Proximate determinants of tuberculosis in Indigenous peoples worldwide: a systematic review

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Summary

Background Indigenous peoples worldwide carry a disproportionate tuberculosis burden. There is an increasing awareness of the effect of social determinants and proximate determinants such as alcohol use, overcrowding, type 1 and type 2 diabetes, substance misuse, HIV, food insecurity and malnutrition, and smoking on the burden of tuberculosis. We aimed to understand the potential contribution of such determinants to tuberculosis in Indigenous peoples and to document steps taken to address them.

Methods We did a systematic review using seven databases (MEDLINE, Embase, CINAHL, Global Health, BIOSIS Previews, Web of Science, and the Cochrane Library). We identified English language articles published from Jan 1, 1980, to Dec 20, 2017, reporting the prevalence of proximate determinants of tuberculosis and preventive programmes targeting these determinants in Indigenous communities worldwide. We included any randomised controlled trials, controlled studies, cohort studies, cross-sectional studies, case reports, and qualitative research. Exclusion criteria were articles in languages other than English, full text not available, population was not Indigenous, focused exclusively on children or older people, and studies that focused on pharmacological interventions.

Findings Of 34 255 articles identified, 475 were eligible for inclusion. Most studies confirmed a higher prevalence of proximate determinants in Indigenous communities than in the general population. Diabetes was more frequent in Indigenous communities within high-income countries versus in low-income countries. The prevalence of alcohol use was generally similar to that among non-Indigenous groups, although patterns of drinking often differed. Smoking prevalence and smokeless tobacco consumption were commonly higher in Indigenous groups than in non-Indigenous groups. Food insecurity was highly prevalent in most Indigenous communities evaluated. Substance use was more frequent in Indigenous inhabitants of high-income countries than of low-income countries, with wide variation across Indigenous communities. The literature pertaining to HIV, crowding, and housing conditions among Indigenous peoples was too scant to draw firm conclusions. Preventive programmes that are culturally appropriate targeting these determinants appear feasible, although their effectiveness is largely unproven.

Interpretation Indigenous peoples were generally reported to have a higher prevalence of several proximate determinants of tuberculosis than non-Indigenous peoples, with wide variation across Indigenous communities. These findings emphasise the need for community-led, culturally appropriate strategies to address smoking, food insecurity, and diabetes in Indigenous populations as important public health goals in their own right, and also to reduce the burden of tuberculosis.

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See Comment page e6

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Introduction

Although Indigenous peoples represent less than 5% of the world population, the burden of tuberculosis disproportionately affects Indigenous communities worldwide.[1] Ethnic minorities, such as Indigenous peoples, living with tuberculosis account for a large proportion of the 4·3 million under-reported or so-called missing cases of tuberculosis, representing a huge health burden to those people and communities, as well as a major barrier to eliminating the disease.[2] Although the mechanisms are not fully understood, this discrepancy in tuberculosis prevalence appears to be related to socioeconomic disparities such as poverty, poor access to health care, and marginalisation.[3]

Even before *Mycobacterium tuberculosis* was identified by Koch in 1882 as the causative agent of tuberculosis, we already understood that there was a relationship between tuberculosis and socioeconomic conditions such as poverty, malnutrition, and crowded living conditions.[4] More recently, growing evidence suggests that social and behavioural determinants (eg, tobacco, alcohol and drug use, housing conditions, overcrowding, and malnutrition), as well as medical conditions such as diabetes and HIV, which are partly driven by social

Research in context

Evidence before this study

Previous reviews have shown that Indigenous people bear a disproportionate burden of tuberculosis compared with non-Indigenous populations. Social and behavioural determinants such as alcohol, substance, and recreational tobacco misuse, poor housing, crowding, and food insecurity, as well as medical risk factors such as type 2 diabetes and HIV, are associated with the development of active tuberculosis.

Added value of this study

This systematic review is the first to attempt a global portrait of the prevalence of proximate social, behavioural, and medical determinants of tuberculosis in Indigenous populations, and to collate information on preventive programmes aimed at these determinants in Indigenous communities. We found that illicit drug use, food insecurity, and recreational tobacco use were prevalent in Indigenous people worldwide, while diabetes and binge drinking were more prevalent in Indigenous people from high-income countries. We could not draw firm conclusions about HIV, crowding, and housing conditions given the scarcity of the literature. Although very few studies assessed their efficacy, culturally appropriate preventive programmes that address the development of these social and medical determinants of tuberculosis were generally well received by Indigenous people where such programmes were implemented in partnership with the communities concerned.

Implications of all the available evidence

This evidence highlights some of the health disparities affecting Indigenous people worldwide. The increased prevalence of these proximate social, behavioural, and medical determinants might partly explain the disproportionate global burden of tuberculosis in Indigenous populations. This systematic review also highlights geographical inequalities in the published literature, as most of it pertains to Indigenous people from high-income countries. Despite many studies documenting the prevalence of diabetes and recreational tobacco use in Indigenous people, few describe preventive programmes to address these issues. More evidence generated through community-led research is urgently needed.

determinants, are linked to the development of active tuberculosis.[5]

Indeed, in a seminal article that highlighted the importance of social determinants to the epidemiology and prevention of tuberculosis, Lönnroth and colleagues[3] identified: (1) proximate determinants such as overcrowding, tobacco, and alcohol use; and (2) upstream social determinants such as poverty and poor education. Social determinants are in turn driven by weak and inequitable social, economic, and environmental policies as well as by such phenomena as globalisation and migration.[3] Upstream social determinants underlie the more easily measured proximate risk factors: for example, inadequate educational opportunities and poor access to health care are associated with unhealthy behaviours such as tobacco use and delays in tuberculosis diagnosis (which perpetuate the cycle of transmission and infection within communities).

One study has estimated that the presence of alcohol-related problems confers more than a 3-times increased risk of active tuberculosis (3·33, 95% CI 2·14–5·19),[6] while tobacco use increases the risk 2–3 times compared with that of not smoking.[7–9] Several systematic reviews have concluded that diabetes increases the risk of active tuberculosis by about 3 times.[10–12] In many countries with a high tuberculosis burden, HIV infection is the leading potentially modifiable risk factor for active tuberculosis, with a relative risk exceeding 20.[5]

In Indigenous peoples, the general socioeconomic determinants are important contributors to health inequity, but highly relevant are factors that relate to the cultural and historical events specific to the people affected. Colonisation, globalisation, forced migration, loss of Indigenous language and culture, as well as disconnection from the land have all contributed to Indigenous health inequality.[13]

Given the scarcity of information about the distribution of these social and behavioural determinants of tuberculosis among the world's Indigenous peoples, we did a systematic review to document the prevalence of several proximate determinants that are intricately linked to key upstream social determinants such as poverty, food insecurity, housing, and working conditions, as well as colonisation. We also aimed to identify culturally appropriate preventive programmes targeting these determinants, when specifically assessed in Indigenous communities.

Methods

Search strategy and selection criteria

We used the UN definition of Indigenous peoples, characterised by self-identification as Indigenous people; a historical continuity with precolonial or presettler societies; strong links to territories and surrounding natural resources; distinct social, economic, or political systems; distinct language, culture and beliefs; non-dominant status within society; and the resolve to maintain and reproduce their ancestral environments and systems as distinctive people and communities.[14]

For this systematic review, candidate studies were identified by searching electronic databases and by scanning reference lists of articles deemed relevant. A medical librarian (MM) constructed a systematic search strategy for Ovid Medline (appendix). The strategy comprised a combination of Medical Subject Headings, key words, truncation, and Boolean operators, and included terms to denote "low socioeconomic or

See Online for appendix

sociodemographic status", "Indigenous peoples", and "prevalence/epidemiology". We then applied the search strategy to Embase, CINAHL, Global Health, LILACS, Scopus, Web of Science, Cochrane, and DARE. All databases were searched on Aug 12, 2014, and again on Dec 20, 2017.

We included any randomised controlled trials, controlled studies, cohort studies, cross-sectional studies, case reports, and qualitative research pertinent to our search question, and only articles written in English published after 1980. Articles were included if they contained any information about prevalence of one or several of the social determinant and medical risk factors for tuberculosis, or if the articles presented details of interventions or preventive programmes to address these determinants in any sense, which would also potentially help reduce the tuberculosis burden in Indigenous communities.

This systematic review reflects the conceptual model of proximate versus upstream social determinants outlined by Lönnroth and colleagues.[3] The proximate determinants and medical risks included are alcohol use, substance misuse, recreational tobacco use, malnutrition or food insecurity, overcrowding or poor housing conditions, HIV infection, and diabetes, as these proximate determinants presented the highest relative risk increases for active tuberculosis in several reviews.[5–12] Articles that focused only on the prevalence of tuberculosis were not included, as the focus of the review was determinants.

Two reviewers (MC, MG) independently did an initial eligibility assessment for each candidate article in an independent standardised manner, based on the title and abstract of the article; any disagreements or discrepancies were resolved by discussion with a third reviewer (OO). Two reviewers (CEB, DSN'D) reviewed the full texts of selected articles; disagreements were resolved by a third reviewer (MC).

Articles were excluded for the following reasons: the full text was unavailable; no data on Indigenous populations were available; the study did not have relevant data on prevalence or preventive programmes for one of the identified social determinants of tuberculosis; the article was a prevalence study focused primarily on young (aged <15 years) or older (aged >65 years) people; the article was a prevalence study exclusively of participants with one of the studied conditions or determinants (eg, all had diabetes); the study population was limited to a specific subgroup of the Indigenous population (eg, pregnant women, injection drug users); the intervention or programme involved cessation of established recreational tobacco or substance use, rather than prevention; and the study focused on pharmacological interventions.

Data analysis

Data were extracted using a standardised data abstraction sheet. We used the WHO geographic regions to classify articles by location; we further divided the Americas into North America and Latin America. The variables collected from each study were: (1) study name; (2) country of origin; (3) publication year; (4) name of Indigenous groups; (5) determinants analysed and how they were measured and defined; (6) study design; (7) sampling frame; (8) years when data were collected; (9) sample size; (10) reported prevalence of the tuberculosis determinant; (11) non-Indigenous comparison group studied, if available; (12) when relevant, nature and results of the preventive programme. All subsequent analyses were descriptive. No meta-analysis was done because of the heterogeneity between populations and studies. Regular alcohol use varied from occasional alcohol use (around once per month) to up to two drinks per day. In this Article, we used excessive alcohol use as a general term that encompasses alcohol misuse and binge drinking. Excessive alcohol use was either defined by questionnaires (AUDIT score, CAGE score), history (binge drinking, personal, or legal problems related to drinking, etc), or by medical criteria for alcohol misuse or dependence (Diagnostic and Statistical Manual of Mental Disorders [DSM-IV], DSM-IV-TR, DSM-5). We classified alcohol use or misuse

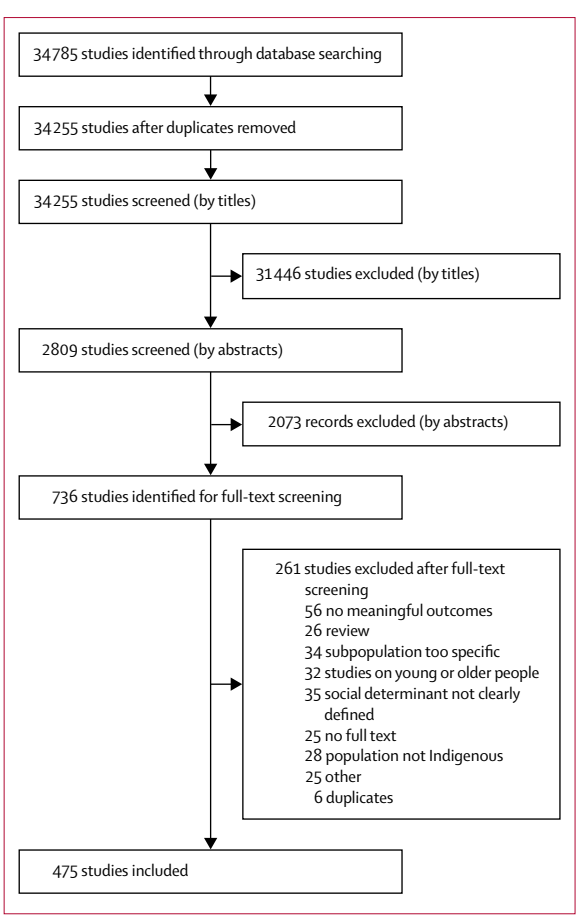

Figure: **Study selection**

	Studies (n)	Prevalence of excessive alcohol use	
		Range among Indigenous population	Range among comparator population
Southeast Asia			
Scheduled Tribes of India	5	0–55·3%[a1-a5]	9·3% (India)[x2]
Europe			
Greenland and Denmark Inuit	4	4·9–27·7%[a6-a9]	..
Roma and Gypsies	5	6·7–89·0%[27–29, a10,a11]	6·8–27·1% (non-Roma)[28,a10,a13]
Sami	1	11·7–28·4%[a12]	19·5–24·5% (Sweden)[a12]
Latin America			
Colombian Indigenous	1	35·1%[a14]	..
Mexican Mixtec or Indigenous	2	18·9–38·3%[a15,a16]	22·9% (Mexico)[a16]
Venezuelan Indigenous	2	7·5–80·8%[a17,a18]	..
Ecuadorian Indigenous	1	13%[a19]	..
Guatemalan Indigenous	1	0·0–19·6%[a20]	..
North America			
USA: Alaska Natives, Native Hawaiians, and Native Americans	36	1·3–75·7%[15–26,30–41,a21–a34]	4·3–88·5% (USA)[15,16,18,20,23–25,32,33,35,a22,a26,a28–a31,a46]
Canadian First Nations and Inuit	18	8·3–73·1%[42–47,a35–a45, a293]	7·8–78·0% (Canada)[43,47, a35,a37,a38,a41]
Western Pacific			
Australian Aboriginals and Torres Pacific Islanders	13	15·7–86·0%[a47–a59,a166,]	17·6% (Australia)[x57]
Malay Orang Asli	1	34·8%[a60]	..
New Zealand Maori and Torres Pacific Islanders	3	33·0–85·2%[48,a61,a62]	78·1–85·0% (New Zealand)[a61,a62]
Taiwanese Aboriginals	4	10·3–67·7%[a63–a66]	36·0% (Taiwan)[a66]

References a1–a296 are listed in the appendix.

Table 1: **Prevalence of excessive alcohol use, including alcohol misuse and binge drinking**

according to the authors' definition for each specific study, but we did not include the data if we judged that the criteria used did not adequately reflect regular alcohol use, or alcohol misuse. The definition of crowding was variable and heterogeneous from study to study. Classically, crowding is defined by more than one person per room. Other studies used different criteria such as the American Crowding Index, the Canadian National Occupancy Standards, or the Equivalized Crowding Index. The definition of diabetes depended on which diagnostic criteria were used (fasting plasma glucose, HbA_{1C}, oral glucose tolerance test) and the different diagnostic cut-offs used, which often varied throughout the years as guidelines changed. Depending on the study, we also included diagnoses of diabetes based on self-report, diagnoses based on medications taken, physician-based diagnoses, and database diagnostic codes. We did not find any study where we felt that the diagnosis of diabetes was based on inadequate criteria. Malnutrition was defined by a calculated body-mass index (BMI) of less than 18·5 kg/m2. The definition of food insecurity was also highly variable from study to study. Some used questionnaires (specific answers to one or several questions) and food insecurity scores (US Department of Agriculture Food Insecurity Score, Health Canada Food Security Classification, Household Food Security Survey Module). The details for each study are found in the appendix.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The search initially identified 34 255 distinct articles; after a full-text review of 736 articles, 475 were retained for the systematic review (figure). Of the 475 studies included, 420 examined only the prevalence of behavioural or social determinants, 46 examined only preventive programmes aimed at reducing the burden of these phenomena, and nine considered behavioural or social and preventive programmes. The most studied region was North America, with 264 articles, followed by the Western Pacific region with 99, Southeast Asia with 48, Europe with 32, Latin America with 24, Africa with five, and the Eastern Mediterranean region with three.

Overall, prevalence and patterns of alcohol use varied substantially. Prevalence of regular alcohol use, alcohol misuse, and binge drinking was consistently higher in men than in women in Indigenous and non-Indigenous populations, when sex-specific data were available. Regular drinking was generally less prevalent, while binge drinking was usually more prevalent in Indigenous

	Studies (n)	Prevalence of overcrowding and poor housing conditions	
		Range among Indigenous population	Range among comparator population
Southeast Asia			
Scheduled Tribes of India	2	Overcrowding (20·3–58·3%)[53,a67]	..
Europe			
Slovakia Roma	2	Overcrowding (37%);[a68] poor housing conditions (62·2%)[a69]	Poor housing conditions (19·4%)[a69]
North America			
Canadian First Nations and Inuit	5	Mean person per room (0·7–1·1);[51,52] overcrowding (25·1–57·5%);[54,a70] poor housing conditions (32·8%)[55]	Mean person per room (0·4–0·5);[51,52] poor housing conditions (7%)[a70]
Western Pacific			
New Zealand Pacific Peoples	1	Overcrowding (37%)[a71]	..

References a1–a296 are listed in the appendix.

Table 2: **Prevalence of overcrowding and poor housing conditions**

populations in higher-income countries, compared with the corresponding non-Indigenous populations (in the USA, Canada, and Australia). For example, the prevalence of regular alcohol use was lower in Native Americans (37–61%) than in the general US population (47–70%),[15–19] but that of binge drinking was higher (15·6–93·0%) in Native Americans than in non-Indigenous Americans (15·0–67·0%).[20–26] In Europe, studies examining alcohol use in the Roma population most often reported higher prevalence of regular alcohol use, binge drinking, and alcohol misuse (18·1–35·7%) than among the general population (6·8–27·1% in non-Indigenous Europeans).[27–29] Table 1 shows the reported prevalence of excessive alcohol use (including binge drinking and alcohol misuse) in different Indigenous populations and comparator populations when available. Full details of all study results are available in the appendix.

Two school-based prevention programmes that targeted Native American youth and aimed to reduce teenage alcohol use were reviewed. Cheadle and colleagues[49] found that a school-based counselling programme of 4 years led to a 33% relative reduction in binge drinking reported by adolescents in a US Plains State reservation, while Dixon and colleagues[50] found no reduction in a group of urban Native American youth in the southwest USA. More information on preventive programmes is available in the appendix.

Most studies of overcrowding were done in Canada. Crowding, defined by the number of persons per room (ppr) in a household, was found to be greater in First Nations communities on reserve (mean 0·7–1·1 ppr) than the Canadian average (0·4–0·5 ppr).[51,52] Larcombe and colleagues[52] addressed housing conditions on two Canadian First Nation reserves, in Lake Brochet and Valley River, in which 65–93% of the surveyed population reported a subjective perception of poor air quality. Table 2 shows data regarding crowding and housing conditions in different populations. No studies reported prevention programmes for this determinant. Full details of all study results are available in the appendix.

Generally, Indigenous populations in high-income countries had a higher prevalence of diabetes than the corresponding general population, while among Indigenous populations in low-income countries there was a lower prevalence of diabetes, although this was not a universal finding. US Native American Tribes (Choctaw, Samoans, Cherokee, and Navajo in the south, and Chippewa, Menominee, Mohawk, and Plain Indians in the north) have been extensively studied and have some of the highest prevalence estimates for diabetes among Indigenous communities worldwide (2·0–71·0%).[19–22,30–36,56–92] The lowest diabetes prevalence was reported among Malaysian Orang Asli (0·3%),[93] Brazilian Amerindians (0%),[94] Scheduled Tribes in central India (0·38%),[95] and Russian Chukoyka (0·27%).[96] Table 3 shows the reported prevalence of diabetes in different Indigenous groups and comparator populations when available. Full details of all study results are available in the appendix.

Multiple preventive programmes in Canada, New Zealand, and the USA were reviewed. Programmes generally focused on promoting healthy lifestyles through diet and exercise in communities known to be at risk of diabetes. Overall, although generally well accepted by the communities involved, the reported effectiveness of the programmes was variable (appendix).[48,102–109] A randomised trial by Thompson and colleagues[110] looked at the effect of a diabetes prevention programme for Native American women, comprising regular discussion sessions focusing on healthy diet and physical activity; after 4 years this programme yielded no significant change in BMI, insulin sensitivity, and diabetes compared with the control group. However, community classes in New Zealand focusing on cooking skills, exercise, and smoking cessation were associated with a significant decrease in the prevalence of diabetes over 3 years (from 12·6% to 10·6%, p=0·003).[48]

Reported data on substance use in Indigenous populations are sparse. Most of the data come from the USA, where the estimated prevalence of substance use in Native American populations was frequently higher than

	Studies (n)	Prevalence of diabetes	
		Range among Indigenous population	Range among comparator population
Africa			
Tanzanian Natives	1	0·7%[a294]	..
Cameroon Fulbe	1	3·6%[97]	3·9% (Cameroon)[97]
South East Asia			
Bangladesh Hill Tract Tribes	1	8·4%[a72]	3·8% (Bangladesh)[a72]
United Arab Emirates Emirati	1	7–11%[a73]	..
Micronesia Ponhpei and Kosrae	2	14–38%[a74,a75]	..
Scheduled Tribes of India	5	0·38–39·1%[95,98,a76–a78]	0·38–15·0% (India)[95,a77]
Eastern Mediterranean region			
Sudan Dangala	1	7·5–9·9%[a79]	..
Europe			
Greenland and Denmark Inuit	9	0·3–10·8%[a6-a9,a80-a84]	7·8% (Greenland)[a81]
Roma and Gypsies	5	7·0–19·7%[28,a85-a88]	3·2–10·0% (Non-Roma)[28,a91-a93]
Russian Natives	3	0·27–1·06%[96,a89,a90]	1·15% (Russia)[a89]
Hungary, England, and Slovakia Gypsies	3	4–30%[a91-a93]	..
Latin America			
Brazil Indigenous	2	0–1·4%[94,a94]	..
Mexico Natives	8	0–26·2%[a15,a95-a101]	8·6–14·9% (Mexico)[a97,a100,a101]
Peru Natives	1	2·6–2·9%[a102]	
Chile Mapuche and Aymara	2	1·0–4·1%[a103,a104]	5·3% (Chile)[a105]
Guatemalan Indigenous	1	1·3–4·6%[a20]	..
North America			
USA: Alaska Natives, Native Hawaiians, and Native Americans	77	2–71%[19–22,30–38,56–92,a26,a99,a106–a133]	2·5–16·5% (USA)[35,64,65,82,84,85,87,90,a26,a107, a110,a115,a117,a126,a128]
Canadian First Nations, Métis, and Inuit	43	0·4–46·6%[43,45–47,96,99,100,101,a37,a38,a134–a164]	2·5–9·0% (Canada)[a46,a37,a38, a138,a140,a143,a150–a156,a158]
Western Pacific			
Australian Aboriginals and Torres Strait Islanders	22	4–54·2%[a47,a48,a53,a55,a59,a167–a182,a295]	1·9–7·0% (Australia)[a170,a173,a174]
New Zealand Maori and Pacific Islanders	12	3·8–28·5%[48,a51,a183–a192]	0·6–8·5% (New Zealand) [a183,a185,a188–a192]
Malay Orang Asli	3	0·3–8·4%[93, a193]	4·4%[93] (Malaysia)
Taiwanese Aboriginals	2	3·7–10·8%[a194,a195]	11·0% (Taiwan)[a194]

References a1–a296 are listed in the appendix.

Table 3: **Prevalence of diabetes**

among the general US population.[16,17,37–41,111,112,113] Table 4 shows data on substance use in Indigenous populations and general populations when available. Full details of all study results are in the appendix.

We reviewed preventive programmes in Australia and the USA that are aimed at reducing the development of substance use in high-risk Indigenous youth, through community-based and school-based education programmes. Although often well accepted by the groups involved, the programmes yielded conflicting results. Cheadle and colleagues[49] found that a school-based counselling programme of 4 years led to a 36% relative reduction in cocaine use reported by adolescents in a Plains State reservation. Bryce and colleagues[116] found no reduction of petrol sniffing in a group of Aboriginal adolescents in Central Australia following individual and family counselling (appendix).

Most studies of HIV prevalence focused on Native American communities. Studies reported a low prevalence of HIV infection, ranging from 0·10 to 10·8 per 1000 population.[117–123] A few studies were done among Iranian, Roma, and Peruvian Indigenous populations; all studies suggested a higher prevalence of HIV than that in the general population, but most involved convenience samples, which cannot be considered representative.[114,124–126] Table 5 shows the reported prevalence of HIV in groups from different Indigenous and comparator populations, when available. Full details of all study results are available in the appendix.

A cohort study to prospectively assess an HIV prevention programme of 2 years was done in a high-risk Bulgarian Roma community, in which local leaders were trained to counsel community members on safe sex practices. Although the self-reported prevalence of unprotected sexual contact decreased by 20% compared with that of the control group, no data were available on the effect of the preventive programmes on the transmission of HIV (appendix).[29]

	Studies (n)	Prevalence of substance use	
		Range among Indigenous population	Range among comparator population
Southeast Asia			
Scheduled Tribes of India	2	Cannabis (13·6%); opioids (2·1–10·6%) [a1,a196]	..
Europe			
Roma and Gypsies	3	Injection drug use (20%);[114] toluene (2%);[a197] drug use in the past month (14·8%)[a11]	..
Latin America			
Honduras Garifunas	1	Cannabis (7%); cocaine (4%); other (0·3%)[a198]	..
North America			
USA: Alaska Natives, Native Hawaiians, and Native Americans	16	0·6–60·1%[16,17,26,31,37–41,111,112,a25,a199–a202]	1·5–26·5% (USA)[16,111,112, a34,a46,a199–a202]
Canadian First Nations and Inuit	4	10·9–54·7%[43,115,a40,a293]	11% (Canada)[43]
Western Pacific			
Australian Aboriginals and Torres Strait Islanders	7	1–80%[a49,a56,a203–a207]	..
Taiwan Aboriginals	1	0%[a65]	..

References a1–a296 are listed in the appendix.

Table 4: **Prevalence of substance use**

Most of the literature pertaining to malnutrition in Indigenous adult groups reflects data collected among the Scheduled Tribes of India through repeated Demographic and Health Surveys. The overall estimated prevalence of malnutrition was 15·3–64·5% in Indian Scheduled Tribes, compared with 24–49% in the non-Indigenous population.[53,98,127–148] Food insecurity in Canadian Inuit communities was estimated to be present in 29–80% of people assessed, compared with 1·7–4·0% in the non-Indigenous Canadian population, and 16·4% among Inuit populations in Greenland.[42,54,55,149–155] Table 6 shows the reported prevalence of malnutrition and food insecurity in groups from different Indigenous and comparator populations, when available. Full details of all study results are available in the appendix.

In one study, semi-structured interviews were done with key staff members from different community food programmes in Australian Aboriginal communities. A community-driven initiative, a culturally acceptable environment, and strategies to ensure sustainability were thought to be key factors for a successful programme.[156]

Overall, Indigenous peoples worldwide had a higher estimated prevalence of tobacco use than did the corresponding non-Indigenous populations. The highest prevalence of tobacco consumption was found among the Inuit population in Canada, among whom 52–100% of adult survey respondents were active smokers.[43–47,99,100,115,157,158,159] The study that reported an estimated prevalence of 100% included primarily adult males younger than 40 years, who had agreed to participate in a longitudinal cohort study. The lowest prevalence of tobacco use in Indigenous communities worldwide (2·1%) was reported in Indigenous peoples in Cameroon.[97] Up to 70% of women from Indigenous communities in Taiwan and Malaysia were estimated to use smokeless tobacco.[160,161] Table 7 shows the reported prevalence of tobacco consumption in different Indigenous and comparator populations, when available. Full details of all study results are available in the appendix.

	Studies (n)	Prevalence of HIV infection	
		Range among Indigenous population	Range among comparator population
Africa			
Cameroon Baka people	1	4·10%[a208]	..
Southeast Asia			
Scheduled Tribes of India	2	0·1–6·6%[a67,a209]	..
Thailand Hill Tribes	1	2·1%[a210]	1·0–1·5% (Thailand)[a210]
Eastern Mediterranean			
Iran Gypsies	1	4·4%[124]	0·4% (Iran)[124]
Europe			
Roma and Gypsies	2	0% in Hungary;[114] 0·5% in Bulgaria[a11]	..
Latin America			
Peru Amazonians	2	2·1–7·5%[125,126]	0·2–0·6% (Peru)[125]
Honduras Garifunas	1	4·5%[a198]	..
Brazil Indigenous	1	0·13%[a211]	..
Argentina Indigenous	1	0%[a212]	4 per 1000 population (Argentina)[a212]
North America			
USA: Alaska Natives and Native Americans	7	0·10–10·8 per 1000 population[117–123,a213]	5·9–11·8 per 100 000 population (USA)[118,120,121]
Canadian First Nations	2	4·8–1260 per 100 000 population[121,a214]	1·1 per 100 000 population (Canada)[121]
Western Pacific			
Australian Aboriginals	1	9·7 per 100 000 population[a216]	..

References a1–a296 are listed in the appendix.

Table 5: **Prevalence of HIV infection**

	Studies (n)	Prevalence of malnutrition and food insecurity	
		Range among Indigenous population	Range among comparator population
Africa			
San People of Namibia	1	Malnutrition (15–52%)[a217]	..
Nigeria Andibila	1	Malnutrition (23·1%)[a218]	..
Cameroon Indigenous	1	Underweight (20·2–24·9%)[97]	12·5–12·8% (Cameroon)[97]
Southeast Asia			
Scheduled Tribes of India	28	Malnutrition (15·3–64·5%)[53,95,98,127–148,a67,a219,a220]	24·3–60·0% (India)[127–129,a219,a220]
Europe			
Greenland Inuit	1	Food insecurity (16·4%)[152]	..
Roma	2	Malnutrition (8% in Croatia),[a221] malnutrition (4·2–4·9% in Romania)[a88]	Malnutrition (1% in Croatia);[a221] malnutrition (3·6–6·5% in Romania)[a88]
Latin America			
Argentina Mbya and Guaranis	1	Malnutrition 2·5%[a222]	..
North America			
USA: Alaska Natives and Native Americans	3	Food insecurity (38·7–76·7%),[a223,a224,a296] malnutrition (30·4%)[89]	..
Canadian First Nations, Metis, and Inuit	13	Food insecurity (29–80%)[42,54,55,149–151,153–155,a63,a225,a226,a227]	Food insecurity (1·7–9·2%)[55,153]
Western Pacific			
Australian Aboriginals and Torres Strait Islanders	4	Food insecurity (17·7–76·0%)[a54,a57,a228,a166]	5·4% (Australia)[a54,a57,a233]
New Zealand Maori and Pacific Islanders	1	Food insecurity (29·2%)[a229]	15·8% (New Zealand)[a229]
Malaysian Orang Asli and Iban	4	Malnutrition (6·1–26·7%)[a60,a230–a232]	..

References a1–a296 are listed in the appendix.

Table 6: **Prevalence of malnutrition and food insecurity**

Nationwide programmes that are aimed at preventing tobacco use by means of taxation, introduction of smoke-free workplaces, and prohibition of tobacco advertising were also found to be effective in Indigenous populations in the USA, Australia, and New Zealand, and were generally well accepted by the communities involved (appendix).[162–167]

Discussion

This systematic review is the first to attempt to paint a global portrait of the prevalence of proximate social determinants and medical risks for tuberculosis in Indigenous communities, and of preventive programmes addressing these determinants. We found that, where studied, the prevalence of tobacco consumption and excessive alcohol use are often higher in Indigenous populations than in non-Indigenous populations. Furthermore, Indigenous peoples in high-income countries had a higher prevalence of diabetes than those in low-income countries. Available data pertaining to crowding, housing conditions, malnutrition, HIV, and substance use were too scant to permit firm conclusions. The burden and effect of these determinants is variable among Indigenous communities; however, it is clear that some are intimately tied to acculturation—the phenomenon whereby Indigenous peoples adopt values, attitudes, beliefs, and behaviours from non-Indigenous cultures—and the rate of change in these determinants is directly related to the extent to which the community has moved away from a traditional lifestyle.[101,168]

To the extent that these determinants contribute to the excessive burden of tuberculosis, there is little evidence supporting specific approaches to address them. Only 55 of the 475 articles retrieved addressed preventive programmes; although available data primarily confirm the feasibility and acceptability of such programmes, most studies do not address efficacy. A recurrent and unsurprising observation is that programmes yielded better acceptability if the community was directly involved in its conception than if the community was not involved. Countrywide programmes such as taxation, which included, but were not specific to, Indigenous communities, were found to decrease the prevalence of smoking in Indigenous communities in high-income countries and seemed to yield the best results. Resource requirements and costs of some programmes (not assessed in our review) might hamper their application, given the frequent underfunding of public health systems in Indigenous settings.

Strengths of our review are that we used a highly comprehensive and sensitive systematic search strategy developed by a medical librarian; standardised, rigorous eligibility criteria for the studies; and two independent reviewers who assessed the eligibility of studies at every

	Studies (n)	Prevalence of recreational tobacco use	
		Range among Indigenous population	Range among comparator population
Africa			
Cameroon Indigenous	1	2·1%[97]	6·5% (Cameroon)[97]
Southeast Asia			
Scheduled Tribes of India	9	1·9–85·1%[98,160,a2,a5,a67,a234–a237,a165]	3·8–24·0% (India)[a2,a235,a237]
Bangladesh Tribes	1	35·8%[a238]	35·9% (Bangladesh)[a238]
Europe			
Roma and Gypsy people	6	34·0–72·3%[27,a69,a87,a88,a92,a239]	15·9–44·4% (non-Roma)[27,28,a88,a92,a93,a239]
Greenland Inuit	5	64·0–73·2%[a7–a9,a80,a83]	..
Latin America			
Mexican Indigenous	2	8–14%[a15,a100]	16% (Mexico)[a100]
Peru Andean Hispanics	1	5·6–34·6%[a102]	..
Guatemala Indigenous	1	0·0–13·0%[a20]	..
North America			
USA: Alaska Natives, Native Hawaiians, and Native Americans	48	6·7–75·4%[17,19,22,25, 36, 41,81,90,a27,a110,a111,a117,a119,a128,a133,a240–a270]	11·1–35·8% (USA)[16,17,20,25,33,35,90,a26,a110,a111,a117,a119,a128,a130,a240,a241,a244,a246,a248–a250,a252,a254,a257,a258,a263,a264,a269,a270]
Canadian First Nations and Inuit	19	26·6–100%[43–47,99,100,115,149–155,157–159,a35,a38,a44,a45,a134,a271–a277]	17–34% (Canada)[43,47,100,a35–a37,a38,a272–a275,]
Western Pacific			
Australian Aboriginals and Torres Strait Islanders	13	30·4–83·0%[162,a57–a59,a182,a205,a278–a284]	19·1–22·8% (Australia)[a57,a279]
New Zealand Maori and Pacific Islanders	9	23·2–58·0%[163,164,a285–a291]	15·0–35·0% (New Zealand)[163,164,a285–a291]
Taiwan Aboriginals	2	27·3–57·5%[a195,a292]	23·2% (Taiwan)[a195,a292]
Malaysia Bajaus	1	3·3–77·0%[160]	..

References a1–a296 are listed in the appendix.

Table 7: **Prevalence of recreational tobacco use**

step of the selection process. Limitations of our review include variability in the definitions of proximate determinants between studies, difficulty in defining Indigenous groups, and variability in study design and location. Given the diversity of studies and marked variation in sampling mechanisms (many involved convenience samples rather than more rigorous methods of selection), we could not explicitly account for study quality. The variable sampling frames and definitions of target populations and parameters could also have led to substantial biases in some cases. The heterogeneity of settings, populations, methodologies, definitions, and findings precluded formal meta-analysis. The review was also limited to studies published in English, which might have created some bias in the articles that were ultimately retained for the analysis. Moreover, each study focused on the prevalence or prevention of a single determinant, which oversimplifies and obscures more complex relationships between the various determinants—eg, the association between poverty, crowding, and substance use.[3] A more nuanced approach accounting for the overlap and interplay between these determinants was beyond the scope of the studies we reviewed but will be essential moving forward.

This review also highlights geographical disparities in research reports. Most of the available literature pertains to Indigenous populations within high-income countries in North America, Europe, and the Western Pacific region; few studied Indigenous populations in Southeast Asia, the Eastern Mediterranean region, and Africa. Despite the high frequency of serious public health gaps, such as tobacco consumption in Inuit communities in Canada, or malnutrition in Scheduled Tribes in India, there are few rigorous studies reporting preventive programmes in these settings. This gap highlights the urgent need for community-driven programmes and operations research targeting these social and behavioural health determinants. Addressing these determinants not only has the potential to reduce the excessive burden of tuberculosis in Indigenous peoples, but also to improve many other important health outcomes.

Proximate determinants of tuberculosis appear to be prevalent in Indigenous populations worldwide, although there is wide variation. A substantial fraction of tuberculosis in Indigenous peoples is probably attributable to such determinants, given their prevalence and the epidemiological evidence linking them to tuberculosis.[6–12] Our findings emphasise the need for more research and support to develop strategies that are community-led, community-based, and culturally appropriate to address smoking, food insecurity, malnutrition, alcohol, and substance misuse, HIV, overcrowding, and diabetes as important public health goals in their own right, as well as to tackle the

disproportionate tuberculosis burden among Indigenous populations. For these projects to be as successful as possible, Indigenous peoples should have leadership roles in all aspects of development and implementation.[169] It will also be important for those involved in developing culturally appropriate programmes to disseminate their experiences to help to improve public health approaches in other settings where these risk factors, and tuberculosis more widely, are an ongoing problem.

Contributors

KS, OO, DSN'D, and MC conceived the research project, coordinated the contributors, and revised drafts of the manuscript. MC, DSN'D, AMdS, JG, DC, MG, CEB, RK, AU, and OO participated in the study selection and data extraction. MC, DSN'D, CEB, OO, and KS interpreted the findings. MC wrote the first draft, revised subsequent drafts, and prepared the manuscript. KS and OO revised drafts of the manuscript and contributed to data analysis. MM developed the search strategy, searched the databases, and contributed to the revision of the manuscript.

Declaration of interests

We declare no competing interests.

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