Social and environmental factors in 10 Aboriginal communities in the Northern Territory: relationship to hospital admissions of children

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Objective: **To identify social and environmental differences associated with differences in admission rates of children from 10 rural Aboriginal communities in the Northern Territory.**

Design: **Between March 1986 and December 1987, records of hospital admissions of the cohort of children for 1976–1985 were examined retrospectively; cross-sectional measurements of 74 historical, social and environmental characteristics of each community were collected.**

Sample: **All 1961 children born between 1 January 1976 and 31 December 1985 and still living in the 10 communities.**

Method: **Scores on social and environmental factors for each community were generated by factor analysis. Generalised linear interactive modelling was used to investigate the association between these scores and admission rates.**

Results: **Mean admissions per child-year at risk were higher in Central Australian communities (range, 0.41–0.93) than Top End communities (0.26–0.38). Factor I accounted for 30% of the social and environmental differences between communities: communities with a high score on this factor had more houses, fewer shared toilets, more electrical appliances, better personal hygiene and a history of mission administration. High scores on this factor were predictive of lower admission rates and the factor explained most of the differences in admission rates between the Top End and Central Australian communities. Factor VI, correlated with dilapidated dwellings and fewer Aboriginal Health Workers, explained some differences in admission rates between six Top End communities.**

Conclusions: **Social and environmental factors correlated with the degree of community development are associated with the health of Aboriginal children. Improved development programs should be community-controlled and evaluated to identify the social, educational, behavioural and environmental changes that are most effective in improving health.**

(Med J Aust 1992; 156: 529-533)

The poor health of Aboriginal children has been well documented. Aboriginal infant mortality rates are falling, but are still higher than they are for other Australians;[1] patterns of mortality and morbidity for Aboriginal children are similar to those in developing countries,[2-4] with high rates of gastroenteritis, respiratory and other infections.[5,6]

The socioeconomic status of Aboriginal people in Australia is low, with high unemployment[7,8] and low educational achievement.[9,10] A large proportion of Aboriginal people have lived in substandard and overcrowded accommodation with poor water supplies and sanitary facilities;[11,12] these conditions persist in many communities. Inadequate housing and sanitary facilities have been recognised as determinants of poor health, as have unemployment and low educational achievement.[13-16] In international comparisons, better maternal education is strongly associated with better health outcomes after taking account of economic differences.[17]

Health improvements in developed and developing societies are due, in part, to historical improvements in sanitation and living standards.[18,19] Analytical studies have shown that broad criteria such as the degree of socioeconomic development are correlated with health improvements,[20,21] although more specific environmental measures are not always found to be associated with improved health. Such results may reflect methodological problems in the studies,[22] the time lags between social changes and health outcomes, and the complexity of the causal pathways involved; threshold–saturation models suggest that there is a threshold of change which must be reached before health improvements will follow, and a saturation point beyond which further improvements in social and environmental circumstances will not lead to further health improvements.[23]

In a separate paper (see page 524), we have shown that there are substantial differences in hospital admission rates for children from different Aboriginal communities in the Northern Territory.[24] In this paper we examine social and environmental differences between communities to identify the factors that are most strongly associated with high rates of hospital admission. Such information should increase the awareness of Aboriginal people, politicians, community leaders, administrators and health educators of the magnitude of the social, environmental and health differences between communities and of the strong rationale for interventions to improve the health of Aboriginal children.

Methods and results

As described previously,[24] the sample was ascertained in 10 Aboriginal communities in the Northern Territory; each community chosen had a population of more than 70 children under five years of age and required a nurse (E M) between March 1986 and December 1987. All children who were born between 1 January 1976 and 31 December 1985 and who were living in the communities were identified from records in the community health centre.

Hospital admissions for all 1961 children studied were ascertained retrospectively from health centre and hospital records for the period from birth until 31 December 1985 or five years of age, whichever was earlier. To protect privacy, communities have been identified by number; ethical procedures were as described previously.[24]

Hospital admissions

The GLIM (generalised linear interactive modelling) software package was used to calculate the number of admissions per child-year at risk (admission rate) for each community.[25,26] As we have reported for the larger data set that included outstations,[24] communities in Central Australia had higher admission rates than those in the Top End (north of latitude 15°S in the Northern Territory). There were marked differences in the admission rates between communities ($\chi^2_9 = 659.6$; $P < 0.001$).

Social and environmental data

With permission from community councils, information on living conditions and sanitary facilities was obtained from householders; tribal information was obtained from community councils; demographic, social and historical information was obtained from local organisations, government agencies, schools, community health centres, stores, councils, the Department of Aboriginal Affairs and the Australian National Archives.

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To overcome language difficulties, an Aboriginal Health Worker or a council employee assisted at all interviews; all people contacted agreed to participate. Attempts were made to visit all dwellings; when people were not at home, they were revisited whenever possible. Variables that could not be measured were graded by a single observer (E M). The few missing values were replaced by the mean value of observations from other communities.

Historical background

Traditionally, Aboriginal people did not live in fixed settlements. Before 1877, when community C9 settled around a mission, none of these communities had an established settlement. C3 was the last community to be established, in 1969. Six communities settled around missions. The number of tribal groups in each community ranged from one to 15. At the time of the study most of the communities were administered by Aboriginal community councils and all had freehold title to their land.

Location and communication

Two of the six communities in the Top End were accessible by road but only in the dry season (from about May to October); all had regular air flights. Communities in Central Australia were accessible by road and only one had regular commercial flights.

In 1986–1987 three communities in the Top End had telephones, while only one community in Central Australia was not within walking distance of a telephone. Four communities had television reception.

Type of dwelling

Between March 1986 and December 1987, 546 dwellings were visited, representing approximately 75% of the total number of dwellings in these communities. Although the majority of people lived in houses, 15% of the dwellings were humpies (Table 1). There were more humpies in Central Australian than in Top End communities. Table 2 summarises selected social and environmental conditions in the 10 communities.

TABLE 1: Type of dwelling and people per type of dwelling

Type of dwelling	Dwellings	People
House	419 (77%)	3705 (84%)
Shed	44 (8%)	269 (6%)
Humpy	83 (15%)	426 (10%)
Total	546	4400

Dwelling occupancy

Over all 10 communities, the average number of people per dwelling ranged from 5.5 to 10.1 and the average number of adults per dwelling ranged from 3.2 to 6.0. The number of bedrooms per dwelling also differed between communities, but in many houses any floor space was used for sleeping; we recorded the number of bedrooms in houses (for humpies, all "rooms" were used for sleeping), and the number of adults (Table 2) and children per dwelling.

Sanitary facilities

Most houses had inside toilets, but some had access only to communal showers and toilets (Table 2). In some communities up to 32% of showers and toilets were not in working order. Pit toilets were common in Central Australian communities but only in those communities with humpies.

Household facilities

Differences in facilities for food storage, laundry, entertainment and communication were assessed in terms of the percentage of dwellings with refrigerators, washing machines, radio, television and video recorders (Table 2).

Environmental and personal hygiene

Methods of disposal of household waste, and monthly sales of cleaning materials and disposable nappies from the community store were measured; cleaning materials were standardised as kilograms or items sold per year per child in the cohort. Personal hygiene was measured (scale, 1–2) by rating the cleanliness of clothing (Table 2); tidiness of the community was assessed in terms of the amount of visible rubbish.

Health services

Staffing levels of health centres in each community were measured in terms of the number of children in the cohort per Aboriginal Health Worker, per nurse and per doctor-visit per year. Health care was measured by observing and grading (1–3) the follow-up and supervision of treatment for children with diarrhoea and chest infection. Health centre administration was measured (scale, 1–3) by observing the medical sundries stock and turnover of medications.

Education and literacy

School attendance, as a percentage of enrolment, ranged from 41% to 80%. Sales of reading material (newspapers, magazines and comics) from community stores were measured as items sold per child per year. Two communities sold no reading material; community C9 sold the most. At eight of the 10 communities all Aboriginal Health Workers could read and write.

Intoxicating substances

The availability of alcohol and kava and whether petrol sniffing was perceived as a problem was recorded for each community. Observed use and abuse of substances was graded 1–4. Two communities used kava. In five communities health personnel and council members believed petrol sniffing was a problem. Alcohol was sold in only three communities; despite this, inebriation was observed in all but one community.

Food availability

To assess the availability of fresh food, the store in each community was visited every day during the period of data collection; the frequency of availability of fresh fruit and vegetables was graded 1–3. In only four communities could fresh food be bought every day.

Economy

For the majority of families, the main source of income was from social security benefits. However, in some communities, mining royalties (recorded yes/no) and the sale of artefacts and paintings (scale, 1–3) provided extra income.

TABLE 2: Selected social and environmental variables in ten communities

Community	No. of dwellings surveyed	Mean number per dwelling		Percentage of dwellings								
		Rooms	Adults	Houses	Humpies	Inside toilet	Communal toilet	Shower or bath	Electricity	Washing machine	Fridge	Personal hygiene
Top End												
C1	74	2.4	5.9	88%	0	74%	0	73%	73%	27%	43%	good
C2	42	2.5	6.0	93%	2%	93%	0	95%	88%	64%	57%	good
C3	35	1.7	4.6	60%	9%	57%	14%	57%	66%	29%	26%	fair
C4	51	2.6	5.8	96%	0	80%	20%	80%	96%	27%	29%	good
C5	59	2.4	4.9	88%	0	68%	3%	68%	83%	24%	51%	good
C6	26	2.8	5.1	88%	0	88%	12%	88%	100%	65%	88%	good
Central Australian												
C7	62	1.7	3.2	53%	21%	50%	50%	50%	50%	18%	32%	fair
C8	90	2.1	4.4	69%	31%	60%	13%	61%	44%	21%	23%	fair
C9	30	2.2	4.0	97%	0	83%	0	80%	83%	53%	70%	good
C10	77	1.6	3.3	57%	42%	23%	60%	38%	1%	3%	0	fair

Statistical analysis

More variables were measured than there were communities and this would have contributed to statistical "overdetermination" in any attempt to predict hospital admission rates by means of all 74 social and environmental variables. Furthermore, there was a need to summarise and give meaning to the social and environmental measurements.

Accordingly, the data matrix (74 variables by 10 communities) was analysed by principal component factor analysis, a multivariate technique which reduces the large number of variables into a smaller number of factors comprising groups of variables.[27-29] This technique adjusts for the correlation between variables, and each factor is derived so as to be as independent as possible from each of the others.

Based on the community characteristics, the analysis generated a factor score for each community. These community scores were then incorporated into a linear model, as previously fitted under GLIM,[24] to assess whether differences in admissions between communities were correlated with differences in environmental factor scores. Having identified an important factor, those variables with the heaviest loadings on the factor were identified to examine their specific impact on admission rates.

Identification of socioenvironmental factors

Principal component analysis reduced the 74 variables to nine factors, each summarising a different set of characteristics. The variables with higher loadings on a factor ($P<0.05$) are closely related to that factor (see Box). Some of the variables measured were not significantly associated with any of the nine factors; this implies that community differences for these variables were not sufficiently correlated with community differences for other variables.

The meaning to be attached to factors can be illustrated by the loading of variables on Factor I that relate to community development, most particularly housing development. The four communities with the highest scores for this factor were established as missions over 30 years ago and at least 70% of the dwellings were houses (rather than humpies or sheds) with electricity and water connected, internal toilets and showers. Some houses also had washing machines and fridges. At these communities, levels of personal hygiene were good and all Aboriginal Health Workers could read and write. Less developed communities had more humpies, each able to house fewer adults, with communal toilets and without electricity, thus resulting in lower scores on Factor I (Table 2, Box, and Figure).

Factor I was important, firstly because it explained 30% of all the variance (differences) between communities in social and environmental variables, and secondly because it could be interpreted in terms of a single dimension that could be loosely identified with "community development". None of the other factors explained as much of the overall social and environmental variance (see Box), and none could be given such a simple interpretation.

Variables with maximum loadings on factors identified by principal component factor analysis with varimax rotation[29]

	Factor I	v = 29.7%
***	Humpies as % dwellings	−0.908
***	Houses as % dwellings	0.883
**	Rooms per dwelling	0.843
**	Adults per dwelling	0.753
*	No. dwellings surveyed	−0.651
	Percentage of dwellings with:	
***	Toilet inside	0.972
***	Shower and/or bath	0.968
***	Water tap inside	0.960
**	Communal toilet	−0.787
***	Electricity	0.944
***	Video	0.871
**	Washing machine	0.842
**	Fridge	0.799
***	Personal hygiene	0.877
*	Literacy of Aboriginal Health Workers	0.721
**	Past DAA administration	−0.750
**	Past mission administration	0.750
*	Year established	0.728
*	Anglican church	0.661
*	Arid zone	−0.630
*	Road open all year	−0.630
NS	Petrol sniffing	−0.542
	Factor II	**v = 19.3%**
***	Kava drinking observed	−0.943
***	Kava availability	−0.918
***	Uniting church	−0.918
*	Children per dwelling	−0.698
*	Detergent for dishes	−0.691
*	School attendance	0.687
*	Rubbish drum outside	0.671
*	Laundry water disposal	−0.654
*	% showers working	−0.628
NS	Laundry detergent	−0.579
	Factor III	**v = 11.6%**
***	Health care	0.924
***	Mops	0.918
**	Detergent for floors	0.831
*	Art and craft	0.733
NS	% children aged 0–5 years	0.585
NS	No toilet	0.501
	Factor IV	**v = 11.2%**
**	Magazines	0.832
**	Radio	0.819
**	Newspapers	0.796
**	Nappies sold (material)	0.770
*	Lutheran church	0.662
*	Public transport	0.637
NS	Tidiness of town	−0.503
	Factor V	**v = 8.2%**
**	No. of tribal groups	−0.775
**	% of taps working	0.743
*	Coastal	−0.721
*	Drunkenness observed	0.702
*	School enrolment	0.684
NS	Alcohol limitations	0.600
NS	Alcohol availability	−0.541
NS	Sniffing observed	0.481
	Factor VI	**v = 7.4%**
**	Dwellings dilapidated	0.787
**	Comics	0.734
*	Child/AHW ratio	0.679
*	Royalties	0.637
*	Fresh food availability	0.618
NS	Baptist church	0.597
	Factor VII	**v = 5.1%**
***	Telephone in community	−0.865
***	Nurses	0.851
*	CHC administration	0.691
*	Availability of doctor	−0.628
NS	Dogs per dwelling	0.544
	Factor VIII	**v = 4.7%**
***	Disposable nappies sold	0.943
**	Pit toilet	0.755
**	Sheds	0.745
	Factor IX	**v = 2.8%**
***	Sewerage	0.910
**	Television	0.787
**	Television reception	0.736
*	Dwellings not surveyed	0.682
NS	Island	0.579
NS	Bleach	0.544

v = percentage variance in social and environmental conditions explained by the factor. NS = not significant; * = $P<0.05$, ** = $P<0.01$, *** = $P<0.001$. These significance levels (derived from normal theory assumptions) may be biased, but they indicate the relative importance of each variable for each factor.

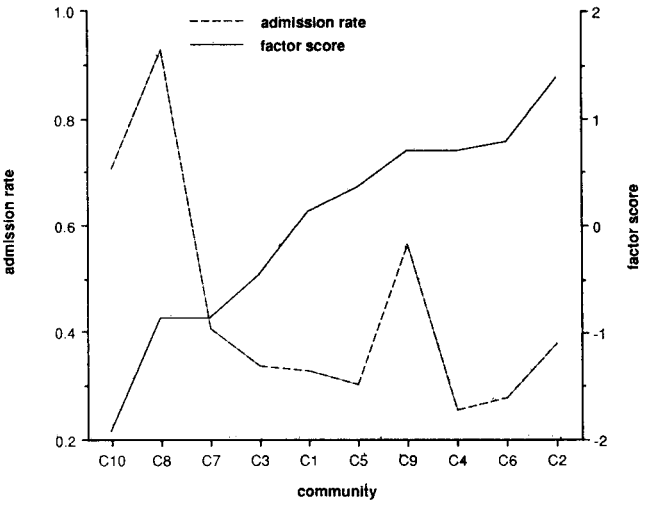

FIGURE: Mean admission rates, 1976–1985, and environmental score for Factor I (see Box) by community.

Socioenvironmental factors and hospital admission rates

Mean admission rates were higher in all four Central Australian communities (C7–C10) than

in any of the six Top End communities(C1–C6). There was greater variation in admission rates in Central Australian communities (range, 0.41–0.93 mean admissions per child-year at risk) than in Top End communities (range, 0.26–0.38) (Figure). Therefore the factor scores for each community were used to explore the relationships between social and environmental conditions and the admission rates of children.

Factors I and VI provided the best discrimination and explained up to 78% of the difference in admission rates between communities. Factor I, measuring aspects of community development, explained 43% of the deviance in admission rates due to communities (Table 3). While Factor I explained most of the differences between admission rates in the Top End and Central Australia as well as the differences between Central Australian communities, it did not explain the differences in admission rates between Top End communities (Figure), probably because there was little variation between Top End communities to be explained.

Factor VI, which included variables related to health centre staffing and empty dilapidated dwellings (see Box), explained a further 35% of the differences in admission rates between communities, and helped to explain community differences in admission rates in both the Top End and Central Australia.

The associations between admission rates and particular variables within Factors I and VI were explored further. Once the effects on admission rates of age, sex and year were removed, it could be shown that variables with the largest loading on Factor I correlated better with admission rates than variables with smaller loadings. Having removed the effects of age, sex, year and region, the proportion of dilapidated dwellings proved to have a stronger correlation with admission rate than any other variables from Factor VI.

Differences in admission rates between Top End communities were best explained by the average number of children for each Aboriginal Health Worker employed in the community (see Box).

The positive association of houses and mean number of adults per dwelling with Factor I and the negative association of this factor with admission rates suggest that Aboriginal children are less likely to be admitted to hospital if they live in an overcrowded standard house than if they live in a humpy. (The paradox in terms of the number of adults per dwelling would have been avoided if we had measured overcrowding in terms of the number of persons per unit area, rather than per dwelling.)

TABLE 3: Statistical summary relating factor scores to admission rates

Variables fitted*	Scaled deviance	Total df†	Deviance change‡	Percentage of community difference explained	Change in df	Regression coefficient§	Standard error of estimate¶
None	3578.6	878	—	—	—	—	—
Age + gender + year	1929.3	864	1649.3	—	14	—	—
+ Factor I score	1645.0	863	284.3	43.1%	1	−0.257	0.019
+ Factor VI score	1417.4	862	227.7	34.5%	1	0.231	0.014
+ Residual due to communities	1269.8	855	147.6	22.4%	7		

*The methods for model-fitting are described in the companion paper;[24] the background is described elsewhere.[26]
†The number of degrees of freedom (df) depends upon the number of informative cells in the data matrix: 5 age groups, 2 sexes, 10 years and 10 communities.
‡The deviance change in a Poisson model follows an asymptotic χ^2 distribution.
§The negative regression coefficient indicates that the admission rate decreases as the Factor I score increases; the positive coefficient for Factor VI indicates that admission rate tends to rise with an increasing factor score.
¶As these regression coefficients are so much larger than their standard errors, the coefficients are certainly of statistical significance.

Discussion

This paper has documented the poor living conditions and social circumstances in 10 Aboriginal communities in 1986 and 1987 (Tables 1, 2). Our major finding is that hospital admission rates for children over the period 1976 to 1985 were highest for those communities with poorer living conditions and less community development (Table 3, Box, and Figure).

Although many community characteristics were strongly associated with differences in admission rates between communities, inferences about the causal significance of individual variables cannot be made easily, because at least some of the associations will be indirect and non-causal.

A second limitation of the study is that data on hospitalisation covered a preceding period of 10 years, while the social and environmental data reflected mainly circumstances at the time the communities were visited; much information on social and environmental conditions in the past was either unavailable or unreliable.

A third limitation is that hospital admission rates are an indirect measure of childhood morbidity; in our previous paper we suggested that community differences in admission rates are due more to differences in morbidity than to community differences in admission policy or practice.[24]

In spite of such potential shortcomings, our study has shown that hospital admission rates for Aboriginal children in the Northern Territory are higher for communities where housing, water supplies, sanitation and electric power are less well developed or maintained, where literacy and hygiene are less, where there are more empty, dilapidated houses and more children for each Aboriginal Health Worker employed. From what is already known about the social and environmental origins of childhood morbidity,[3,21,22] it is very likely that some of these variables contribute directly to higher childhood morbidity and hospital admission rates. Nevertheless, without an intervention study to show that reductions in the prevalence of putative risk factors are followed by reductions in hospital admissions, it is impossible to formally demonstrate the causal status of any of the associated variables.

Indeed, some of the associated variables may reflect the causal importance of other variables, such as those relating to beliefs and behaviour, that were not measured directly in this study. For example, dilapidated housing, a variable loading on Factor VI (see Box), is associated with hospital admissions. In Central Australia, houses become dilapidated when left vacant after a death in the house, whereas in the Top End, ceremonial cleansing allows reoccupation of the house within a short time of the death, so that there is less dilapidation of newer dwellings. Thus dilapidation will be correlated with all consistent differences between Central Australia and Top End communities, including any consistent differences in admission rates, and it is not clear whether the latter differences are partly caused by behavioural differences correlated with dilapidation of housing, or whether the causal pathways are even more indirect.

Nevertheless, our principal finding is irrefutable, namely that childhood morbidity, as measured by high hospital admission rates, was worse in those Aboriginal communities with poorer living conditions and less community development. In one sense, this result is not surprising, as it simply restates, in the context of a comparison between communities in the Northern Territory, the well-documented association of poor health with economic and social disadvantage.[3,17,21,22]

However, our studies are encouraging, firstly because they show that the health outcomes in some Aboriginal communities can be much better than in others,[24] and secondly because it is plausible, on the basis of the associations reported here, that improvements in social, behavioural and environmental conditions in Aboriginal communities will be followed by improvements in childhood health outcomes. There is already a strong rationale for Aboriginal community development on the grounds of social equity; longitudinal evaluations of broadly-based programs of community development are now needed to identify the most effective environmental, social, behavioural and medical strategies for health improvement.

Our cross-sectional findings strongly support the rationale for accelerated social action and community development because of the improved health outcome that will almost certainly follow. As has been observed with other disadvantaged populations,[17] outcomes in Aboriginal communities will improve more rapidly when there is a broadly based social and political commitment to better education and health for all. Programs of community development and social action are likely to be most

effective when Aboriginal people have themselves acquired the knowledge[30] and are empowered to control the planning and management of changes in their own communities.[31] The social, educational and economic development of Aboriginal communities should continue until the present disparities in living standards and health outcomes between Aboriginal people and other Australians have been eliminated.

Acknowledgements

We thank the Aboriginal Health Workers, nurses, councils and residents in the communities for their support and assistance, the staff in the Department of Health and Community Services and colleagues at the School for their advice and assistance in various aspects of the work. Dr Anthony Smith provided valuable advice in the statistical analysis and Dr Tarun Weeramanthri, Dr Ivan Bastian, Judith Boswell and Sue Hutton provided helpful comments. This work was supported by the Northern Territory Government through its core grant to the Menzies School of Health Research.

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(Received 26 Mar, accepted 2 Oct 1991)