
Observations on the Relation of Environmental and Behavioral Factors to the Occurrence of Otitis Media Among Indian Children

JAMES R. SHAW, MD
N. WENDELL TODD, MD
MELVIN H. GOODWIN, Jr., PhD
CLYDE M. FELDMAN, BA

OTITIS MEDIA AND ASSOCIATED ADVERSE SEQUELAE are a leading cause of morbidity among American Indians. Rates of acute infection and hearing loss are reported to be considerably higher than among the general U.S. population. Such differences have not been explained adequately, although a variety of factors has been examined. The work reported here was undertaken in connection with a study of the epidemiology and methods for controlling otitis media among four Indian populations living on reservations in Arizona (1). In this

Dr. Shaw and Dr. Goodwin are professors and Mr. Feldman is computer programmer in the Department of Family and Community Medicine, College of Medicine, University of Arizona, Tucson. Dr. Todd is an otolaryngologist, Phoenix Indian Medical Center.

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Tearsheet requests to James R. Shaw, MD, Department of Family and Community Medicine, Arizona Health Sciences Center, Tucson, Ariz. 85724.

report, we present an evaluation of the association of some environmental and behavioral factors with the occurrence of otitis media.

Background Information

The association of high incidence and prevalence of otitis media with poor housing and sanitation has been observed in several studies. Reed and associates (2) cited, for example, reports of strong relationships between otitis media and poor living conditions and noted the same associations among the Eskimo children they studied. In subsequent work with similar populations, Reed and Dunn (3) sought, but could not demonstrate, associations between the incidence of otitis media and the size of family, sibship, crowding, welfare assistance, parental interest, and sanitary conditions. However, these authors rated the socioeconomic status of all the children they studied from "poor to miserable."

In contrast, Johonnott (4) found only 4.4 percent (6 of 136) Eskimo children in Anchorage with chronic otitis media and 18.3 percent (17 of 300) among rural Eskimo children. The most obvious differences between the two populations were factors associated with the higher standard of living in the urban environment, for example, better socioeconomic conditions, better sanitation, and greater availability of health care. Beal (5) also suggested a positive relation of improved housing, sanitation, diet, and health practices with

reduction in rates of chronic otitis media. Zonis (6), however, did not observe differences in occurrence of otitis media among Apache Indians in Arizona who lived under contrasting conditions of sanitation.

Spivey and Hirschhorn (7) compared rates of otitis media among 40 adopted reservation-born Apache children with rates among 46 non-Apache children in the adoptive home. The Apache children had significantly more episodes of otitis media, and significantly more children were affected, than the non-Apache children. The adopted Apache children experienced less otitis media than comparable reservation children, but not significantly so.

In summary, the results of the studies cited and similar observations by others have not provided tenable indications of causal relationships between environmental and behavioral factors and the occurrence of otitis media. The present activities were designed to delineate and assess opportunities for intervention to control or prevent occurrence of otitis media among Indian populations in the Southwestern United States.

Health Services for Study Populations

The populations observed in this study receive comprehensive health care from the Phoenix Area Indian Health Service of the U.S. Public Health Service. Each population has available a Service Unit that includes a general hospital of 30 or more beds staffed by qualified physicians and supporting staff. Consultation is available from the Phoenix Indian Medical Center, and specialists visit the Service Units on a regular schedule. Outlying clinics provide ambulatory medical care and preventive health services at locations generally accessible to a majority of the populations. Each Service Unit has a Field Health Office that carries out a public health program and provides followup services, as directed by the medical staff at the hospital. In addition, the tribal health departments conduct supplemental visiting programs through local community health representatives who provide transportation to health facilities and conduct health education in the homes.

Study Methods

The study included selected Indian populations living on three Arizona reservations. The study areas comprised eight Apache communities near the San Carlos Service Unit, three Navajo communities and all Hopi communities on the first three mesas near the Keams Canyon Service Unit, and three communities of the Colorado River Indian Tribes associated with the Parker Service Unit. Criteria for selecting the study sites included high rates of otitis media and interest

expressed by the local tribal authorities and health-care providers. Efforts also were made to select areas that represented a variety of climatic, physiographic, economic, and cultural factors.

Records of all births in the study populations were obtained from the respective Service Units. Efforts were made to visit the home of each infant 6 weeks after birth. In some instances, however, the home visit was delayed for several months. During the visit, selected living conditions and physical attributes of the environment were evaluated. These visits were made by indigenous technicians specially trained for the study. Data were collected on the number of persons in the household, number of sleeping rooms, type of water supply and sewage disposal facilities, type of heating and cooling systems, availability of electricity, method of feeding infants, distance to health care facility, and mother's education. (In this context, mother's education is considered an environmental factor. The mother's education may affect personal hygiene practices of family members and may reflect her ability to cope with adverse sanitary conditions in the environment.) Conditions of the household and premises were reexamined when subsequent visits were made by the otitis media technicians to follow up patients with acute otitis media. In any event, revisits were made at least once a year.

Data on the occurrence of ear disease were obtained from records at each Service Unit. Report forms for ambulatory patient care were examined each working day to identify children among the study populations for whom treatment for ear disease was sought. Records of the dates of encounters for acute suppurative otitis media (ASOM) were maintained for each patient. For the analyses, each encounter was considered a discrete episode. Encounters for persistent attacks were excluded from the analyses. A more detailed account of procedures, record systems, and data management was published earlier (1).

The criterion in this study for diagnosis of ASOM was observation of a bulging, inflamed tympanic membrane, which is usually associated with pain and fever. A perforation might be present, but usually it is too small for easy observation. Drainage also might be observed.

From mid-1974 through June 1979, environmental and behavioral data were collected during home visits to 1,428 children observed during the first year of life. Data were also obtained on all episodes of ASOM among these children for which treatment was sought at the Service Units during this period. These data were analyzed to assess the association of the environmental factors, previously mentioned, with the occur-

rence of ASOM. These analyses included (a) a comparison of the rates of ASOM and the frequency of encounters during the first year of life among each of the four populations, (b) an evaluation of the relation of rates of ASOM among infants to selected environmental factors at each location, (c) an evaluation of the relation between frequency of encounters for ASOM and the selected environmental factors, (d) a comparison of the frequency of the selected environmental factors in homes of children with contrasting rates of ASOM, and (e) a comparison of the rates of ASOM among children living in homes having each environmental factor with the rates among children living in homes without the environmental factor.

Results

Rates and frequency of encounters. The rates of encounters for ASOM ranged from 1.1 attacks per child at Parker to 2.2 at San Carlos (table 1). Similar trends were observed in the frequency of attacks at the four locations. Overall, no encounters for ASOM were recorded for 37 percent of all the children, 24 percent had only 1 encounter, 16 percent had 2, and only 24 percent had 3 or more. Children having three or more attacks constitute the high-risk group that is presumed to be more likely to experience serious ear disease in later life as a result of repeated infection.

By the chi-square test, the frequency of encounters—that is, the percentage of children with 0, 1, 2, or 3 or more attacks—differed significantly among the populations, except for the comparison between the population at Parker and the Hopis at Keams Canyon (Hopi versus Navajo, $P < .01$; Hopi versus San Carlos, $P < .001$; Navajo versus Parker, $P < .001$; Parker versus San Carlos, $P < .001$).

Relation of rates to environmental factors. The relation between rates of ASOM during the first year of life and selected environmental factors is shown in table 2. The factors listed are presumed to be associated with crowding, poor housing, adverse sanitation on premises, inadequate personal hygiene, and inconvenient access to medical services.

The trends of the data in table 2 may be illustrated by a few comparisons. For example, as shown in table 1, the lowest rates of ASOM were observed at Parker and the highest at San Carlos. The San Carlos and Hopi rates also were significantly different, as noted previously. The presence or absence of the tabulated environmental factors was not consistently associated with either high or low rates of ASOM (table 2). In general, the more favorable housing and crowding

Table 1. Rates and frequency of encounters for acute suppurative otitis media during first year of life among four Indian populations, by Service Unit

Encounters	Keams Canyon (Hopi)	Keams Canyon (Navajo)	San Carlos	Parker	Total
Total Infants	529	250	428	221	1,428
Encounters per infant ..	1.3	1.7	2.2	1.1	1.6
Percent of infants with:					
No encounter	42	31	27	48	37
1 encounter	25	25	22	26	24
2 encounters	15	20	16	13	16
3 or more encounters.	19	24	36	14	24

conditions at Parker than at San Carlos suggest a possible positive association between adequacy of housing and lower rates of ASOM. In contrast, however, the rates at San Carlos were higher than those among both the Navajos and Hopis at Keams Canyon, where housing and crowding conditions were less satisfactory.

Relation of encounter frequency to environmental factors. As indicated in the preceding analyses, the differences in rates of ASOM between the four populations could not be related to the percentage of children in the community who lived in houses having the factors considered in this study. Further analyses were made to determine whether the number of encounters experienced by children during the first year of life was related to the presence or absence of these factors in their homes. Two questions were addressed: Does the presence or absence of any factor distinguish between children who have ASOM from those who do not? Does the presence or absence of any factor distinguish between children who have 1, 2, or 3 or more encounters for ASOM? Analyses were made for each population separately and for all populations combined. When each population was considered individually, chi-square tests indicated no significant differences in occurrence or non-occurrence of ASOM, or in the frequency of encounters, among children from homes with any one factor and among children from homes without that factor. None of the factors appeared to be related to occurrence or frequency of ASOM.

Chi-square tests of combined data for all populations indicated statistically significant differences in the occurrence of ASOM in relation to two attributes—the ratio of persons to sleeping rooms ($P < .03$) and the distance from a health facility ($P < .004$). These analyses were based on the data in table 3, which show the relation between the presence or absence of the factors and the percentage of children who experienced

Table 2. Relation between rates of visits for acute suppurative otitis media during first year of life and selected environmental factors among four Indian populations, by Service Unit

<i>Environmental factor</i>	<i>Keams Canyon (Hopi)</i>	<i>Keams Canyon (Navajo)</i>	<i>San Carlos</i>	<i>Parker</i>	<i>Total</i>
Encounters per infant	1.3	1.7	2.2	1.1	1.6
	Percent of infants				
Four or more persons in household	92	91	93	81	90
Three or more persons per sleeping room ..	66	88	53	10	57
No electricity	27	91	0	0	26
No indoor plumbing	58	90	11	1	41
No central heating	69	91	15	5	47
No central cooling	80	98	22	0	53
More than 5 miles from health facility	90	56	26	55	60
Mother's education 9 years or less	5	30	14	14	13

0, 1, 2, or 3 or more encounters. For example, in respect to the "number of persons in the household," 36 percent of the children who lived in households having 4 or more members had no encounters for ASOM, and 41 percent of the children who lived in households with fewer than 4 members had no encounters for ASOM.

The relevance of the statistical indicator of significance to delineation of causal relationships is question-

able. First, none of the environmental factors were significant for an individual population. The results from analyses of the combined data may be attributed to aggregation of highly variable, inconsistent data. The significance of the crowding factor, that is, ratio of persons to sleeping rooms, was not corroborated by the analyses that are described subsequently. Second, definitive data were not available on the number of persons who actually occupied each sleeping room. It is note-

Table 3. Relation between distribution of encounters for acute suppurative otitis media during the first year of life and selected environmental factors among four Indian populations

<i>Environmental factor</i>	<i>Number of encounters</i>			
	<i>0</i>	<i>1</i>	<i>2</i>	<i>3 or more</i>
	Percent of infants			
Four or more persons in household:				
Yes	36	23	16	25
No	41	29	14	17
Three or more persons per sleeping room:				
Yes	33	23	18	26
No	39	25	13	23
Electricity:				
Yes	36	24	15	25
No	37	24	16	23
Indoor plumbing:				
Yes	37	23	15	25
No	35	25	18	22
Central heating:				
Yes	37	24	14	25
No	35	25	18	22
Central cooling:				
Yes	37	24	14	25
No	36	24	17	23
More than 5 miles from health facility:				
Yes	38	25	16	21
No	35	22	14	29
Mother's education 9 years or less:				
Yes	36	24	16	24
No	37	26	13	24

worthy that the number of persons in the household was not significantly related to the occurrence of ASOM.

More children living within 5 miles of a health facility had 3 or more encounters for ASOM (29 percent) than did children living at a greater distance (21 percent); $P < .01$. The apparent lower frequency of attacks observed among children living farther from the health facility probably reflects difficult access rather than lower rates. This factor also may account, at least in part, for the observed differences in rates between locations.

Results of additional analyses undertaken to assess the relation of the same factors to occurrence of ASOM during the second, third, and fourth years of life were essentially the same as those based on occurrence during infancy. Similar results also were obtained from separate analyses of 539 families that had only 1 child under 5 years old.

Frequency of environmental factors among groups with contrasting rates. The data in table 4 show the comparative frequency of environmental factors in homes of children with contrasting rates of ASOM. The groups compared consisted of children for whom no encounters were recorded during the first year of life and children for whom three or more encounters were recorded. The association of environmental factors is shown as the percentage of children in each group living in households with the factor listed in the stub of table 4.

A comparison of the percentages for the two groups of children, by location and environmental factors, indicates the similarity in frequency of these factors between the two groups. Results of chi-square tests on the comparative frequency of each factor for each population and for all populations collectively were consistent with those reported previously for the relation of rates to environmental factors. No statistically significant differences were apparent between the frequency of any factor for the children with no encounter and those with three or more encounters. Only the factor of distance from a health facility was found to be significant in analyses of the combined data for all populations ($P < .03$). According to this finding, children who lived more than 5 miles from a health facility appeared to have less chance of having an attack of ASOM than children nearer to the facility. However, as mentioned before, the observation probably is attributable to greater difficulty of access.

Comparison of rates in homes with and without environmental factors. Comparisons were made of rates of ASOM among children living in homes with the factors and those from homes lacking them. Data were analyzed for all children and for 341 high-risk children, that is, children who had 3 or more encounters during the first year of life. Two rates are shown in table 5 for each factor previously considered. These rates were calculated from a distribution of encounters in relation to the presence or absence of each factor. Chi-square tests were made, as in the analyses described previously, of the differences between rates of ASOM

Table 4. Comparative frequency of selected environmental factors among four groups of Indian infants with contrasting rates of encounters for acute suppurative otitis media, by Service Unit

Environmental factor	Number of encounters									
	Keams Canyon (Hopi)		Keams Canyon (Navajo)		San Carlos		Parker		Total	
	0	3 or more	0	3 or more	0	3 or more	0	3 or more	0	3 or more
Number of infants	222	98	77	61	116	152	106	30	521	341
	Percent of infants									
Four or more persons in household	90	99	91	93	95	91	80	83	89	93
Three or more persons per sleeping room	65	67	90	86	46	53	6	17	53	60
No electricity	29	30	91	87	0	1	0	0	26	24
No indoor plumbing	56	56	91	84	7	13	1	0	39	37
No central heating	66	70	91	87	12	15	5	7	45	43
No central cooling	80	80	99	97	17	26	0	0	53	52
More than 5 miles from health facility	88	92	51	51	24	27	55	40	62	51
Mother's education 9 years or less	7	4	31	31	14	14	15	10	13	13

Table 5. Comparison of rates of acute suppurative otitis media among cohorts of Indian infants in relation to presence or absence of selected environmental factors, by Service Unit

Environmental factor	Number of encounters per infant				
	Keams Canyon (Hopi)	Keams Canyon (Navajo)	San Carlos	Parker	Total
Total infants	529	250	428	221	1,428
Four or more persons in household:					
Yes	1.4	1.7	2.2	1.2	1.7
No	0.7	1.9	2.6	1.0	1.4
Three or more persons per sleeping room:					
Yes	1.3	1.7	2.0	2.3	1.7
No	1.6	2.3	2.0	1.1	1.6
Electricity:					
Yes	1.4	2.1	2.2	1.1	1.7
No	1.3	1.6	⁽¹⁾	0.0	1.5
Indoor plumbing:					
Yes	1.4	2.3	2.2	1.2	1.7
No	1.3	1.7	2.7	⁽¹⁾	1.6
Central heating:					
Yes	1.3	2.2	2.2	1.1	1.7
No	1.4	1.7	2.1	2.0	1.5
Central cooling:					
Yes	1.5	⁽¹⁾	2.2	1.4	1.7
No	1.3	1.7	2.3	0.0	1.6
More than 5 miles from health facility:					
Yes	1.4	1.7	2.2	1.0	1.5
No	1.1	1.8	2.2	1.3	1.9
Mother's education 9 years or less:					
Yes	0.9	1.6	2.2	1.1	1.6
No	1.4	1.8	2.2	1.2	1.6

¹ Fewer than 8 Infants.

among children from homes with the factor present and children from homes lacking the factor.

Statistically significant differences were apparent in three instances. First, among the Hopi population, children from homes with four or more persons apparently had higher ASOM rates than did children from homes with fewer persons. This trend, however, was not consistent among the other populations. Second, children at Parker from homes where the ratio of persons to sleeping rooms was three or more had higher rates than did children from homes that were less crowded ($P < .01$). This relationship was not apparent at the other locations. The third statistical indication of difference in rates was reflected by the aggregated data for all populations. Children who lived more than 5 miles from a health facility apparently experienced significantly lower rates of ASOM than did children who lived at a greater distance ($P < .001$). As suggested before, this finding probably is due to access rather than to real differences in rates of ASOM.

Similar data for the 341 high-risk children are shown in table 6. A statistically significant difference was

apparent in only one instance. Among the Hopi population, children from homes where the ratio of persons to sleeping rooms was three or more apparently had lower rates of ASOM than did children from homes with fewer persons per sleeping room; the rates were 3.9 and 5.2 encounters per person respectively ($P < .05$). This observation is inconsistent with results previously described and does not appear to be epidemiologically relevant.

Method of feeding. Data on method of feeding were collected for 1,349 infants (table 7). Of these, only 6 percent were breast fed, 85 percent were bottle fed, and 9 percent were breast and bottle fed. The rate of ASOM was lower among infants who were both breast and bottle fed than among infants who were only bottle or breast fed. The difference was not statistically significant. However, the number of infants who were not bottle fed was too small for tenable analyses.

Discussion

Although several studies have addressed the issue, the causal association between environmental and behavioral factors with otitis media is not clear. Manning

Table 6. Comparison of rates of acute suppurative otitis media among high-risk infants in relation to presence or absence of selected environmental factors, by Service Unit

Environmental factor	Number of encounters per Infant				
	Keams Canyon (Hopi)	Keams Canyon (Navajo)	San Carlos	Parker	Total
Total infants	98	61	152	30	341
Encounters per infant	4.3	4.4	4.8	4.7	4.6
Four or more persons in household:					
Yes	4.3	4.2	4.7	4.6	4.5
No	(1)	(1)	4.7	(1)	5.0
Three or more persons per sleeping room:					
Yes	3.9	4.2	4.4	(1)	4.2
No	5.2	5.4	4.6	4.4	4.7
Electricity:					
Yes	4.4	4.9	4.8	4.7	4.7
No	4.1	4.2	(1)	0.0	4.2
Indoor plumbing:					
Yes	4.5	4.4	4.7	4.7	4.7
No	4.2	4.4	5.0	0.0	4.4
Central heating:					
Yes	4.7	4.9	4.9	4.4	4.8
No	4.2	4.3	4.1	(1)	4.3
Central cooling:					
Yes	5.1	(1)	4.9	4.7	4.9
No	4.1	4.4	4.2	0.0	4.2
More than 5 miles from health facility:					
Yes	4.3	4.3	4.4	4.3	4.3
No	4.3	4.5	4.9	4.9	4.8
Mother's education 9 years or less:					
Yes	(1)	4.4	4.9	(1)	4.6
No	4.4	4.8	4.7	4.7	4.6

¹ Fewer than 8 Infants.

Table 7. Method of feeding and rate of encounters for acute suppurative otitis media among 1,349 infants

Method of feeding	Infants		Number of encounters per Infant
	Number	Percent	
Breast	84	6.2	1.58
Bottle	1,141	84.6	1.72
Breast and bottle	124	9.2	1.31

and co-workers (8) point out that the incidence of otitis media varies widely between populations in different environments. High rates have been observed among Alaskan Eskimo children, the Maori of New Zealand, aborigines of Australia, and American Indians. In contrast, otitis media was uncommon in East Africa—even among malnourished infants with infections such as measles, pneumonia, and tuberculosis. Schaefer (9) reported a higher incidence of healed and persistent otorrhea among Eskimos in the Canadian Arctic who lived in the larger settlements than among similar populations living in smaller communities and following more traditional ways. Increases in incidence

of chronic otitis media were observed despite vast improvements in housing, hygiene conditions, and medical care. These observations discount the alleged significance of harsh climate leading to more upper respiratory disease, primitive and crowded housing, poor sanitary conditions, lack of personal hygiene, and access to medical care as causes of high incidence of chronic otitis media. As indicated earlier, similar results were reported by Reed and Dunn (3).

Results from the present longitudinal study did not indicate that any environmental or behavioral factor observed was consistently or strongly associated with either the incidence of ASOM or the frequency of attacks. No consistent, epidemiologically relevant differences were apparent in the frequency of adverse environmental conditions in homes of infants with contrasting rates of ASOM. Neither overall rates of ASOM nor high rates of ASOM, that is, three or more encounters during the first year of life, were associated with either the presence or the absence of adverse environmental conditions.

The contrasting rates of occurrence among children living under apparently similar environmental condi-

tions suggest that factors, as yet unidentified, characterize those at high risk of repeated infections. Among the possible determinants to be evaluated are morphological and racial factors. Klein (10) cited studies by Doyle of the skulls of American blacks, whites, and Indians. Among these three groups, significant differences were seen in the length, width, and angle of the bony eustachian tube. These differences suggest the possible association of an anatomical factor with susceptibility to otitis media, a possibility that is supported by the observations of Spivey and Hirschhorn (7) cited earlier. Familial occurrence of high rates of ASOM was noted in the present study, even among relatives living in separate households, but data were inadequate for tenable quantitative evaluation. Observations that were largely subjective suggested that "mother efficiency" and parental neglect may influence the occurrence and persistence of ASOM. These factors will be the subjects of further investigations.

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SYNOPSIS

SHAW, JAMES R. (College of Medicine, University of Arizona), TODD, N. WENDELL, GOODWIN, MELVIN H., Jr., and FELDMAN, CLYDE M.: *Observations on the relation of environmental and behavioral factors to occurrence of otitis media among Indian children. Public Health Reports, Vol. 96, July-August 1981, pp. 342-349.*

Studies were conducted to assess the relation of environmental and behavioral factors to occurrence of acute suppurative otitis media (ASOM) among four populations of Indian children in Arizona. Episodes of ASOM were recorded for 1,428 children observed during the first year of life. Data obtained on the households and premises of these children included number of persons

in the household, number of sleeping rooms, type of water supply and sewage disposal, type of heating and cooling, availability of electricity, method of infant feeding, distance to a health facility, and mother's education.

The rates of ASOM for the four populations ranged from 1.1 to 2.2 attacks per child and differed significantly from each other, with one exception. The differences between populations apparently were not related to any of the factors evaluated. Additional analyses to evaluate the association of each factor with occurrence of ASOM included (a) a comparison of rates among children living in homes having each factor with rates among children living in homes lacking the factor, (b) a comparison of the frequency of each

factor in homes of children who had no recorded attacks of ASOM with the frequency in homes of children who had three or more attacks (high-risk children), and (c) an evaluation of the relation between frequency of encounters for ASOM and the environmental factors.

Results did not indicate that any environmental or behavioral factor observed was consistently or strongly associated with either the incidence of ASOM or the frequency of attacks. Similarly, no differences were apparent in the frequency of adverse environmental conditions in homes of infants with contrasting rates of ASOM. Rates of ASOM during the first year of life were not associated with either the presence or the absence of adverse environmental conditions.