socioeconomic and environmental determinants and access to culturally appropriate primary health care.[1–3] Bacterial skin infections are one example of poorer health outcomes and a common reason for Indigenous children to access primary health care services.[4] Such infections are common in Indigenous communities and pose a burden on families as they are difficult to eradicate, often recur and impact health, school attendance and quality of life.[4–5]

The most common organisms causing bacterial skin infections are group A beta haemolytic streptococci and *Staphylococcus aureus*.[6–8] While group A streptococcus (GAS) has been reported as the predominant bacteria causing skin infections in Indigenous children in Australia,[5,9] studies show evidence that the rising rates of *S. aureus* are the causative agent for skin and soft tissue infections[7,10,11] and that co-infection with both GAS and *S. aureus* is common.[9] The infections are communicable, with transmission occurring mainly through direct skin-to-skin contact, fomite contact or by close contact with nasal carriers.[12] When they are diagnosed early and appropriate treatment is instituted these skin infections are generally curable and heal without scarring.[13] Delayed or inadequate treatment can lead to nephritis, carditis, arthritis, septicaemia and antibiotic resistance.[13] Colonisation and invasion of the skin by bacteria occurs when the normal flora of the skin is transformed by changes in ambient temperature and humidity and by low levels of personal and environmental hygiene.[13] Other factors associated with bacterial skin infections include living in crowded dwellings, skin injuries, scabies co-infection and previous antimicrobial drug treatment.[6,13] Signs and symptoms include erythema, warmth, pain or tenderness, swelling, crusting and drainage from skin lesions.[12] Skin infections with *Streptococcus pyogenes* are linked to acute rheumatic fever or rheumatic heart disease (RHD) and acute post-streptococcal glomerulonephritis (APSGN), often leading to significant morbidity. Between 1989 and 1993 the average annual rate of RHD was 0.014% in the general Australian population, compared with 3% in remote Indigenous communities.[14] While available evidence supports the hypothesis that GAS plays a role in the pathogenesis of RHD, this link is yet to be fully understood.[15] Experiencing APSGN during childhood is associated with a sixfold increase in the risk of acquiring renal disease in adulthood.[10] In Indigenous peoples these complications are a result of pyoderma rather than the more common route via throat infections.

Acquiring pyoderma at an early age, together with recurrent infections, increases the risk of developing more serious cardiac and renal disease, making this an important public health problem.[16] In 2005 the World Health Organization estimated that in less developed countries more than 111 million children under the age of 15 had pyoderma at any one time.[14] Infection with pyoderma often occurs in the first year of life with presentations to health services peaking at 2 months of age.[11] Developed countries, including Australia, the USA, New Zealand and Canada report a higher prevalence of pyoderma among Indigenous populations (particularly those living in the most disadvantaged settings), compared with the non-Indigenous population, where the prevalence of skin infection is generally low.[11] Data on the incidence of pyoderma in Australia is not routinely collected. In remote Indigenous communities of the Northern Territory, skin infections and infestations are one of the most common reasons for children to access primary health care.[4] In 2000 the prevalence rates of pyoderma in Northern Territory children in remote communities were reported to be between 10 and 70%.[5] This may reflect differences in living conditions, tropical versus arid environments and limitations in data quality and availability. In August 2004 in East Arnhem Land (in the Northern Territory's tropical north) the average monthly prevalence of pyoderma in children was 36%.[17] In non-tropical Perth, Western Australia, a study reported approximately that 16% of general practice consultations for Indigenous children were for skin disorders. [18] Skin infections caused by *S. aureus* are usually purulent and are known to recur frequently when methicillin-resistant *S. aureus* (MRSA) is the causative organism. The superficial skin infections caused by S*. aureus* can lead to deeper infections, invasive disease and ultimately to sepsis.[19,20] The nasal carriage of *S. aureus* has been associated with recurrent episodes of skin infections.[21,22]This may be due to persistent colonisation with *S. aureus* and the emergence of community-associated MRSA (CA-MRSA).[7,22]

Common modes of *S. aureus* transmission are through close contact with an infected person and contact with open lesions.[23] It is recommended that children with pyoderma be isolated until lesions have dried up or antimicrobial treatment has commenced[23] This may be difficult in settings where the disease is common. In cases of recurrent infections, isolation will cause frequent absence from school, adding to poorer educational outcomes for the patients, which are underlying determinants of higher rates of pyoderma.[5] Adult carers may have to take time off work in order to care for sick children,[23] which can exacerbate financial hardship.[11,14]

This systematic review aims to identify and critically analyse the available literature describing the treatment and prevention of bacterial skin infections in Indigenous children aged 0–19 years in both community and hospital settings.

Material and Methods

The design and reporting of the review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement and checklist.[25] Literature in electronic databases from August 1994 to September 2016 was included. The electronic databases included MEDLINE, CINAHL, Scopus, ProQuest Health and Medical Complete, Informit and Google Scholar. In Informit the search was conducted on multiple databases including the Australasian Medical Index, Health and Society, Aboriginal and Torres Strait Islander Health and RURAL. Keywords included 'skin infections,'

'bacterial,' 'children,' 'MRSA,' 'CA-MRSA,' '*Staphylococcus aureus,*' '*Streptococcus pyogenes,*' 'pyoderma,' 'Indigenous,' 'prevention,' 'hygiene' and 'decolonization' (Supporting Information •••.). Inclusion criteria were studies involving only Indigenous children 0–19 years that had been conducted in Australia, New Zealand, the USA or Canada; studies describing the treatment or prevention of bacterial skin infections and the related outcome. These countries were chosen as they share a similar history of invasion and the subsequent displacement of Indigenous peoples. Exclusion criteria were studies involving only adults aged 20 years and over, studies undertaken on animals, studies describing treatment only for fungal, viral and parasitic skin infections and those which described skin infections due to systemic illnesses and involving immunocompromised patients. A total of 1474 studies were identified from the initial search of the databases. Ten articles fulfilled the inclusion and exclusion criteria (Fig. 1), all Australian. They included one randomised control trial, a post hoc analysis, a pilot study, a prospective cohort study, two ecological studies, an intervention study and three observational studies.

Results

The results are described under the themes of the management of active infections and lesions, environmental and personal hygiene measures, the installation of swimming pools and screening and treatment (Table 1).

Management of active infections and lesions

Two articles focused on the management of active infection and lesions.[26,27] An open label, randomised, controlled, non-inferiority trial compared short-course oral co-trimoxazole with i.m. benzathine benzylpenicillin as systemic agents for impetigo.[26] Short-course oral co-trimoxazole was found to be non-inferior to one i.m. injection of benzathine benzylpenicillin (ideally used in *S. pyogenes*-prevalent areas). The trial assigned 508 Indigenous children in the Northern Territory to receive either one benzathine benzylpenicillin injection, short-course oral co-trimoxazole twice daily for 3 days or once daily for 5 days. On day 7 the outcome of treatment success (healed or improved) showed non-inferiority between the pooled short-course oral co-trimoxazole groups and the i.m. benzathine benzylpenicillin. All groups resulted in an 85% success rate. At day 7, culture-positive rates of *S. pyogenes* were reduced from 85 to 7% in the pooled short-course oral co-trimoxazole groups and the i.m. benzathine benzylpenicillin group. At day 7, culture-positive rates of *S. aureus* were reduced from 83 to 20% in the pooled short-course oral co-trimoxazole group and from 81 to 52% in the i.m. benzathine benzylpenicillin group. The recovery rate for MRSA (from swabs taken before treatment and at day 7) fell from 19 to 11% in the BPG group and from 13 to 2% in the pooled short-course oral co-trimoxazole. Short-course oral co-trimoxazole is practical, available and carries fewer risks. The authors concluded that it is low cost and generally pain free, making it the preferred option (unless oral medications are contra-indicated). Limitations included the lack of a placebo group (but due to the serious nature of impetigo it was not ethical to include a placebo group) and the open-label design, which meant that at some stages, researchers were aware of which treatment had been given to which patient. This may have influenced their assessment of treatment success. There was no long-term follow up, so recurrence may have been a factor. [26]

A post-hoc analysis by Tasani and colleagues (2016) of the study described above by Bowen and colleagues (2014) examined the importance of scabies co-infection in treatment considerations for impetigo.[27] The study found a high burden of scabies in children in the trial (84/508, 17%) and that children with scabies co-infection had more severe impetigo and were less likely to respond to antibiotics. Treatment success for impetigo with and without scabies co-infection was 76 and 87%, respectively; an absolute difference of 11% (95% CI 1–21%). Treatment success with co-infection was more likely with short-course oral co-trimoxazole than with i.m. benzathine benzylpenicillin. Due to the severity of impetigo associated with scabies co-infection it is important to treat both parasitic infestations and bacterial infection simultaneously. The study's limitations included a clinical diagnosis rather than scrapings and microscopy. Scabies treatment was not observed and children were not stratified by the presence of scabies.[27]

Environmental and personal hygiene measures

Three articles focused on environmental and personal hygiene measures.[5,28,29] In a pilot study conducted by Bailie and colleagues (2005), the health records of 138 children in three remote communities in the Northern Territory found rates of skin infections to be higher in houses that lacked functioning facilities for removing faeces or that had concrete floors (the latter was exacerbated by crowding). Younger children in older houses were more at risk. Socio-demographic variables appear to be directly associated with high rates of skin infections.

The cross-sectional nature of the data limited its capacity to infer causation. Other limitations included the small sample size and poor quality of health records in one community.[5]

A second prospective cohort study, also by Bailie and colleagues (2012), of 418 children aged 7–10 years, living in 185 houses in 10 Indigenous communities used inspection of houses and interviews with carers following a housing improvement programme in 2004–2005. There was no consistent reduction in parents reporting common childhood infections including skin infections related to building and infrastructure improvements but these were strongly associated with improvements in the hygienic conditions of the house. Building programmes alone cannot reduce infections and need to be supported by a range of appropriate community initiatives for them to appreciate the potential health gains for children. This highlights the need for further, contextual research on socioeconomic and socio-demographic factors. The limitations of the study included recall bias, the potential for chance associations in analyses and loss to follow up.[28]

An ecological study in remote Aboriginal communities by McDonald and colleagues (2010) used mixed methods to identify the social, economic, cultural and environmental factors that contributed to inadequate hygiene and to determine approaches that would improve hygiene and reduce infection in children.[29] A housing survey (86 houses), focus groups (nine participants), case studies (five) and individual interviews (nine) were conducted. The study found that crowding, non-functioning health hardware and poor hygiene underlay the high burden of infection in children. Improving the environmental conditions that contribute to skin infections was seen as a complex problem requiring a strategic approach that recognised and incorporated cultural practices and beliefs, was multifaceted, built capacity and empowered individuals and communities. The limitations of the study were that only

one community was involved. Limited resources meant researchers could not investigate other contributing factors.[29]

Installation of swimming pools

Four articles examined the potential benefits of swimming pools on skin health.[30–33] Two articles explored the benefits of new swimming pools[30,31] opened in September 2000 in two remote Indigenous communities (A and B) in Western Australia, located more than 1200 km north of Perth. An interventional study in 2003 measured the prevalence and severity of pyoderma in 162 children at 6-monthly intervals for 18 months after the pools were opened.[30] The rate of pyoderma declined from 62 to 18% in community A and from 70 to 20% in community B. Over the same period the rate of severe pyoderma fell from 30 to 15% in community A and from 48 to 0% in community B. The chlorinated or salt water was found to be useful not just to cleanse the skin but also by providing a nasal and ear washout. The study limitations included loss to follow up of children due to population mobility and the lack of a control community.[30] In an observational study in Jigalong (131 children) and Mugarinya (128 children), Western Australia, the local clinic records were examined from 1998 to 2005 to determine the effects of the pools on antibiotic use and clinical attendance for infections.[31] The study found a 68% decline in skin infections in Jigalong and a rate of decline between 53 and 77% annually in Mugarinya. In Jigalong the antibiotic prescription rate decreased by 45% between 1999 and 2000 and 2004–2005, while the decline was minimal in Mugarinya. The limitations of the study include high population mobility, which could have affected the interpretation of results, poor follow up and selection bias, as 'healthy' children may not have attended the clinics.[31]

In South Australia the Department of Health and Ageing undertook a 2-year evaluation of the health benefits of swimming pools in four communities on the Anangu Pitjantjatjara Yankunytjatjara Lands.[32] Between September 2007 and April 2009 four 6-monthly visits were undertaken by researchers, at which time a medical doctor assessed children for pyoderma and classified them as non-severe if they had 1–4 lesions and severe if they had five or more. In total, 262 children aged 0–19 years were assessed. Due to high population mobility only 10 (4%) children were seen all four times and 145 (55%) were seen at least once. In the two communities where pre-swimming pool data was available, one year after opening the swimming pool the proportion of children with no sores increased from 32 to 78% ($z = 3.362$, $P < 0.001$). In the same period there was a reduction in the proportion of those presenting with severe pyoderma from 25 to 6% ($z = 3.103$, $P = 0.001$). Study limitations included small sample sizes, high population mobility, the fact that pools were not always open during the evaluation period and there was a high burden of other infections and illnesses that may have limited the positive impact of the swimming pools on skin health.[32]

A comparison study conducted by Carapetis and colleagues (1995) in the Northern Territory used two surveys of pyoderma rates in children before and after the opening of a community swimming pool.[33] The skin lesions were graded by Aboriginal health workers and the district medical officer as mild, if less than 5 and moderate if 5–20. In September 1994, 81 children were surveyed and 39 (48%) had pyoderma, with 90% being mild and 10% moderate. In December, after the opening of the pool in October that year, 54 children were surveyed and 22 (41%) had pyoderma, all of which were considered mild ($\chi 2 = 0.72$, $P = 0.40$). Children who swam more than once a week had fewer skin

sores than those who swam once a week or less (30 *vs* 57%). This was more pronounced in children aged less than 9 years. Nine of 16 children (56%) who swam once or less had pyoderma compared with four of 18 (22%) who swam more than once a week. The limitations of the study included a small sample size and the fact that populations surveyed before and after were not identical groups.[33]
With high rates of infections and chronic disease and the broad health and social gains associated with swimming pools, their use has been recommended.[34] A number of limitations in these studies have been identified and caution is recommended in interpreting outcomes and in generalising results. It was unclear how often children should use the pool and for how long in order to achieve positive results. More rigorous evaluations are required.[34] The installation, and maintenance of swimming pools and supervising children when they are swimming may not always be feasible, as resources are limited.[23] However, if swimming pools reduce pyoderma and therefore reduce the rate of GAS-related chronic illness and associated costs of renal dialysis and heart valve replacement, they may be cost-effective.[31]

Screening and treatment

One article focused on screening and treatment.[17] This 3-year ecological study in five remote communities in the Northern Territory used active surveillance for skin infections (pyoderma and scabies) among children aged less than 15 years. There were 6038 skin assessments conducted on 2329 children in health centres, homes, schools and other community settings. The diagnosis of pyoderma was based on the appearance, site and number of lesions. All children diagnosed with pyoderma were referred to a clinic for treatment according to clinical guidelines. The prevalence of pyoderma fell from 47% at commencement to a median of 32% (OR 29–41%) during the follow-up period. An increase in treatment uptake was also identified over the same period. The authors noted that pyoderma has become normalised in Indigenous communities and that the main driver for decreasing its prevalence was an increased uptake of treatment through basic PHC, with surveillance playing an important role. Study limitations included population mobility, lack of control of confounders and potential bias in care-seeking behaviour.[17]

Discussion

This systematic review aimed to identify and critically analyse the available literature describing the treatment and prevention of bacterial skin infections in Indigenous children aged 0–19 years in both community and hospital settings. There were few studies that both met our selection criteria and provided a high level of evidence. While a number of studies have explored the epidemiology and clinical features of staphylococcal skin infections, there are few evidence-based studies on effective prevention and treatment, particularly for recurrent skin infections.[35] Some studies may be been missed where Indigenous children were included in the sample without being identified as such. Some studies were limited by a lack of quality data, loss to follow up and reliance on self-reporting. There was an absence of exact recommendations on the use of swimming pools. Population mobility is common among Indigenous peoples in Australia and this may have affected the interpretation of the results in all studies. It was not clear whether other interventions were being undertaken at the same time. There were no studies that explored prevention and treatment strategies from an Indigenous perspective, or studies that provided practical solutions to the underlying determinants

influencing disease occurrence, such as crowding and poor housing infrastructure. It was not possible to compare the articles described due to variations in context (differing geography, climate and cultures).

The results from the articles reviewed point to possible treatment and prevention strategies for bacterial skin infections in Indigenous children. However, the problem is complex and has multiple determinants. Until the underlying socioeconomic and environmental conditions that contribute to the persistence of skin infections are addressed they will continue to be a significant problem affecting Indigenous children.[36] This review revealed a need for rigorous and large-scale studies to develop the evidence required for methods to prevent and manage skin infections in Indigenous children. More research needs to be done in other states in Australia where the context differs from the remote communities in Western Australia, the Northern Territory and South Australia and in other countries such as New Zealand, the USA and Canada, where the colonial experiences of Indigenous peoples have been similar.

Acknowledgements

All funds for this systematic review were internal and formed part of employees' salaries. The work is not part of a grant.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

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Figure legends

Figure 1. PRISMA flowchart: The flowchart describes the steps taken in searching the databases for relevant literature, the inclusion of 159 records for full text reading, those excluded, with rationale, and where additional articles were included, arriving at 10 articles for final inclusion.

Table 1. Summary of eight Australian studies identifying methods for the treatment and prevention of skin infections in Indigenous children, 1994–2016

Reference no, author, year	Description
Management of active infections and lesions Bowen *et al.* 2014[26] Tasani *et al.* 2016[27] **Environmental and personal hygiene measures** Bailie *et al.* 2005[5] Bailie *et al.* 2012[8] McDonald *et al.* 2010[29] **Installation of swimming pools** Lehmann *et al.* 2003[30] ********** Silva *et al.* 2008[31] Australian Government Department of Health 2009[32] Carapetis *et al.* 1995[33] **Screening and treatment** Andrews *et al.* 2009[11]	Open-label, randomised, controlled, non-inferiority trial • Evidence level: II • Benzathine benzylpenicillin i.m. *vs* twice-daily co-trimoxazole for 3 days *vs* once-daily co-trimoxazole for 5 days • Participants: 508 Aboriginal children aged 3 months to 13 years • Primary outcome measure: treatment success at day 7 in a modified intention-to-treat analysis. Secondary outcome: (i) treatment success at day 2 according to digital images; (ii) clinical success at days 2 and 7 according to unmasked clinical assessment by research nurses; (iii) detection of *S. aureus* and *S. pyogenes* on days 0, 2, and 7; (iv) antibiotic susceptibility profile of *S. aureus* and *S. pyogenes;* (v) nasal carriage of *S. aureus* on days 0 and 7; (vi) comparison of individual co-trimoxazole groups with IM benzathine benzylpenicillin • Result: primary outcome: non-inferiority of co-trimoxazole to benzathine benzylpenicillin in a 10% margin (absolute difference 1%, 95% CI: 6.2–7.3). Outcomes for 3-day co-trimoxazole groups were similar; per-protocol analysis showed non-inferiority of co-trimoxazole. Secondary outcomes: similar for co-trimoxazole and benzathine benzylpenicillin with no difference when 3-day co-trimoxazole (86%) was compared with 5-day co-trimoxazole (86%; absolute difference 0.1%, 95% CI 6.5–6.5). *S. pyogenes* reduced from 85% at day 0 to < 7%

	at day 7 while *S. aureus* fell from 83% at day 0 to 20% at day 7 with co-trimoxazole, and from 81 to 52% with benzathine benzylpenicillin (*P*< 0.0001 for a comparison of recovery rates at day 7). • Limitations: absence of placebo or control group. The open-label design meant the researchers were aware of which treatment was given to each patient, which may have influenced their assessments. • Post hoc analysis of the Bowen *et al.* skin sore trial • Of the 508 children treated for impetigo 84 (17%) had scabies. • Key findings: high burden of scabies in children in the trial. Children with scabies co-infection had more severe impetigo and were less likely to respond to treatment with antibiotics. • Treatment success for impetigo with and without scabies co-infection independent of treatment group was 76 and 87%, respectively; absolute difference 11% (95% CI 1–21%). • Treatment success with scabies co-infection may be more likely to be achieved with oral SXT than BPG. • Limitations: clinical dx rather than scrapings or microscopy for dx of scabies; scabies treatment not observed; randomisation was not stratified by +ce of scabies. ********** Qualitative study • Evidence level: IV • Objective: test approaches of data collection, analysis and feedback for a follow-up study of the impact of housing conditions on child health • Three remote communities in the NT were selected to participate; there was variation in the size of the population, development and geographical spread. • Methods: survey of dwelling conditions, interviews with the main householder and carer of each child <7 years of age; and an audit of health centre records

	• Children were eligible to participate if they were <7-years old and had lived at least for 6 months during the previous 12 months in the community. • Skin infection data of 138 children in two communities were obtained. • Four models were developed to test significant associations between various aspects of household infrastructure and the incidence of skin infections. • Result: almost 40% of children had not presented for skin infections at a health centre; about 34% had two or more presentations and 10% had five or more. Healthy living practices and skin infections presentations had a positive association; other positive associations (with skin infections) were found with children < 3 years of age, younger and older carers, low family income, carers with an education of year 8 or below and having three carers in the dwelling. The strongest association was between skin infection incidence and household composition as well as social process. • Limitations*:* this was a pilot study. Prospective cohort study • Evidence level: III • Objective: to determine whether improvement in poor housing infrastructure in Australian Indigenous communities results in a reduction in common childhood illness and to identify important mediating factors in this relationship • Method: 148 children aged < 7 years in 10 Indigenous communities that had benefited from government-funded housing programmes from 2004–2005 were selected. • Data describing the state of housing, reports of common illnesses and on socioeconomic conditions were collected through inspections of households and interviews with carers. • Result: after adjusting for confounders there was no consistent reduction in the reporting of common childhood illnesses, including skin infections, associated with improvements in housing infrastructure.

	• Limitations: (i) difficulty of defining and measuring appropriate indicators for a range of complex constructs; (ii) potential respondent and recall bias in interview data; (iii) potential of chance associations in analyses; (iv) potential measurement error of state of hygiene of the house at time of survey; (v) OR may overestimate the strength of association for high prevalence exposures; (vi) variation in time between surveys and occupation of new houses, (vii) loss to follow up Ecological study • Evidence level: IV • Aim: to identify social, economic, cultural and environmental factors that contribute to poor hygiene in remote Aboriginal communities in the NT and identify approaches to reduce the burden of infection among children • Methods: narrative and systematic literature review, quantitative and qualitative community-based studies • Result: complex historical and contemporary interrelated factors are responsible for poor living conditions and the continued high rates of childhood infections in Aboriginal communities. A strategic, intersectoral approach needed to address the underlying issues • Limitations: only one community involved. Limited time and resources ********** Interventional study • Evidence level: III-2 • Installation of swimming pools in two remote Aboriginal communities in Western Australia • Participants: Children aged <17 years • Outcome measures*:* primary*:* prevalence of and severity of pyoderma • Results: community A: initial pyoderma prevalence: 62%; 30% severe pyoderma. The prevalence of any skin infection at four consecutive surveys was 64, 51, 43 and 18%, respectively.

	Community B: initially 70% pyoderma and 48% was severe. At four consecutive surveys the rates were 78, 43, 69 and 20%, respectively. The prevalence of severe pyoderma fell to 31% 1 year later. Limitations: poor follow up of children and lack of control community Observational study • Evidence level: III-2 • Effect of installation of pools on antibiotic use and clinical attendance for infections • Participants: children aged <17 years of age; 131 children in Jigalong and 128 in Mugarinya • Outcome measures: clinical attendance rates for skin, middle-ear and respiratory tract infections and trauma; prescription rates for antibiotics • Decline in skin infections in Jigalong: clinic-based selection method showed a 68% decline and Mugarinya: between 53 and 77% decline annually until 2003–2004 • Limitations: high population mobility can affect the interpretation of results, attendance at clinics may have been reduced for other reasons, selection bias, as healthy children may not have been attending the clinic, leading to an overestimate of morbidity rates Observational study • Evidence level: III-2 • Participants: 262 Aboriginal children aged 0–19 years in four communities • Aim: to assess the skin health and social benefits of the swimming pools in four communities • Outcome measures: presence and severity of pyoderma at four 6-monthly visits with 0 meaning no pyoderma, 1–4 lesions were classed as non-severe and 5 or more were severe • Result: in two communities where pre-swimming pool data was available, 1 year after opening a swimming pool, the proportion of children with no sores increased from 32 to 78% (z = 3.362, P < 0.001). In the same period, there was a reduction in the proportion of those presenting with severe pyoderma, from 25 to 6% (z = 3.103, P = 0.001).

	• Limitations: small sample sizes, high population mobility, pools were not always open during the evaluation period and a high burden of other infections and illnesses that may have limited the positive impact of the swimming pools on skin health. Observational study • Evidence level:111–2 • Participants: schoolchildren in the tropical NT • Aim: to determine whether regular swimming in a chlorinated pool may help reduce the prevalence of pyoderma • Outcome measure: mild pyoderma if less than 5 lesions and moderate if 5–20 lesions • Results: in September 1994, 81 children were surveyed and 39 (48%) had pyoderma with 90% being mild and 10% moderate. In December, after the opening of the pool in October that year, 54 children were surveyed and 22 (41%) had pyoderma, all of which were considered mild ($\chi^2 = 0.72$, $P = 0.40$). Children who swam more than once a week had fewer skin sores than those who swam once a week or less (30 *vs* 57%). This was more pronounced in children aged less than 9 years where nine of 16 children (56%) who swam once or less had pyoderma compared with four out of 18 (22%) who swam more than once a week. • Limitations included a small sample size, populations surveyed before and after were not identical groups (33). ********** Ecological study • Evidence level: IV • Active surveillance for skin infections (scabies and pyoderma) was conducted over a 3-year period

	• Two pictorial flipcharts developed; one to explain the 'healthy skin story' in lay terms to study participants; the other to assist in diagnosis, focusing primarily on recognition and treatment of pyoderma, scabies and tinea • Participants: 2329 children <15 years of age; screened at either the local health centre, home, community or at school using a standard data collection form • Primary outcome measure: for pyoderma, reduction of prevalence from 50% (expected pre-programme) to < 25%. Secondary objective: to reduce the severity of pyoderma in the target group; moderate/severe from 40% (pre-programme) to <15% • Result: the pyoderma prevalence at baseline was approximately 47%; dropping to a median of 32% (IQR 29–41%) during the follow up. The absolute reduction was 14.7% (IQR 5–17%). Over the previous 18 months: an absolute reduction in pyoderma prevalence of 18 cases per 100 children. Treatment uptake increased over the same period. • Limitation: population movement between communities over time; potential bias in care-seeking/screening-seeking behaviour and lack of control for potential confounding factors

IQR, interquartile range; NT, Northern Territory

Figure 1 PRISMA flowchart