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Climatic and community sociodemographic factors associated with remote Indigenous Australian smoking rates – an ecological study of health audit data

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ABSTRACT

Australian Indigenous smoking rates are highest in remote communities but likely vary between communities; few studies have assessed community features in relation to Indigenous smoking rates. **Design and Objective:** This ecological study evaluated the associations between smoking rates, and community sociodemographic and climatic characteristics for a large sample of remote Indigenous communities. **Setting and sample:** Records (n=2689) from an audit of community health centres in the Northern Territory and Queensland were used to estimate smoking rates dichotomised at the median for 70 predominantly Indigenous remote communities. Community characteristics were similarly dichotomised. **Methods:** Cross-tabulations were used to calculate the odds of a community classified as high for a sociodemographic or climatic factor also being high for smoking rate. Additional cross-tabulations, stratified by sociodemographic, region (coastal or central), and geographic connectivity levels, were performed to assess potential confounding. **Results:** Community smoking rates ranged from 25-96% (median 60.2%). Moderately strong relationships were observed between community smoking rate and population size (OR 6.25, [95% CI 2.18-17.95]), education level (OR 3.67 [1.35-10.01]), income (2.86 [11.07-7.67]), and heat (2.86 [1.07-7.67]). **Conclusions:** Smoking rates in Australian remote Indigenous communities are universally high. Smoking rates are associated with greater community-level socioeconomic status and size, most likely reflecting greater means of accessing tobacco with mass of smokers sufficient to sustain a normative influence. Severe heat was also associated with high smoking rates suggesting such a stressor might support smoking as a coping mechanism. Community sociodemographic and climatic factors bear consideration as context-level correlates of community smoking rates.

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Strengths and Limitations:

This study contributes to the limited literature on smoking rates in remote Australian Indigenous communities which thus far has been based on considerably smaller samples of communities.

This study is unique in estimating ecological associations between smoking rates and relevant community-level sociodemographic, geographic and climatic factors.

Community smoking rates derived from health service data were linked with census, geographic connectivity, and climatic information.

Sample loss due to missing smoking information most likely indicates random deficiencies in health assessment at the local level, thus biasing results towards the null.

Study results are generalisable to Australian remote Indigenous communities and may be broadly generalisable to remote-dwelling indigenous populations in other developed countries.

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INTRODUCTION

Tobacco smoking is a major risk factor for a range of chronic health conditions including cardiovascular disease, type 2 diabetes and cancer[1, 2]. Indigenous populations worldwide have higher smoking rates than non-Indigenous populations. Disparities in smoking prevalence are apparent in New Zealand (Maori 35.5%; New Zealand adults 14.2%), the US (American Indians/Alaska Natives 29.2%; US adults 16.8%), and Canada (First Nations, off-reserve 26.8%; Inuit 48.9%; Canadian non-Aboriginal population 15.1%)[3-5]. In Australia, Aboriginal and Torres Strait Islander peoples (hereafter Indigenous Australians) are 2.7 times as likely to smoke daily as non-Indigenous Australians, with age-standardised prevalence rates of 42% and 15%, respectively[6]. Tobacco-related conditions are estimated to account for half of the health gap between Indigenous and non-Indigenous Australians [7].

Greater smoking in Indigenous Australians has been attributed to socioeconomic factors (low income, financial stress, unemployment, low education, and housing [rental versus ownership, overcrowding]); sociocultural factors (smoking exposure and normalisation); social factors (boredom, or being: arrested; incarcerated; removed from family [or removal of a relative]; a victim of violence or threats); and stress, including stress associated with a history of colonisation and dispossession (racism, marginalisation, family dislocation, disconnection from the land, loss of traditional diet and lifestyle and the adoption of Western habits and practices)[8-10].

Adult Indigenous Australian smoking rates vary from 39% in Major Cities to 49% in Remote and 56% in Very Remote areas[11, 12]. This is unsurprising given smoking varies by social disadvantage[9] and, in Australia, social inclusion and socioeconomic status (SES) lessen with

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distance from major metropolitan areas[13]. Thus, it is reasonable to anticipate greater smoking amongst Indigenous Australians in more remote regions.

Smoking rates also differ between remote Indigenous communities with one study reporting rates ranging from 59% to 80%[14]. This variation may be driven by community-specific factors. In research not focused on Indigenous communities, factors such as neighbourhood disadvantage, perceived crime and neighbourhood stress, and perceived acceptability of smoking have been linked to greater likelihood of an individual smoking[15-17]. Thus, variation in community exposures may shape differences in smoking behaviours between remote Indigenous communities, yielding differences in consequent disease outcomes. Specific to Indigenous smoking, geographic variation in smoking rates (i.e., generally higher smoking rates in northern coastal regions) has been attributed to historical factors, with smoking behaviour introduced across the northern coastal region of Australia by Macassan fishermen[10, 18] beginning around 1780[19]. Minimal research has investigated differences between Indigenous communities, despite geographic variations in smoking rates that likely reflect geographic variation in environmental predisposing factors.

A further potential influence on smoking prevalence is extreme weather, which is demonstrably 'more extreme' in remote Australian regions. Temperature extremes can vary from 34.8-38.0°C in the Darwin (metropolitan) region, to 42.0-46.3°C in the remote Rabbit Flat region [20]. Cigarette sales across the US demonstrate seasonality, increasing in the summer months [21], with this pattern also evident within smaller geographic areas (i.e. within New Jersey) [22]. This apparent association between temperature (higher in summer months) and smoking may be the result of the relationship between extreme high temperatures and negative affective states, stress and violence [23, 24], as stress is well

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accepted as being linked to smoking[9, 25, 26]. Extreme high temperatures may influence smoking behaviour by increasing stress and anxiety levels.

Tobacco use is of major significance to the health gap affecting Indigenous Australians and is highest in socially disadvantaged populations in geographically remote locations. Few studies have assessed community exposures in relation to Indigenous smoking behaviour. This study assessed smoking rates for remote Indigenous communities in relation to community sociodemographic and climatic factors.

METHODS

This study is part of the Environments and Remote Indigenous Cardiometabolic Health (EnRICH) Project which aimed to identify community features related to the cardiometabolic health of Indigenous Australians living within remote communities across the Northern Territory and Queensland. This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethics approvals were obtained from multiple Human Research Ethics Committees (details in Ethics Approval section).

Sampling

This study used community health service records from the *One21seventy* program, applying protocols for auditing of preventive healthcare developed by the Audit and Best Practice for Chronic Disease (ABCD) Project[27]. The ABCD Audit Protocols defines community health service client records eligible for audit via the following criteria: 1) aged between 15 and 54 years; 2) a community resident for ≥6 months per last 12 months; 3) not previously diagnosed with diabetes, cardiovascular disease or chronic kidney disease; and 4) not pregnant or <6 weeks postpartum. The audit sample was drawn from the identified eligible client records with sample size determined according to program recommendations[27].

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Where there were more than 30 eligible records, records were randomly sampled with the size of the sample determined by a sliding scale based on the number of eligible records. Where the number of eligible client records was 30 or less, all records were sampled.

The current study accessed audit data according to the following inclusion criteria, the community was: (1) located within the Northern Territory or Queensland; (2) a 'remote' location[28]; and (3) a predominantly Indigenous community signed up to the ABCD National Research Partnership. Such communities were assigned a unique spatial identifier, allowing linkage with other datasets including ABS Census data expressed for Indigenous Locations (ILOCs)[28]. ILOCs are the smallest resolution at which Indigenous Census data are available, typically representing small (minimum 90 persons) Indigenous communities. Some (n=3) ILOCs include multiple nearby and associated very small communities. Communities belonging to such ILOCs were excluded from this study. Seventy communities met the above inclusion criteria and were included in this study.

Audit data for the years 2010-2014 were extracted for each community (total n=8561 records). Audit records were assessed for multiple client coverage using date of birth and sex, with the most recent record retained (n=5412). Records were excluded where the clients identified as 'Neither' an Aboriginal and/or Torres Strait Islander person (n=337) and clients whose last health centre attendance was prior to 1 January 2010 (n=395), leaving 4680 records remaining. Audit data were aggregated by community.

Patient and Public Involvement

Due to the reliance of this study on audit data of health service record, patients and the public were not involved in the design or execution of this research. However, sampled

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communities were extensively consulted and voluntarily participated in the *One21Seventy* program from which health record audit data were sourced.

Measures

Dependent variable

Community smoking rates were calculated from audit records. For each community, smoking rate was calculated as the count of clinical records documenting status as 'smoker' divided by the total records with a valid smoking status (i.e., sum of 'smoker' and 'non-smoker'). Where smoking status was not recorded (i.e., 'no record' or 'not applicable') the audit record was excluded (n=1991), leaving a final sample of 2689 records of Indigenous Australians with an identifiable smoking status.

Independent variables

Community-level Indigenous sociodemographic data were extracted from the ABS 2011 Population and Housing Census[29] and expressed at the ILOC spatial unit[28]. Data included: *population size* (all persons); *count of Aboriginal and Torres Strait Islander persons*; *age* (median); *overcrowding* (the percentage of dwellings requiring one or more additional bedrooms based on household demographics); and *income* (median household). Proportions of Indigenous persons were calculated from the Census data for *education* (grade 10 schooling or higher) and *employment* (aged 15 years and over in labour force).

Geographic connectivity was expressed as a count of other Indigenous communities within a 250km road-network distance[30] (mainland communities only; n=56).

Climate profiles were obtained from surface maps sourced from the Australian Bureau of Meteorology for the period 1961-2012[31]. Community-level climate measures representing

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heat and *heavy rain* were determined as follows. Heat was operationalised as the average of the annual sum of 'cooling degree.days' in each community. 'Cooling degree.days' is a standard measure[32] defined as the number of degrees by which a day's mean temperature exceeds 18°C. For example, a day with a mean daily temperature of 25°C would attract a cooling degree.days score of 7 degree.days, whereas as day with a mean daily temperature of 16°C would attract a score of 0 degree.days. *Heavy Rain* was operationalised as the mean of the annual number of days with greater than 25 millimetres of precipitation.

Region was determined according to the community geographic location within Australian Bureau of Meteorology Climate Zones[33], with the climate zones 'Equatorial' and 'Tropical' collapsed to form the 'Coastal' Region, and the climates zones 'Desert' and 'Grassland' collapsed to form the 'Central' Region. Of the 70 included remote communities, 43 were classified as Coastal and 27 as Central.

Data preparation

Communities were classified as "high" or "low" based on the median community value for each variable except Region (classification defined above) (Table 1). Alternative cut points were considered, such as the 25th and 75th percentiles, however, use of other cut points resulted in very small cell sizes, particularly within stratified cross-tabulations, such that some cells included zero counts.

Statistical analysis

Odds ratios (ORs) were calculated by two-by-two cross-tabulations of counts of communities classified as high or low smoking rate and counts of communities with high or low classifications of sociodemographic and climatic variables. Additional two-by-two cross-

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tabulations stratified by community-level measures (sociodemographic measures, geographic connectivity, and region) were conducted to assess potential confounding. Where the stratified groups were homogeneous (Breslow-Day test of homogeneity of ORs), adjusted pooled ORs were calculated using the mid-*p* method. Due to small counts within cells, 'exact' options (mid-*p* and mid-*p* 95% confidence intervals) were used throughout[34]. All data preparation and analyses were conducted in SAS (version 9.4, SAS Institute Inc, Cary, North Carolina) and WinPepi (Compare2, version 3.85, J. Abramson).

RESULTS

Features of communities are described in Table 1. Median population size was 332. Median population proportion identifying as Indigenous (i.e. Aboriginal and/or Torres Strait Islander) was 90.7%. Median smoking rate was 60.2% with a large range (25.0% - 96.0%).

Table 1: Features of communities sampled (n=70)

Community feature	Mean	Median	IQR	Min	Max
Population size (Count of total persons[a])	522.9	331.5	210.0-686.0	111	2124
Indigenous persons (as proportion of total persons[a]; %)	87.8	90.7	88.0-94.0	52.2	100.0
Indigenous persons:					
Proportion who are smokers (% of audited records)	59.5	60.2	50.0-70.0	25.0	96.0
Age (median[a]; years)	23.0	22.0	20.0-25.0	16.0	31.0
Income (median household[a]; AUD/week)	952.41	912.00	722.00-1125.00	312.00	2111.00
Education (proportion with Year 10 schooling or greater[a]; %)	55.3	58.2	36.8-73.1	9.4	85.2
Employment (proportion in labour force[a]; %)	38.3	34.6	27.6-52.0	10.7	73.5
Overcrowding (proportion of households requiring additional bedrooms[a])	44.8	43.1	31.1-60.0	11.6	84.4

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Geographic connectivity (count of Indigenous communities within 250km[b]-road network distance)	10.8	6.0	4.0-14.0	2.0	39.0
Heat (average annual cooling degree.days) [c]	2908.5	3178.0	2293-3353	1678.0	3644.0
Heavy Rain (average annual number of days with greater than 25 millimetres of precipitation, days/year)	14.4	15.7	4.2-24.4	2.4	25.6

[a]data relate to the ILOC associated with the selected community; [b]*n*=56 [mainland communities only]; [c] Heat, cooling degree.days is calculated as the average of the annual sum of the number of degrees by which each day's mean temperature exceeds 18°C.; AUD – Australian Dollars; ILOC – Indigenous Locations

Table 2 reports the results of the two-by-two (presented highest to lowest magnitude of OR) and stratified two-by-two cross-tabulations. Relatively high population communities were more likely to have high smoking rates (OR 6.25, [95% CI 2.18-17.95], $p<0.001$) compared to communities with low population size. Stratification into high and low conditions for sociodemographic measures and geographic connectivity revealed no differences in ORs between conditions (Breslow-Day test of homogeneity p>0.05) and pooled ORs remained moderately large (ORs ranging from 5.35-6.88, *p*-values <0.01 or smaller) though with greater attenuation when accounting for region (OR 4.43 [1.47-13.92], $p<0.01$).

High education communities were more likely to have high smoking rates (OR 3.67 [1.35-10.01], $p=0.010$) than communities with low education. Stratification by geographic connectivity and employment revealed differences in ORs between the high and low conditions. Amongst communities with high geographic connectivity, high community-level education was associated with high smoking rates (OR ∞ [2.68-∞], $p=0.002$). This relationship was not statistically significant among communities with low geographic connectivity. Similarly, amongst communities with low employment, the odds of high education communities being high in smoking rate rose strongly (OR 26.67 [3.03-621.30], $p<0.001$) while there was no statistically significant association with the high employment condition. Pooled ORs for high education communities being high in smoking rate, after

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accounting for other measures, were small to moderate (OR 3.47 to 6.45, p <0.05 or smaller), except when accounting for region when the association became null. This reflects the differing directions of associations between regions though the difference between groups did not quite reach statistical significance (Breslow-Day test of homogeneity p=0.066).

Communities with frequent heavy rain were more likely to have high smoking rates (OR 3.67 [1.35-10.01], p=0.010). These odds were greater for communities with an older population (OR 18.20 [2.96-139.00], p<0.001) or low education (OR 10.50 [1.61-84.86], p=0.006) while the odds became non-significant for communities with a younger population or high education. Pooled ORs remained of small to moderate strength when accounting for household income (OR 3.51 [1.28-10.05] p=0.014), employment (OR 3.12 [1.03-9.89], p=0.043), overcrowding (OR 4.67 [1.51-16.28] p=0.007), and geographic connectivity (OR 7.45 [1.86-33.39] p=0.004). However, upon accounting for population size the odds of communities with frequent heavy rain being high in smoking rate were non-significant. When stratifying by region, no central communities were classified as having frequent heavy rain and the association between frequent heavy rain and smoking was null for the coastal communities.

Community income was associated with smoking rate (OR 2.86 [1.07-7.67], p=0.036). Stratification into high and low conditions for sociodemographic measures and geographic connectivity revealed no differences in ORs between groups, and pooled ORs were small to moderate (range 2.31-3.75) but were not statistically significant when accounting for population size, geographic connectivity, or region.

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Heat was also associated with community smoking rate (OR 2.86 [1.07-7.67], *p*=0.036) and the odds of a hotter climate community being high in smoking rose notably under the following conditions: low education (OR 13.33 [2.30-79.93], *p*=0.001); low employment (OR 12.67 [2.06-98.54] *p*=0.004), high overcrowding (OR 9.17 [1.82-50.20], *p*=0.004), high connectivity (OR ∞ [5.44-∞] *p*<0.001), and central region (OR ∞ [2.61-∞], *p*<0.01). Amongst coastal communities, high heat was associated with a lesser likelihood of being a high smoking community (OR 0.15 [0.01-1.07], *p*<0.05). Pooled ORs were small to moderate when accounting for average population age (OR 3.80 [1.31-12.04] *p*=0.013), and income (OR 2.90 [1.07-8.23] *p*=0.036) but there was no statistically significant association when accounting for population size.

Community employment was not associated with smoking rate (OR 2.25 [0.85-5.94], *p*=0.103) but under the low community education condition the odds of high employment communities being high in smoking rose substantially (OR 6.67 [1.20-39.16], *p*=0.026). Stratifying by location revealed ORs differing in directions. Amongst coastal communities, high employment rate was inversely associated with smoking rate (OR 0.32 [0.04-1.63]) while amongst central communities, high employment was directly associated with high smoking rate (OR 4.75 [0.37-53.66]). These region-specific associations, however, did not reach statistical significance. Pooled ORs accounting for other sociodemographic measures or geographic connectivity yielded small but statistically non-significant effects (ORs ranging from 2.05-2.88).

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Table 2: Associations between counts of communities with high levels of sociodemographic and climatic features, and high smoking proportion, accounting for potential confounders (n=70, 95% CIs calculated using exact methods [mid-*p*])

Exposure	OR (95% CI)	Stratifying variable	OR (95% CI) (high condition or coastal region)	OR (95% CI) (low condition or central region)	Breslow-Day test of homogeneity	Pooled OR (95% CI)
Population size	6.25 (2.18-17.95)***	Age	18.20 (2.96-139.00)***	3.30 (0.80-13.92)	0.134	6.44 (2.27-19.81)***
		Income	4.27 (0.95-19.29)	7.65 (1.56-38.03)**	0.589	5.35 (1.90-15.95)**
		Education	8.50 (1.65-47.26)*	4.57 (0.98-21.87)	0.578	5.81 (2.01-18.11)**
		Employment	4.06 (0.92-18.84)	15.00 (2.55-113.26)**	0.258	6.88 (2.36-22.19)***
		Overcrowding	5.11 (1.14-23.81)*	9.33 (1.86-50.93)**	0.584	6.41 (2.26-19.72)***
		Geographic connectivity[a]	2.92 (0.53-15.91)	16.00 (1.98-141.91)**	0.192	5.66 (1.67-20.72)**
		Region	5.66 (1.36-23.67)*	3.20 (0.41-23.38)	0.633	4.43 (1.47-13.92)**
Education	3.67 (1.35-10.01)*	Population size	4.96 (0.97-27.80)*	2.67 (0.56-13.04)	0.578	3.47 (1.18-10.79)*
		Age	3.78 (0.85 – 17.67)	4.50 (1.03-20.58)*	0.868	3.96 (1.45-11.51)**
		Income	4.81 (1.01-25.98)	4.81 (1.01-25.98)	1.000	4.59 (1.59-14.62)**
		Employment	0.68 (0.12-3.43)	26.67 (3.03-621.30)***	0.005	-
		Overcrowding	4.36 (0.73-34-91)	11.90 (1.44-284.38)*	0.485	6.45 (1.75-30.92)**
		Geographic connectivity[a]	∞ (2.68-∞)**	1.00 (0.16-5.69)	0.016	-
		Region	0.72 (0.13-3.25)	10.00 (0.56-307.27)	0.066	1.37 (0.36-4.86)
Heavy Rain	3.67 (1.35-10.01)*	Population size	4.75 (0.93-24.21)*	1.42 (0.28-6.70)	0.274	2.50 (0.85-7.44)
		Age	18.20 (2.96-139.00)***	1.29 (0.33-5.02)	0.016	-
		Income	4.82 (1.06-22.78)*	2.80 (0.65-12.18)	0.603	3.51 (1.28-10.05)*
		Education	0.57 (0.07-3.34)	10.50 (1.61-84.86)**	0.020	-
		Employment	1.28 (0.25-6.25)	9.50 (1.55-74.66)*	0.089	3.12 (1.03-9.89)*

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		Overcrowding	7.11 (1.24-58-4.83)*	3.50 (0.71-19.50)	0.553	4.67 (1.51-16.28)**
		Geographic connectivity[a]	∞ (2.68-∞)**	3.25 (0.56-18.53)	0.091	7.25 (1.86-33.39)**
		Region	0.64 (0.08-3.59)	NO DATA	NO DATA	-
Income	2.86 (1.07-7.67)*	Population size	1.78 (0.37-8.28)	3.19 (0.66-15.71)	0.589	2.31 (0.80-6.83)
		Age	2.57 (0.61-10.81)	3.10 (0.76-12.67)	0.852	2.74 (1.04-7.43)*
		Education	3.90 (0.82-21.18)	3.90 (0.82-21.18)	1.000	3.75 (1.29-11.93)*
		Employment	3.60 (0.84-15.69)	2.17 (0.52-8.97)	0.615	2.70 (1.01-7.41)*
		Overcrowding	2.60 (0.59-12.18)	4.67 (0.97-25.35)	0.589	3.33 (1.18-10.07)*
		Geographic connectivity[a]	2.75 (0.56-14.03)	3.14 (0.56-19.17)	0.909	2.81 (0.91-9.16)
		Region	2.18 (0.57-8.34)	4.00 (0.54-35.79)	0.608	2.58 (0.89-7.80)
Heat	2.86 (1.07-7.67)*	Population size	1.50 (0.32-6.94)	4.96 (0.97-27.80)*	0.277	2.59 (0.90-7.77)
		Age	7.22 (1.28-55.09)*	2.45 (0.57-11.30)	0.344	3.80 (1.31-12.04)*
		Income	2.31 (0.55-9.97)	3.94 (0.88-18.40)	0.606	2.90 (1.07-8.23)*
		Education	0.31 (0.04-1.72)	13.33 (2.30-79.93)**	0.001	-
		Employment	0.55 (0.10-2.66)	12.67 (2.06-98.54)**	0.007	-
		Overcrowding	9.17 (1.82-50.20)**	1.10 (0.27-4.43)	0.043	-
		Geographic connectivity[a]	∞ (5.44 - ∞)***	0.80 (0.15-4.25)	0.002	-
		Region	0.15 (0.01-1.07)*	∞ (2.61-∞)**	<0.001	-
Employment	2.25 (0.85-5.94)	Population size	1.63 (0.35-7.91)	6.00 (1.06-46.31)*	0.258	2.88 (0.97-9.28)
		Age	2.75 (0.65-11.89)	2.04 (0.51-8.16)	0.762	2.30 (0.88-6.19)
		Income	2.80 (0.65-12.18)	1.69 (0.40-7.03)	0.615	2.18 (0.79-5.80)
		Education	0.17 (0.01-1.35)	6.67 (1.20-39.16)*	0.008	-
		Overcrowding	2.73 (0.54-15.53)	2.73 (0.54-15.53)	1.000	2.65 (0.87-8.66)
		Geographic connectivity[a]	6.67 (0.95-56.74)*	0.79 (0.13-4.38)	0.091	2.05 (0.61-6.91)

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Region	0.32 (0.04-1.63)	4.75 (0.37-53.66)	0.040	-

OR = Odds Ratio; CI = Confidence Interval; [a] *n*=56 (mainland communities only); **p*<0.05; ***p*<0.01; ****p*<0.001

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DISCUSSION

This ecological study assessed Indigenous Australian smoking rates based on health-audit records, within predominantly Indigenous remote communities, in relation to community-level sociodemographic and climatic factors. We observed substantial variation in Indigenous smoking rates between remote communities, from 25% to 96%, a broader range than previously reported. Other studies reported rates as ranging between 59% to 80%[14] and 27% to 68%[35].

Our observed variation may be, in part, due to the large degree of sample loss resulting from audit client records missing smoking information. Wright and colleagues[35] noted particularly small sample sizes available for some Indigenous regions which may impact on the precision of estimates and artificially inflate the range of smoking rates reported. To better understand geographic variation in smoking rate, its associated factors, and change in rates over time, better quality data are needed. Regardless, our findings align with previously identified substantial geographic variation in smoking between remote Indigenous communities. This variation has important implications for intervention strategies, suggesting the need for localised approaches targeting communities according to smoking prevalence. It is, however, important to note that regional variation in smoking rates has a basis in the history of tobacco usage among Indigenous Australians, with exposure to smoked tobacco (in contrast to the custom of chewing native, nicotine-containing flora) preceding Western colonisation and occurring in littoral regions of the Northern Territory and Queensland via trade[10]. This study stratified cross-tabulations by region in order to account for this previously established variation in smoking rates.

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Our findings indicate smoking rate covaries with community-level features, notably, population size, education level, income, heat, and frequency of heavy rain. Some effects varied given other community conditions. Communities with larger populations were more likely to have high smoking rates. This may reflect greater access to cigarettes as larger communities likely have more services including retail outlets for cigarettes. Relatively high-income communities were also more likely to have high smoking rates, suggesting greater ability to afford cigarettes. This association was nullified, however, by accounting for population size, geographic connectivity, and region (itself related to both population size and geographic connectivity), given that with greater population size and geographic connectivity comes greater income earning opportunity.

Communities with a relatively high education level were more likely to have high smoking rates, particularly if the community also had low levels of employment or high geographic connectivity to other Indigenous communities. The direction of this relationship is unexpected, as individual-level education and area-level SES are both inversely related to individual smoking in the Australian population in general, and Indigenous Australians in particular[36, 37]. Greater education with lesser opportunity to apply that education through employment could, however, constitute a substantial stressor that supports smoking as a coping strategy.

It is possible that relationships observed between community smoking rate and sociodemographic features (population size and education level) reflect complex historic and ongoing social pathologies. Larger communities may consist of multiple displaced, and sometimes feuding, family groups forcefully relocated from their traditional homelands to a mission site[38]. Forced removal from traditional lands breaks the important connection that

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Indigenous Australians have to Country, a connection important to their wellbeing[39]. Moreover, forced dispossession and resettlement disrupted established traditional lifestyles and social systems whilst failing to provide an adequate alternate cultural system, resulting in reduced quality of lifestyle[40].

This disruption of traditional structures and inadequate replacement with new structures, and the lack of acceptance into the western social system could lead to anomie and collective despondency, exacerbated by cultural bereavement[41-43]. It follows that such communities would have higher smoking rates amongst other social problems. Indeed, communities with a long history of receiving forcefully displaced groups and where maximum dysfunctional cultural change has occurred are most likely to exhibit social pathologies and disorder, including violence and self-harm[40]. We speculate that the unexpected association found in this study between high education and high smoking rate, particularly in communities with low employment, exemplifies the lack of social integration and acceptance into western social structures and resultant coping behaviour.

Relatively high community-level Western-style education may correspond to a reduced reliance on traditional social structures. Yet, higher levels of education may not overcome institutional racism and enable Indigenous individuals and groups to be truly accepted within the broader, non-Indigenous societal structures and take advantage of related opportunities. This latter point would be highlighted to the individual and the community by lack of employment. Smoking rate is likely a symptom of the broader issues faced by remote Indigenous communities and attempts to reduce smoking without considering these broader issues are unlikely to be effective. Interventions targeting proximal individual-level determinants of smoking need to be supported by efforts to improve distal community-level

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and societal factors[44]. Broad ecological approaches collaborating with local Indigenous representatives to facilitate local empowerment are needed with the focus on reducing the underlying social problems and ensuing social psychological states that predispose individual smoking behaviours[26].

Regarding climatic exposures, the influence of weather on smoking has rarely been assessed, especially in Indigenous populations. We observed frequent heavy rain to be associated with high smoking rates, particularly where community residents had a higher median age. However, this relationship may be an artefact of the association between region and smoking, as frequent heavy rain occurred only in the coastal region, and coastal communities were more likely to be high in smoking rate. Heat was also associated with high smoking rates, particularly in communities with low education, low employment, high overcrowding, high geographic connectivity and central region. This supports our premise regarding heat as a stressor affecting smoking behaviour, an effect seemingly compounded by other adverse conditions. In particular, the strong positive relationship between high heat and smoking in the central region suggests the relationship between heat and smoking rate is not due to confounding by region. If stress due to ongoing, inescapable heat is indeed related to smoking, as our findings suggest, this supports the need for better quality, culturally appropriate housing to ameliorate such stress. It is possible, however, that the apparent association between heat and smoking rate is due to other factors not measured here. These associations are novel and warrant further exploration.

This study builds on and expands the literature on Australian Indigenous smoking as few studies have assessed smoking rates of remote Indigenous communities, especially in relation to community-level factors. It identifies relationships between community smoking

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rate and community features and provides a snapshot of smoking rates in remote Indigenous communities. Though specific to Australian remote Indigenous communities, these findings may be broadly generalisable to other remote-dwelling indigenous populations in high-income countries as such populations have similar characteristics and have experienced similar historical exposures. Some limitations should be noted. The cross-sectional nature of this study limits inference on the temporal direction of associations. Use of clinical audit data only captures information for individuals who accessed western health-care services. Individual-level audit record sample loss due to missing smoking information may have introduced bias to the data and be indicative of deficient health assessment and data collection procedures at the local health service level. Similarly, the use of audit records creates a selection bias (e.g., not including records with chronic diseases) hence our results likely under-estimate the prevalence of smoking. Limitations in the assessment of community-level smoking have been noted in other studies[35, 45]. Potential confounding due to residential self-selection toward smaller and potentially healthier communities could not be accounted for. Given the small sample size and the desire to assess simple associations, the common and recommended[46] epidemiological approach of dichotomising the data at the median was utilised. We acknowledge that the categorisation of these data results in some information loss. Finally, this study is ecological and associations between community smoking rates and community factors should not be inferred at the individual level. The environmental correlates of smoking rates stand to differ from the predictors of individual smoking initiation and cessation.

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CONCLUSION

This study found substantial variation in smoking rates between Australian remote Indigenous communities, and that community-level sociodemographic (relatively large population size, high education level, and high income), and climatic factors (heat and frequent heavy rain) were associated with high smoking rates. Better data are needed to more accurately assess differences in community smoking rates, the ecological factors relating to these differences, and to track change in smoking rates over time. Further assessment of climatic factors, particularly heat, in relation to smoking is warranted. Community smoking rate is likely associated with adverse historical experiences and local pathologies. Efforts to reduce smoking rates should include a focus on improving local social conditions using a collaborative approach distinct from traditional forms of health education.

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DECLARATIONS

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Competing interests

The authors declare they have no competing interests.

Ethics approval and consent to participate

Ethics approval for the present study was obtained from the Human Research Ethics Committee (HREC) of University of South Australia [HREC Reference No. 31874], Central Australian Human Research Ethics Committee [HREC-13-182], Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research [HREC 2013-2083], and Far North Queensland Human Research Ethics Committee [HREC/15/QCH/4-946]. Ethics approvals for the ABCD National Research Partnership, for the

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geographic area pertaining to this study, were obtained from HRECs in the states and territories involved: the HREC of the Northern Territory Department of Health and Menzies School of Health Research (HREC-EC00153); Central Australian HREC (HREC-12-53); Queensland HREC Darling Downs Health Services District (HREC/11/QTDD/47); and the South Australian Indigenous Health Research Ethics Committee (04-10-319). Protocols for sharing de-identified client-level data by participating health services are managed by the ABCD National Research Partnership.

Consent for publication

Not applicable as the research presented in this manuscript is not a case study, nor does it contain any individual person's data in any form.

Data availability

Research involving Aboriginal and Torres Strait Islander peoples is strictly governed in Australia by the Australian Code for the Responsible Conduct of Research and Values and Ethics: Guidelines for Ethical Conduct in Aboriginal and Torres Strait Islander Health Research. In order to comply with these national regulations, both the legal agreements governing health service participation in the ABCD National Research Partnership and the human research ethics committee approvals of multiple jurisdictions preclude the sharing of a de-identified data set without evidence that it's proposed use addresses the ethical requirements of Reciprocity, Respect, Equality, Responsibility, Survival and Protection, and Spirit and Integrity. Data requests addressing these criteria may be sent to the ABCD National Research Partnership Data Access Committee care of Professor Ross Bailie (ross.bailie@sydney.edu.au).

Authors' contributions

SC prepared the data, performed analyses, interpreted results and contributed to the drafting and revision of the manuscript. MJD performed analyses, interpreted results and contributed to the drafting and revision of the manuscript. RB conceived of and designed the study and contributed to the revision of the manuscript. MD conceived of and designed the study, interpreted results and contributed to the drafting and revision of the manuscript. All authors approved the final manuscript.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **The term 'Ecological' is included within the Abstract (Background)**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **See Abstract Section**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **See particularly Introduction para 1, 4 &5**
Objectives	3	State specific objectives, including any prespecified hypotheses **See last line of Introduction**
Methods		
Study design	4	Present key elements of study design early in the paper **Design elements are clearly outlined in the Methods section**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **See Methods Para 1, also Sampling subsection para 3**.
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants **See Sampling subsection para 1-3**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **See Measures subsection**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **See Measures Subsection**
Bias	9	Describe any efforts to address potential sources of bias **Due to the use of secondary data and simple cross-tabulations we could not adjust models or adapt the sampling frame to address potential sources of bias. We do stratify the cross-tabulations to assess confounding and discuss potential data issues within the Discussion section.**
Study size	10	Explain how the study size was arrived at **See Sampling subsection (3rd para) and Measures subsection (1st para)**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **See Data preparation and Statistical Analysis subsections**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **See Statistical Analysis subsection**
		(*b*) Describe any methods used to examine subgroups and interactions **See statistical analysis subsection – additional 2x2 cross-tabulations stratified by region, community and climatic variables**
		(*c*) Explain how missing data were addressed **Each cross-tabulation used only complete data**
		(*d*) If applicable, describe analytical methods taking account of sampling strategy

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		NA
		(*e*) Describe any sensitivity analyses **NA**
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **See Sampling subsection (3rd para) and Measures subsection (1st para), but also note the n=56 mainland communities for the Geographic Connectivity variable**
		(b) Give reasons for non-participation at each stage **NA**
		(c) Consider use of a flow diagram **NA**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **See Table 1 for demographics and potential confounders**
		(b) Indicate number of participants with missing data for each variable of interest **Numbers of audit records with missing data are clearly described. Number of communities lacking geographic connectivity information is provided in the Measures section.**
Outcome data	15*	Report numbers of outcome events or summary measures **Descriptive statistics are provided in Table 1**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **See Table 2 and results text**
		(*b*) Report category boundaries when continuous variables were categorized **See Data preparation subsection, Methods**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **NA**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **NA**
Discussion		
Key results	18	Summarise key results with reference to study objectives **See discussion Para 1 and Conclusion**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **See Discussion para 2 and 9**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **See Discussion**
Generalisability	21	Discuss the generalisability (external validity) of the study results **See Discussion**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if

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	applicable, for the original study on which the present article is based
	See Funding section

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Climatic and community sociodemographic factors associated with remote Indigenous Australian smoking rates – an ecological study of health audit data

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Climatic and community sociodemographic factors associated with remote Indigenous Australian smoking rates – an ecological study of health audit data

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ABSTRACT

Australian Indigenous smoking rates are highest in remote communities but likely vary between communities; few studies have assessed community features in relation to Indigenous smoking rates. **Design and Objective:** This ecological study evaluated the associations between smoking rates, and community sociodemographic and climatic characteristics for a large sample of remote Indigenous communities. **Setting and sample:** Records (n=2689) from an audit of community health centres in the Northern Territory and Queensland were used to estimate smoking rates dichotomised at the median for 70 predominantly Indigenous remote communities. Community characteristics were similarly dichotomised. **Methods:** Cross-tabulations were used to calculate the odds of a community classified as high for a sociodemographic or climatic factor also being high for smoking rate. Additional cross-tabulations, stratified by sociodemographic, region (coastal or central), and geographic connectivity levels, were performed to assess potential confounding. **Results:** Community smoking rates ranged from 25-96% (median 60.2%). Moderately strong relationships were observed between community smoking rate and population size (OR 6.25, [95% CI 2.18-17.95]), education level (OR 3.67 [1.35-10.01]), income (2.86 [11.07-7.67]), and heat (2.86 [1.07-7.67]). **Conclusions:** Smoking rates in Australian remote Indigenous communities are universally high. Smoking rates are associated with greater community-level socioeconomic status and size, most likely reflecting greater means of accessing tobacco with mass of smokers sufficient to sustain a normative influence. Severe heat was also associated with high smoking rates suggesting such a stressor might support smoking as a coping mechanism. Community sociodemographic and climatic factors bear consideration as context-level correlates of community smoking rates.

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Strengths and Limitations:

This study contributes to the limited literature on smoking rates in remote Australian Indigenous communities which thus far has been based on considerably smaller samples of communities.

This study is unique in estimating ecological associations between smoking rates and relevant community-level sociodemographic, geographic and climatic factors.

Community smoking rates derived from health service data were linked with census, geographic connectivity, and climatic information.

Sample loss due to missing smoking information most likely indicates random deficiencies in health assessment at the local level, thus biasing results towards the null.

Study results are generalisable to Australian remote Indigenous communities and may be broadly generalisable to remote-dwelling indigenous populations in other developed countries.

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INTRODUCTION

Tobacco smoking is a major risk factor for a range of chronic health conditions including cardiovascular disease, type 2 diabetes and cancer[1, 2]. Indigenous populations worldwide have higher smoking rates than non-Indigenous populations. Disparities in smoking prevalence are apparent in New Zealand (Maori 35.5%; New Zealand adults 14.2%), the US (American Indians/Alaska Natives 29.2%; US adults 16.8%), and Canada (First Nations, off-reserve 26.8%; Inuit 48.9%; Canadian non-Aboriginal population 15.1%)[3-5]. In Australia, Aboriginal and Torres Strait Islander peoples (hereafter Indigenous Australians) are 2.7 times as likely to smoke daily as non-Indigenous Australians, with age-standardised prevalence rates of 42% and 15%, respectively[6]. Tobacco-related conditions are estimated to account for half of the health gap between Indigenous and non-Indigenous Australians [7].

Greater smoking in Indigenous Australians has been attributed to socioeconomic factors (low income, financial stress, unemployment, low education, and housing [rental versus ownership, overcrowding]); sociocultural factors (smoking exposure and normalisation); social factors (boredom, or being: arrested; incarcerated; removed from family [or removal of a relative]; a victim of violence or threats); and stress, including stress associated with a history of colonisation and dispossession (racism, marginalisation, family dislocation, disconnection from the land, loss of traditional diet and lifestyle and the adoption of Western habits and practices)[8-10].

Adult Indigenous Australian smoking rates vary from 39% in Major Cities to 49% in Remote and 56% in Very Remote areas[11, 12]. This is unsurprising given smoking varies by social disadvantage[9] and, in Australia, social inclusion and socioeconomic status (SES) lessen with

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distance from major metropolitan areas[13]. Thus, it is reasonable to anticipate greater smoking amongst Indigenous Australians in more remote regions.

Smoking rates also differ between remote Indigenous communities with one study reporting rates ranging from 59% to 80%[14]. This variation may be driven by community-specific factors. In research not focused on Indigenous communities, factors such as neighbourhood disadvantage, perceived crime and neighbourhood stress, and perceived acceptability of smoking have been linked to greater likelihood of an individual smoking[15-17]. Thus, variation in community exposures may shape differences in smoking behaviours between remote Indigenous communities, yielding differences in consequent disease outcomes. Specific to Indigenous smoking, geographic variation in smoking rates (i.e., generally higher smoking rates in northern coastal regions) has been attributed to historical factors, with smoking behaviour introduced across the northern coastal region of Australia by Macassan fishermen[10, 18] beginning around 1780[19]. Minimal research has investigated differences between Indigenous communities, despite geographic variations in smoking rates that likely reflect geographic variation in environmental predisposing factors.

A further potential influence on smoking prevalence is extreme weather, which is demonstrably 'more extreme' in remote Australian regions. Temperature extremes can vary from 34.8-38.0°C in the Darwin (metropolitan) region, to 42.0-46.3°C in the remote Rabbit Flat region [20]. Cigarette sales across the US demonstrate seasonality, increasing in the summer months [21], with this pattern also evident within smaller geographic areas (i.e. within New Jersey) [22]. This apparent association between temperature (higher in summer months) and smoking may be the result of the relationship between extreme high temperatures and negative affective states, stress and violence [23, 24], as stress is well

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accepted as being linked to smoking[9, 25, 26]. Extreme high temperatures may influence smoking behaviour by increasing stress and anxiety levels.

Tobacco use is of major significance to the health gap affecting Indigenous Australians and is highest in socially disadvantaged populations in geographically remote locations. Few studies have assessed community exposures in relation to Indigenous smoking behaviour. This study assessed smoking rates for remote Indigenous communities in relation to community sociodemographic and climatic factors.

METHODS

This study is part of the Environments and Remote Indigenous Cardiometabolic Health (EnRICH) Project which aimed to identify community features related to the cardiometabolic health of Indigenous Australians living within remote communities across the Northern Territory and Queensland. This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethics approvals were obtained from multiple Human Research Ethics Committees (details in Ethics Approval section).

Sampling

This study used community health service records from the *One21seventy* program, applying protocols for auditing of preventive healthcare developed by the Audit and Best Practice for Chronic Disease (ABCD) Project[27]. The ABCD Audit Protocols defines community health service client records eligible for audit via the following criteria: 1) aged between 15 and 54 years; 2) a community resident for ≥6 months per last 12 months; 3) not previously diagnosed with diabetes, cardiovascular disease or chronic kidney disease; and 4) not pregnant or <6 weeks postpartum. The audit sample was drawn from the identified eligible client records with sample size determined according to program recommendations[27].

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Where there were more than 30 eligible records, records were randomly sampled with the size of the sample determined by a sliding scale based on the number of eligible records. Where the number of eligible client records was 30 or less, all records were sampled.

The current study accessed audit data according to the following inclusion criteria, the community was: (1) located within the Northern Territory or Queensland; (2) a 'remote' location[28]; and (3) a predominantly Indigenous community signed up to the ABCD National Research Partnership. Such communities were assigned a unique spatial identifier, allowing linkage with other datasets including ABS Census data expressed for Indigenous Locations (ILOCs)[28]. ILOCs are the smallest resolution at which Indigenous Census data are available, typically representing small (minimum 90 persons) Indigenous communities. Some (n=3) ILOCs include multiple nearby and associated very small communities. Communities belonging to such ILOCs were excluded from this study. Seventy communities met the above inclusion criteria and were included in this study.

Audit data for the years 2010-2014 were extracted for each community (total n=8561 records). Audit records were assessed for multiple client coverage using date of birth and sex, with the most recent record retained (n=5412). Records were excluded where the clients identified as 'Neither' an Aboriginal and/or Torres Strait Islander person (n=337) and clients whose last health centre attendance was prior to 1 January 2010 (n=395), leaving 4680 records remaining. Audit data were aggregated by community.

Patient and Public Involvement

Due to the reliance of this study on audit data of health service record, patients and the public were not involved in the design or execution of this research. However, sampled

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communities were extensively consulted and voluntarily participated in the *One21Seventy* program from which health record audit data were sourced.

Measures

Dependent variable

Community smoking rates were calculated from audit records. For each community, smoking rate was calculated as the count of clinical records documenting status as 'smoker' divided by the total records with a valid smoking status (i.e., sum of 'smoker' and 'non-smoker'). Where smoking status was not recorded (i.e., 'no record' or 'not applicable') the audit record was excluded (n=1991), leaving a final sample of 2689 records of Indigenous Australians with an identifiable smoking status.

Independent variables

Community-level Indigenous sociodemographic data were extracted from the ABS 2011 Population and Housing Census[29] and expressed at the ILOC spatial unit[28]. Data included: *population size* (all persons); *count of Aboriginal and Torres Strait Islander persons*; *age* (median); *overcrowding* (the percentage of dwellings requiring one or more additional bedrooms based on household demographics); and *income* (median household). Proportions of Indigenous persons were calculated from the Census data for *education* (grade 10 schooling or higher) and *employment* (aged 15 years and over in labour force).

Geographic connectivity was expressed as a count of other Indigenous communities within a 250km road-network distance[30] (mainland communities only; n=56).

Climate profiles were obtained from surface maps sourced from the Australian Bureau of Meteorology for the period 1961-2012[31]. Community-level climate measures representing

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heat and *heavy rain* were determined as follows. Heat was operationalised as the average of the annual sum of 'cooling degree.days' in each community. 'Cooling degree.days' is a standard measure[32] defined as the number of degrees by which a day's mean temperature exceeds 18°C. For example, a day with a mean daily temperature of 25°C would attract a cooling degree.days score of 7 degree.days, whereas as day with a mean daily temperature of 16°C would attract a score of 0 degree.days. *Heavy Rain* was operationalised as the mean of the annual number of days with greater than 25 millimetres of precipitation.

Region was determined according to the community geographic location within Australian Bureau of Meteorology Climate Zones[33], with the climate zones 'Equatorial' and 'Tropical' collapsed to form the 'Coastal' Region, and the climates zones 'Desert' and 'Grassland' collapsed to form the 'Central' Region. Of the 70 included remote communities, 43 were classified as Coastal and 27 as Central.

Data preparation

Communities were classified as "high" or "low" based on the median community value for each variable except Region (classification defined above) (Table 1). Alternative cut points were considered, such as the 25th and 75th percentiles, however, use of other cut points resulted in very small cell sizes, particularly within stratified cross-tabulations, such that some cells included zero counts.

Statistical analysis

Odds ratios (ORs) were calculated by two-by-two cross-tabulations of counts of communities classified as high or low smoking rate and counts of communities with high or low classifications of sociodemographic and climatic variables. Additional two-by-two cross-

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tabulations stratified by community-level measures (sociodemographic measures, geographic connectivity, and region) were conducted to assess potential confounding. Where the stratified groups were homogeneous (Breslow-Day test of homogeneity of ORs), adjusted pooled ORs were calculated using the mid-*p* method. Due to small counts within cells, 'exact' options (mid-*p* and mid-*p* 95% confidence intervals) were used throughout[34]. All data preparation and analyses were conducted in SAS (version 9.4, SAS Institute Inc, Cary, North Carolina) and WinPepi (Compare2, version 3.85, J. Abramson).

RESULTS

Features of communities are described in Table 1. Median population size was 332. Median population proportion identifying as Indigenous (i.e. Aboriginal and/or Torres Strait Islander) was 90.7%. Median smoking rate was 60.2% with a large range (25.0% - 96.0%).

Table 1: Features of communities sampled (n=70)

Community feature	Mean	Median	IQR	Min	Max
Population size (Count of total persons[a])	522.9	331.5	210.0-686.0	111	2124
Indigenous persons (as proportion of total persons[a]; %)	87.8	90.7	88.0-94.0	52.2	100.0
Indigenous persons:					
Proportion who are smokers (% of audited records)	59.5	60.2	50.0-70.0	25.0	96.0
Age (median[a]; years)	23.0	22.0	20.0-25.0	16.0	31.0
Income (median household[a]; AUD/week)	952.41	912.00	722.00-1125.00	312.00	2111.00
Education (proportion with Year 10 schooling or greater[a]; %)	55.3	58.2	36.8-73.1	9.4	85.2
Employment (proportion in labour force[a]; %)	38.3	34.6	27.6-52.0	10.7	73.5
Overcrowding (proportion of households requiring additional bedrooms[a])	44.8	43.1	31.1-60.0	11.6	84.4

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Geographic connectivity (count of Indigenous communities within 250km[b]-road network distance)	10.8	6.0	4.0-14.0	2.0	39.0
Heat (average annual cooling degree.days) [c]	2908.5	3178.0	2293-3353	1678.0	3644.0
Heavy Rain (average annual number of days with greater than 25 millimetres of precipitation, days/year)	14.4	15.7	4.2-24.4	2.4	25.6

[a]data relate to the ILOC associated with the selected community; [b]*n*=56 [mainland communities only]; [c] Heat, cooling degree.days is calculated as the average of the annual sum of the number of degrees by which each day's mean temperature exceeds 18°C.; AUD – Australian Dollars; ILOC – Indigenous Locations

Table 2 reports the results of the two-by-two (presented highest to lowest magnitude of OR) and stratified two-by-two cross-tabulations. Relatively high population communities were more likely to have high smoking rates (OR 6.25, [95% CI 2.18-17.95], $p<0.001$) compared to communities with low population size. Stratification into high and low conditions for sociodemographic measures and geographic connectivity revealed no differences in ORs between conditions (Breslow-Day test of homogeneity p>0.05) and pooled ORs remained moderately large (ORs ranging from 5.35-6.88, *p*-values <0.01 or smaller) though with greater attenuation when accounting for region (OR 4.43 [1.47-13.92], $p<0.01$).

High education communities were more likely to have high smoking rates (OR 3.67 [1.35-10.01], $p=0.010$) than communities with low education. Stratification by geographic connectivity and employment revealed differences in ORs between the high and low conditions. Amongst communities with high geographic connectivity, high community-level education was associated with high smoking rates (OR ∞ [2.68-∞], $p=0.002$). This relationship was not statistically significant among communities with low geographic connectivity. Similarly, amongst communities with low employment, the odds of high education communities being high in smoking rate rose strongly (OR 26.67 [3.03-621.30], $p<0.001$) while there was no statistically significant association with the high employment condition. Pooled ORs for high education communities being high in smoking rate, after

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accounting for other measures, were small to moderate (OR 3.47 to 6.45, p <0.05 or smaller), except when accounting for region when the association became null. This reflects the differing directions of associations between regions though the difference between groups did not quite reach statistical significance (Breslow-Day test of homogeneity p=0.066).

Communities with frequent heavy rain were more likely to have high smoking rates (OR 3.67 [1.35-10.01], p=0.010). These odds were greater for communities with an older population (OR 18.20 [2.96-139.00], p<0.001) or low education (OR 10.50 [1.61-84.86], p=0.006) while the odds became non-significant for communities with a younger population or high education. Pooled ORs remained of small to moderate strength when accounting for household income (OR 3.51 [1.28-10.05] p=0.014), employment (OR 3.12 [1.03-9.89], p=0.043), overcrowding (OR 4.67 [1.51-16.28] p=0.007), and geographic connectivity (OR 7.45 [1.86-33.39] p=0.004). However, upon accounting for population size the odds of communities with frequent heavy rain being high in smoking rate were non-significant. When stratifying by region, no central communities were classified as having frequent heavy rain and the association between frequent heavy rain and smoking was null for the coastal communities.

Community income was associated with smoking rate (OR 2.86 [1.07-7.67], p=0.036). Stratification into high and low conditions for sociodemographic measures and geographic connectivity revealed no differences in ORs between groups, and pooled ORs were small to moderate (range 2.31-3.75) but were not statistically significant when accounting for population size, geographic connectivity, or region.

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Heat was also associated with community smoking rate (OR 2.86 [1.07-7.67], *p*=0.036) and the odds of a hotter climate community being high in smoking rose notably under the following conditions: low education (OR 13.33 [2.30-79.93], *p*=0.001); low employment (OR 12.67 [2.06-98.54] *p*=0.004), high overcrowding (OR 9.17 [1.82-50.20], *p*=0.004), high connectivity (OR ∞ [5.44-∞] *p*<0.001), and central region (OR ∞ [2.61-∞], *p*<0.01). Amongst coastal communities, high heat was associated with a lesser likelihood of being a high smoking community (OR 0.15 [0.01-1.07], *p*<0.05). Pooled ORs were small to moderate when accounting for average population age (OR 3.80 [1.31-12.04] *p*=0.013), and income (OR 2.90 [1.07-8.23] *p*=0.036) but there was no statistically significant association when accounting for population size.

Community employment was not associated with smoking rate (OR 2.25 [0.85-5.94], *p*=0.103) but under the low community education condition the odds of high employment communities being high in smoking rose substantially (OR 6.67 [1.20-39.16], *p*=0.026). Stratifying by location revealed ORs differing in directions. Amongst coastal communities, high employment rate was inversely associated with smoking rate (OR 0.32 [0.04-1.63]) while amongst central communities, high employment was directly associated with high smoking rate (OR 4.75 [0.37-53.66]). These region-specific associations, however, did not reach statistical significance. Pooled ORs accounting for other sociodemographic measures or geographic connectivity yielded small but statistically non-significant effects (ORs ranging from 2.05-2.88).

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Table 2: Associations between counts of communities with high levels of sociodemographic and climatic features, and high smoking proportion, accounting for potential confounders (n=70, 95% CIs calculated using exact methods [mid-*p*])

Exposure	OR (95% CI)	Stratifying variable	OR (95% CI) (high condition or coastal region)	OR (95% CI) (low condition or central region)	Breslow-Day test of homogeneity	Pooled OR (95% CI)
Population size	6.25 (2.18-17.95)***	Age	18.20 (2.96-139.00)***	3.30 (0.80-13.92)	0.134	6.44 (2.27-19.81)***
		Income	4.27 (0.95-19.29)	7.65 (1.56-38.03)**	0.589	5.35 (1.90-15.95)**
		Education	8.50 (1.65-47.26)*	4.57 (0.98-21.87)	0.578	5.81 (2.01-18.11)**
		Employment	4.06 (0.92-18.84)	15.00 (2.55-113.26)**	0.258	6.88 (2.36-22.19)***
		Overcrowding	5.11 (1.14-23.81)*	9.33 (1.86-50.93)**	0.584	6.41 (2.26-19.72)***
		Geographic connectivity[a]	2.92 (0.53-15.91)	16.00 (1.98-141.91)**	0.192	5.66 (1.67-20.72)**
		Region	5.66 (1.36-23.67)*	3.20 (0.41-23.38)	0.633	4.43 (1.47-13.92)**
Education	3.67 (1.35-10.01)*	Population size	4.96 (0.97-27.80)*	2.67 (0.56-13.04)	0.578	3.47 (1.18-10.79)*
		Age	3.78 (0.85 – 17.67)	4.50 (1.03-20.58)*	0.868	3.96 (1.45-11.51)**
		Income	4.81 (1.01-25.98)	4.81 (1.01-25.98)	1.000	4.59 (1.59-14.62)**
		Employment	0.68 (0.12-3.43)	26.67 (3.03-621.30)***	0.005	-
		Overcrowding	4.36 (0.73-34-91)	11.90 (1.44-284.38)*	0.485	6.45 (1.75-30.92)**
		Geographic connectivity[a]	∞ (2.68-∞)**	1.00 (0.16-5.69)	0.016	-
		Region	0.72 (0.13-3.25)	10.00 (0.56-307.27)	0.066	1.37 (0.36-4.86)
Heavy Rain	3.67 (1.35-10.01)*	Population size	4.75 (0.93-24.21)*	1.42 (0.28-6.70)	0.274	2.50 (0.85-7.44)
		Age	18.20 (2.96-139.00)***	1.29 (0.33-5.02)	0.016	-
		Income	4.82 (1.06-22.78)*	2.80 (0.65-12.18)	0.603	3.51 (1.28-10.05)*
		Education	0.57 (0.07-3.34)	10.50 (1.61-84.86)**	0.020	-
		Employment	1.28 (0.25-6.25)	9.50 (1.55-74.66)*	0.089	3.12 (1.03-9.89)*

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		Overcrowding	7.11 (1.24-58-4.83)*	3.50 (0.71-19.50)	0.553	4.67 (1.51-16.28)**
		Geographic connectivity[a]	∞ (2.68-∞)**	3.25 (0.56-18.53)	0.091	7.25 (1.86-33.39)**
		Region	0.64 (0.08-3.59)	NO DATA	NO DATA	-
Income	2.86 (1.07-7.67)*	Population size	1.78 (0.37-8.28)	3.19 (0.66-15.71)	0.589	2.31 (0.80-6.83)
		Age	2.57 (0.61-10.81)	3.10 (0.76-12.67)	0.852	2.74 (1.04-7.43)*
		Education	3.90 (0.82-21.18)	3.90 (0.82-21.18)	1.000	3.75 (1.29-11.93)*
		Employment	3.60 (0.84-15.69)	2.17 (0.52-8.97)	0.615	2.70 (1.01-7.41)*
		Overcrowding	2.60 (0.59-12.18)	4.67 (0.97-25.35)	0.589	3.33 (1.18-10.07)*
		Geographic connectivity[a]	2.75 (0.56-14.03)	3.14 (0.56-19.17)	0.909	2.81 (0.91-9.16)
		Region	2.18 (0.57-8.34)	4.00 (0.54-35.79)	0.608	2.58 (0.89-7.80)
Heat	2.86 (1.07-7.67)*	Population size	1.50 (0.32-6.94)	4.96 (0.97-27.80)*	0.277	2.59 (0.90-7.77)
		Age	7.22 (1.28-55.09)*	2.45 (0.57-11.30)	0.344	3.80 (1.31-12.04)*
		Income	2.31 (0.55-9.97)	3.94 (0.88-18.40)	0.606	2.90 (1.07-8.23)*
		Education	0.31 (0.04-1.72)	13.33 (2.30-79.93)**	0.001	-
		Employment	0.55 (0.10-2.66)	12.67 (2.06-98.54)**	0.007	-
		Overcrowding	9.17 (1.82-50.20)**	1.10 (0.27-4.43)	0.043	-
		Geographic connectivity[a]	∞ (5.44 - ∞)***	0.80 (0.15-4.25)	0.002	-
		Region	0.15 (0.01-1.07)*	∞ (2.61-∞)**	<0.001	-
Employment	2.25 (0.85-5.94)	Population size	1.63 (0.35-7.91)	6.00 (1.06-46.31)*	0.258	2.88 (0.97-9.28)
		Age	2.75 (0.65-11.89)	2.04 (0.51-8.16)	0.762	2.30 (0.88-6.19)
		Income	2.80 (0.65-12.18)	1.69 (0.40-7.03)	0.615	2.18 (0.79-5.80)
		Education	0.17 (0.01-1.35)	6.67 (1.20-39.16)*	0.008	-
		Overcrowding	2.73 (0.54-15.53)	2.73 (0.54-15.53)	1.000	2.65 (0.87-8.66)
		Geographic connectivity[a]	6.67 (0.95-56.74)*	0.79 (0.13-4.38)	0.091	2.05 (0.61-6.91)

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Region	0.32 (0.04-1.63)	4.75 (0.37-53.66)	0.040	-

OR = Odds Ratio; CI = Confidence Interval; [a] *n*=56 (mainland communities only); **p*<0.05; ***p*<0.01; ****p*<0.001

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DISCUSSION

This ecological study assessed Indigenous Australian smoking rates based on health-audit records, within predominantly Indigenous remote communities, in relation to community-level sociodemographic and climatic factors. We observed substantial variation in Indigenous smoking rates between remote communities, from 25% to 96%, a broader range than previously reported. Other studies reported rates as ranging between 59% to 80%[14] and 27% to 68%[35].

Our observed variation may be, in part, due to the large degree of sample loss resulting from audit client records missing smoking information. Wright and colleagues[35] noted particularly small sample sizes available for some Indigenous regions which may impact on the precision of estimates and artificially inflate the range of smoking rates reported. To better understand geographic variation in smoking rate, its associated factors, and change in rates over time, better quality data are needed. Regardless, our findings align with previously identified substantial geographic variation in smoking between remote Indigenous communities. This variation has important implications for intervention strategies, suggesting the need for localised approaches targeting communities according to smoking prevalence. It is, however, important to note that regional variation in smoking rates has a basis in the history of tobacco usage among Indigenous Australians, with exposure to smoked tobacco (in contrast to the custom of chewing native, nicotine-containing flora) preceding Western colonisation and occurring in littoral regions of the Northern Territory and Queensland via trade[10]. This study stratified cross-tabulations by region in order to account for this previously established variation in smoking rates.

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Our findings indicate smoking rate covaries with community-level features, notably, population size, education level, income, heat, and frequency of heavy rain. Some effects varied given other community conditions. Communities with larger populations were more likely to have high smoking rates. This may reflect greater access to cigarettes as larger communities likely have more services including retail outlets for cigarettes. Relatively high-income communities were also more likely to have high smoking rates, suggesting greater ability to afford cigarettes. This association was nullified, however, by accounting for population size, geographic connectivity, and region (itself related to both population size and geographic connectivity), given that with greater population size and geographic connectivity comes greater income earning opportunity.

Communities with a relatively high education level were more likely to have high smoking rates, particularly if the community also had low levels of employment or high geographic connectivity to other Indigenous communities. The direction of this relationship is unexpected, as individual-level education and area-level SES are both inversely related to individual smoking in the Australian population in general, and Indigenous Australians in particular[36, 37]. Greater education with lesser opportunity to apply that education through employment could, however, constitute a substantial stressor that supports smoking as a coping strategy.

It is possible that relationships observed between community smoking rate and sociodemographic features (population size and education level) reflect complex historic and ongoing social pathologies. Larger communities may consist of multiple displaced, and sometimes feuding, family groups forcefully relocated from their traditional homelands to a mission site[38]. Forced removal from traditional lands breaks the important connection that

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Indigenous Australians have to Country, a connection important to their wellbeing[39]. Moreover, forced dispossession and resettlement disrupted established traditional lifestyles and social systems whilst failing to provide an adequate alternate cultural system, resulting in reduced quality of lifestyle[40].

This disruption of traditional structures and inadequate replacement with new structures, and the lack of acceptance into the western social system could lead to anomie and collective despondency, exacerbated by cultural bereavement[41-43]. It follows that such communities would have higher smoking rates amongst other social problems. Indeed, communities with a long history of receiving forcefully displaced groups and where maximum dysfunctional cultural change has occurred are most likely to exhibit social pathologies and disorder, including violence and self-harm[40]. We speculate that the unexpected association found in this study between high education and high smoking rate, particularly in communities with low employment, exemplifies the lack of social integration and acceptance into western social structures and resultant coping behaviour.

Relatively high community-level Western-style education may correspond to a reduced reliance on traditional social structures. Yet, higher levels of education may not overcome institutional racism and enable Indigenous individuals and groups to be truly accepted within the broader, non-Indigenous societal structures and take advantage of related opportunities. This latter point would be highlighted to the individual and the community by lack of employment. Smoking rate is likely a symptom of the broader issues faced by remote Indigenous communities and attempts to reduce smoking without considering these broader issues are unlikely to be effective. Interventions targeting proximal individual-level determinants of smoking need to be supported by efforts to improve distal community-level

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and societal factors[44]. Broad ecological approaches collaborating with local Indigenous representatives to facilitate local empowerment are needed with the focus on reducing the underlying social problems and ensuing social psychological states that predispose individual smoking behaviours[26].

Regarding climatic exposures, the influence of weather on smoking has rarely been assessed, especially in Indigenous populations. We observed frequent heavy rain to be associated with high smoking rates, particularly where community residents had a higher median age. However, this relationship may be an artefact of the association between region and smoking, as frequent heavy rain occurred only in the coastal region, and coastal communities were more likely to be high in smoking rate. Heat was also associated with high smoking rates, particularly in communities with low education, low employment, high overcrowding, high geographic connectivity and central region. This supports our premise regarding heat as a stressor affecting smoking behaviour, an effect seemingly compounded by other adverse conditions. In particular, the strong positive relationship between high heat and smoking in the central region suggests the relationship between heat and smoking rate is not due to confounding by region. If stress due to ongoing, inescapable heat is indeed related to smoking, as our findings suggest, this supports the need for better quality, culturally appropriate housing to ameliorate such stress. It is possible, however, that the apparent association between heat and smoking rate is due to other factors not measured here. These associations are novel and warrant further exploration.

This study builds on and expands the literature on Australian Indigenous smoking as few studies have assessed smoking rates of remote Indigenous communities, especially in relation to community-level factors. It identifies relationships between community smoking

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rate and community features and provides a snapshot of smoking rates in remote Indigenous communities. Though specific to Australian remote Indigenous communities, these findings may be broadly generalisable to other remote-dwelling indigenous populations in high-income countries as such populations have similar characteristics and have experienced similar historical exposures. Some limitations should be noted. The cross-sectional nature of this study limits inference on the temporal direction of associations. Use of clinical audit data only captures information for individuals who accessed western health-care services. Individual-level audit record sample loss due to missing smoking information may have introduced bias to the data and be indicative of deficient health assessment and data collection procedures at the local health service level. Similarly, the use of audit records creates a selection bias (e.g., not including records with chronic diseases) hence our results likely under-estimate the prevalence of smoking. Limitations in the assessment of community-level smoking have been noted in other studies[35, 45]. Potential confounding due to residential self-selection toward smaller and potentially healthier communities could not be accounted for. Given the small sample size and the desire to assess simple associations, the common and recommended[46] epidemiological approach of dichotomising the data at the median was utilised. We acknowledge that the categorisation of these data results in some information loss. Finally, this study is ecological and associations between community smoking rates and community factors should not be inferred at the individual level. The environmental correlates of smoking rates stand to differ from the predictors of individual smoking initiation and cessation.

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CONCLUSION

This study found substantial variation in smoking rates between Australian remote Indigenous communities, and that community-level sociodemographic (relatively large population size, high education level, and high income), and climatic factors (heat and frequent heavy rain) were associated with high smoking rates. Better data are needed to more accurately assess differences in community smoking rates, the ecological factors relating to these differences, and to track change in smoking rates over time. Further assessment of climatic factors, particularly heat, in relation to smoking is warranted. Community smoking rate is likely associated with adverse historical experiences and local pathologies. Efforts to reduce smoking rates should include a focus on improving local social conditions using a collaborative approach distinct from traditional forms of health education.

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DECLARATIONS

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Competing interests

The authors declare they have no competing interests.

Ethics approval and consent to participate

Ethics approval for the present study was obtained from the Human Research Ethics Committee (HREC) of University of South Australia [HREC Reference No. 31874], Central Australian Human Research Ethics Committee [HREC-13-182], Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research [HREC 2013-2083], and Far North Queensland Human Research Ethics Committee [HREC/15/QCH/4-946]. Ethics approvals for the ABCD National Research Partnership, for the

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geographic area pertaining to this study, were obtained from HRECs in the states and territories involved: the HREC of the Northern Territory Department of Health and Menzies School of Health Research (HREC-EC00153); Central Australian HREC (HREC-12-53); Queensland HREC Darling Downs Health Services District (HREC/11/QTDD/47); and the South Australian Indigenous Health Research Ethics Committee (04-10-319). Protocols for sharing de-identified client-level data by participating health services are managed by the ABCD National Research Partnership.

Consent for publication

Not applicable as the research presented in this manuscript is not a case study, nor does it contain any individual person's data in any form.

Data availability

Research involving Aboriginal and Torres Strait Islander peoples is strictly governed in Australia by the Australian Code for the Responsible Conduct of Research and Values and Ethics: Guidelines for Ethical Conduct in Aboriginal and Torres Strait Islander Health Research. In order to comply with these national regulations, both the legal agreements governing health service participation in the ABCD National Research Partnership and the human research ethics committee approvals of multiple jurisdictions preclude the sharing of a de-identified data set without evidence that it's proposed use addresses the ethical requirements of Reciprocity, Respect, Equality, Responsibility, Survival and Protection, and Spirit and Integrity. Data requests addressing these criteria may be sent to the ABCD National Research Partnership Data Access Committee care of Professor Ross Bailie (ross.bailie@sydney.edu.au).

Authors' contributions

SC prepared the data, performed analyses, interpreted results and contributed to the drafting and revision of the manuscript. MJD performed analyses, interpreted results and contributed to the drafting and revision of the manuscript. RB conceived of and designed the study and contributed to the revision of the manuscript. MD conceived of and designed the study, interpreted results and contributed to the drafting and revision of the manuscript. All authors approved the final manuscript.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **The term 'Ecological' is included within the Abstract (Background)**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **See Abstract Section**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **See particularly Introduction para 1, 4 &5**
Objectives	3	State specific objectives, including any prespecified hypotheses **See last line of Introduction**
Methods		
Study design	4	Present key elements of study design early in the paper **Design elements are clearly outlined in the Methods section**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **See Methods Para 1, also Sampling subsection para 3**.
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants **See Sampling subsection para 1-3**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **See Measures subsection**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **See Measures Subsection**
Bias	9	Describe any efforts to address potential sources of bias **Due to the use of secondary data and simple cross-tabulations we could not adjust models or adapt the sampling frame to address potential sources of bias. We do stratify the cross-tabulations to assess confounding and discuss potential data issues within the Discussion section.**
Study size	10	Explain how the study size was arrived at **See Sampling subsection (3rd para) and Measures subsection (1st para)**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **See Data preparation and Statistical Analysis subsections**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **See Statistical Analysis subsection**
		(*b*) Describe any methods used to examine subgroups and interactions **See statistical analysis subsection – additional 2x2 cross-tabulations stratified by region, community and climatic variables**
		(*c*) Explain how missing data were addressed **Each cross-tabulation used only complete data**
		(*d*) If applicable, describe analytical methods taking account of sampling strategy

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		NA
		(*e*) Describe any sensitivity analyses **NA**
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **See Sampling subsection (3rd para) and Measures subsection (1st para), but also note the n=56 mainland communities for the Geographic Connectivity variable**
		(b) Give reasons for non-participation at each stage **NA**
		(c) Consider use of a flow diagram **NA**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **See Table 1 for demographics and potential confounders**
		(b) Indicate number of participants with missing data for each variable of interest **Numbers of audit records with missing data are clearly described. Number of communities lacking geographic connectivity information is provided in the Measures section.**
Outcome data	15*	Report numbers of outcome events or summary measures **Descriptive statistics are provided in Table 1**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **See Table 2 and results text**
		(*b*) Report category boundaries when continuous variables were categorized **See Data preparation subsection, Methods**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **NA**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **NA**
Discussion		
Key results	18	Summarise key results with reference to study objectives **See discussion Para 1 and Conclusion**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **See Discussion para 2 and 9**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **See Discussion**
Generalisability	21	Discuss the generalisability (external validity) of the study results **See Discussion**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if

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	applicable, for the original study on which the present article is based
	See Funding section

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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