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Changing Patterns of Disease among South American Indians

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ABSTRACT. After an evaluation of the problems faced by South American Indians as they go through the process of acculturation, brief reviews were made of (a) The epidemiology of tuberculosis; (b) The prevalence of pyoderma and associated pathogens; (c) HLA distribution; and (d) Catecholamine excretion rates among Brazilian Indians. The problems and prospects of such investigations were discussed. An appendix, at the end, furnishes a list of other medical studies performed among South American Indians.

THE ROAD TO ACCULTURATION

The course of events that takes place in a South American Indian tribe before and after contact with non-Indians is briefly outlined in Table 1. Before contact they lived in small, isolated nomadic groups, in an intimate relationship with their environment, relying in a subsistence system based on hunting and gathering with simple agriculture. Fertility and mortality were moderate, population density low, but population stability high. The types of houses in which they lived were similar, and hygiene practices common. The degree of physical activity was high, with close contacts among individuals in work and play. The diet was diversified and, in terms of disease, epidemics, intestinal parasytic infections, chronic and degenerative illnesses, exposure to toxic substances and introduction of new pathologies rare. As a result, they would live in a stable ecological and cultural setting.

This way of life changes dramatically after contact with non--Indians. There is a shift of emphasis on elements of the subsistence system, agriculture becoming the dominant activity. Food becomes less varied, with dependence on a major, single crop. Concomitantly, there is aggregation in larger, less isolated, sedentary population units. The lack of adequate sanitation makes individuals from these communities especially vulnerable to sudden, devastating epidemics. Intestinal parasytic infections become universal, exposure to toxic substances increases, and new diseases may occur due to contact with foreigners. Mean ages would increase (since high mortality is coupled with high fertility), and chronic diseases would become more prevalent. There is generally a disruption both in their physical and cultural environment.

As a result of these events, there is usually a deterioration of health conditions; therefore, these groups would initially suffer with the contact, recovery being gradual, as they start receiving the benefits of our technological advance.

MEDICAL STUDIES IN SOUTH AMERICAN INDIANS

This situation can be utilized as a tool to answer questions in epidemiology, relating them to genetic and evolutionary aspects of these populations and of mankind in general. The phylosophy of these investigations, as well as some selected results, can be found in Neel and Salzano (1964), in the proceedings of two symposia held afterwards (PAHO, 1968; Ciba Foundation, 1977), and in Garruto (1981). But the number of medical studies performed among South American Indians is now very large. Appendix 1 gives a non-exhaustive list. The studies start chronologically with Ranke (1898) and continue up to the present. In what follows I will describe some of the studies in which I have been involved, to exemplify some of the possible approaches.

TUBERCULOSIS IN BRAZILIAN INDIANS

During the fifties and sixties N. Nutels and coworkers had systematically surveyed many Brazilian Indian populations looking for infections by the tubercle bacillus, that was probable absent in the New World before Columbus. A summary of the tuberculin tests and X-ray investigations conducted among 16 tribes is presented in Table 2. At the time there were still no reactors in many groups, but the situation was changing rapidly. The problem was particularly serious among the Suiá, Txukahamae and Carajá (the high figure observed among the latter must include many non-specific reactions, since it was obtained with a non-standardized solution of tuberculin; but at least a fraction of them should be "real" reactors). The Iawalapti who in 1960 did not have any reactors showed 5 of 37 in 1966.

Nutels (1968) stated that he was surprised at both the clinico--radiological and epidemiological aspects of tuberculosis in "virgin" populations like the Suiá and Txukahamae. He would have expected different patterns, such as the so-called infant type in adults and the rapidly evolving acute and miliary forms, similar to those found among the Senegalese soldiers taken to France during the First World War. Instead, he found a disease that in its clinical, radiological, and even epidemiological aspects, could be equated with that of persons with a long experience with the bacillus. The occurrence of previous epidemics among these Indians seems unlikely, due to their isolation; another possibility is that the microorganism responsible for the disease among them is less virulent than that which occurs among whites. In any case, this situation is appropriate for planned and controlled research on the response of isolated, previously unexposed populations to the introduction of a new infectious agent.

PYODERMA AND ASSOCIATED PATHOGENS AMONG AMAZONIAN INDIANS

Pyoderma is one of the most common skin diseases among children in the tropics, However, prevalence rates from community-based surveys, as well as bacteriological studies from the material obtained from the lesions, have seldom been reported from remote populations. Such a study was performed by Lawrence et al. (1979), and some of the findings are summarized in Tables 3-5. The unadjusted prevalence rates for the four villages surveyed ranged from 7 to 20% (Table 3). The age-adjusted rates, however, did not show significant differences. Children less than 5 years old generally had the greatest frequency of lesions (31%). Prevalence at any age was not affected by sex.

From 29 of the 87 persons with pyoderma lesions observed in the indicated villages, as well as from 10 others living in communities not surveyed systematically, swabs were taken for bacteriological studies. At least one pathogenic bacterium was resovered from 37 of the 39 persons' cultures, and the results are shown in Table 4. All positive cultures contained *Streptococcus pyogenes*, and this microorganism was the only pathogen recovered from cultures from 17 (44%) of the 39 individuals tested. All were Lancefield group A. Multiple isolates were recovered from cultures from 20 other subjects (51%) in which *S. pyogenes* was found with *Corynebacterium diphtheriae*, *Staphylococcus aureus* or both. Group G streptococci were isolated once from lesions culture-positive for *S. pyogenes* and *C. diphtheriae*, and twice from lesions culture-positive for *S. pyogenes*, *C. diphtheriae*, and *S. aureus*.

While the primary role of the beta-hemolytic streptococcus in causing clinical pyoderma seems well established, additional interest in lesion-associated streptococcal strains derives from the fact that glomerulonephritis can be a fatal non-suppurative complication of pyoderma. Furthermore, it has also been suggested that infection of pyoderma lesions with *C. diphtheriae* influences the epidemiology of diphtheria.

The 14 pyoderma-associated *S. aureus* isolates were tested against standard concentration disks containing different antibiotics and sulfa compounds and the results are presented in Table 5. The most interesting result is the presence of resistance to penicillin, erythromycin and tetracycline. Only 3 of the 14 isolates were simultaneously sensitive to all 3 antibiotics.

People in the villages reported here have had at least some exposure to pharmaceutical penicillin, but it is doubtful whether eventual treatment programs might have induced the changes in antibiotic susceptibility of the species of interest here. There is a possibility that natural environmental antibiotic substances might have influenced the patterns observed.

HLA DISTRIBUTION AND BALANCING SELECTION

In what way genetics can contribute to the interpretation of the epidemiology of disease in these Indians? Data on the human histocompatibility sistem may be instructive in this regard. As is shown in Table 6, Black and Salzano (1981) found significantly less HLA haplotype homozygotes (45) than those expected (73) in a total of 459 individuals from eight Amazonian Indian tribes. These results were considered with some diffidence until we discovered a previous paper describing similar findings among Saharan Touaregs (Degos et al., 1974). New, additional evidence for the action of some form of selection favoring the heterozygotes for such haplotypes has now been obtained by Hedrick and Thomson (1983). They examined data from the A and B loci for 22 populations, which were compared with the expectations of the neutrality theory (for a review see Ewens, 1977). In all cases the observed homozygosity was less than the expected homozygosity assuming neutrality for a given number of alleles and sample size. In addition, the number of alleles represented only once in the sample and the frequency of the most common allele were lower than those expected with neutrality.

Several explanations can be considered for these findings, and they have been carefully examined by Hedrick and Thomson (1983). They concluded that only symmetrical balancing selection appears to be consistent with these data. A plausible mechanism for such type of selection would be a better ability of heterozygotes

METABOLIC DIFFERENCES

General metabolic regulation is so essencial to man that relatively large interpopulation variation in rates are unexpected. However, genetic differences, combined with the varied way in which individuals had grown and lived as adults may condition variability. The question as why, unlike the situation in civilized man, the mean blood pressure does not rise with age in several Brazilian Indian tribes has been investigated by Oliver et al. (1975) among the Yanomama, who until recently had a "no-salt" culture. They determined Na^+, K^+, Cl^- levels, renin activity and aldosterone excretion. No large differences were observed between the Amerindians and whites submitted to low-salt diets. However, the interpretation of the results is complicated by the high potassium intakes of the Yanomama. J.P.B. Vieira Fº is also performing a series of hormone studies among Brazilian Indians (see the bibliography in the Appendix), but the relative roles of specific genetic factors and the environment in the determination such levels is far from being elucidated.

I have recently participated in an investigation of the relationship of catecholamine excretion rates with lifestyles and environmental influences, and the results obtained are shown in Table 7. A comparison was made between the mean excretion rates of adrenaline and noradrenaline of the Pacaás Novos, a recently acculturated Indian tribe that lives near the Brazilian-Bolivian border, with those of two African and one European population. The noradrenaline averages are not very informative, but for adrenaline the traditional groups showed higher means than the Englishmen. These could have occurred due to several causes, but the idea that "primitive people" are happy, unstressed persons may have to be reexamined considering these results (in Oxford, high adrenaline outputs are associated, among other factors, with frustration and general dissatisfaction with life; see Harrison et al., 1981; Reynolds et al., 1981).

PROBLEMS AND PROSPECTS

The studies reviewed here disclosed a series of interesting facts, but did not shed much light on the ways hereditary factors interact with the physical and cultural environment to compound the reaction norm of a certain individual to a pathogenic organism or substance. Table 8 focuses on four points: sampling and analytical strategies, study feasibility and definition of problems, when considering questions of health and disease among South American Indians.

In relation to sampling, the general small sizes of these populations are a problem; this can be partially overcome by the pooling of data from several tribes, when this is feasible. On the other hand, these small sizes make studies of whole communities (or of large parts of it)possible. The problem that remains is the difficulty of unbiased longitudinal investigations, since the sheer presence of the researcher or his (her) group may alter local customs.

As for study feasibility, it is obvious that due to geographic remoteness these groups are more difficult to study than others, of city dwellers. In addition, at least in Brazil, special permission is necessary to reach the tribes; language barriers and the absence of written records are other problems, but cooperativeness of the subjects is in general good.

In the question of definition of problems, populations showing special foci of specific diseases with high prevalences (while in other places these diseases are rare) merit special attention. Generally, however, differential susceptibility to diseases (especially the infectious ones) involves many factors, that should be duly considered. Some analytical strategies, however, seem promising. Among them I would mention correlations between antibody levels and one or a group of genetic markers, as well as the dissection of the region responsible for the immune process, by the modern techniques of DNA analysis. The possibility of finding differences in remote isolates, as compared to populations from industrialized cities (or racial dissimilarities) should be undoubtedly considered.

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TABLE 1. *Consequences of the acculturation process*

Characteristic	Degree of contact with non-Indians	
	Unacculturated	Acculturated
Population size	Small	Larger
Group mobility	High	Low
Isolation	High	Lower
Fertility	Moderate	High
Mortality	Moderate	High
Population density	Low	Higher
Population stability	High	Low
Housing	More similar	Less similar
Hygiene practices	More common	Less common
Physical activity	High	Lower
Physical proximity in work and play	High	Lower
Diet	More diversified	Less diversified
Epidemics	Less common	More common
Intestinal parasytic infections	Less common	More common
Chronic and degenerative diseases	Less common	More common
Exposure to toxic substances	Low	Higher
Introduction of new diseases	Uncommon	Common
Ecosystem stability	High	Low
Cultural system	Stable	Unstable

TABLE 2. *Tuberculin tests and X-ray surveys conducted among 16 Brazilian Indian tribes*

Tribe	Year of examination	No indiv. examined	% with strong reactions	% with abnormal lung shadows
Carajá	1952	240	71	3
Gorotire	1957	100	nt	4
Seven Xingu tribes	1960	209	0	nt
Same	1966	370	0	nt
Kajabi	1960	63	3	nt
	1966	134	1	nt
Mehinaco	1960	38	5	nt
	1966	34	9	nt
Suiá	1960	42	17	nt
	1966	71	20	nt
Iawalapti	1960	37	0	nt
	1966	37	14	nt
Xavante	1964	84	0	nt
Yanomama	1967	88	0	nt
Txukahamae	1966	114	23	7

nt: not tested

Source: Nutels et al. (1967)

TABLE 3. *Prevalence of pyoderma and bacteriological recovery of pathogens from Amazonian Indians*

Tribe and population	Number studied	% with pyoderma	No of patients from whom	
			Cultures were taken	A pathogen was isolated
Ticuna				
Umariaçu	389	12	4	4
Vendaval	221	7	12	11
Kashinawa				
Cana Brava	41	20	2	2
Kanamari				
Três Unidos	124	12	11	10

Source: Lawrence et al. (1979).

TABLE 4. *Pathogenic organisms isolated from Amazonian Indians*

Organisms isolated	Number of patients	% from total
None	2	5
Streptococcus pyogenes	17	44
S. pyogenes[1] + *Corynebacterium diphtheriae*	6	15
S. pyogenes + *Staphylococcus aureus*	4	10
S. pyogenes[2] + *S. aureus* + *C. diphtheriae*	10	26
Total	39	100

[1] Cultures of 1 of the 6 patients contained Lancefield group G streptococcus as a third pathogenic species.

[2] Cultures of 2 of the 10 patients contained Lancefield group G streptococcus as a fourth pathogenic species.

Source: Lawrence et al. (1979).

TABLE 5. *Antibiotic resistance patterns of Staphylococcus aureus isolated from Amazonian Indians*

Antibiotic tested			Number of isolates
Penicillin	Erythromycin	Tetracycline	
Sensitive	Sensitive	Sensitive	3
Sensitive	Sensitive	Resistant	1
Sensitive	Resistant	Sensitive	1
Resistant	Sensitive	Sensitive	7
Resistant	Sensitive	Resistant	1
Resistant	Resistant	Sensitive	1
Total			14
% resistant	% resistant	% resistant	
9/14 = 64	2/14 = 14	2/14 = 14	

All isolates were sensitive to 6 other antibiotics and 2 sulfa compounds.

Source: Lawrence et al. (1979).

TABLE 6. *Expected and observed number of homozygotes in the HLA system in eight tribes of Brazilian Indians*

Population	Number studied	Number of different haplotypes found	Expected number of homozygotes	Observed number of homozygotes
Tiriyo	98	18	11	6
Kaxuyana	14	13	2	1
Molokopote	16	6	4	0
Waiãpi	117	21	13	4
Parakanã Novo	31	8	9	6
Parakanã Velho	67	7	19	15
Xikrin	55	14	8	7
Gorotire	30	17	4	2
Mekranoti	31	11	4	4
All	459	38	73	45

Source: Black and Salzano (1981).

TABLE 7. *Catecholamine excretion rates in four population groups*

Population	No. indiv. studied	Noradrenaline*		Adrenaline*	
		Mean	SE	Mean	SE
Englishmen	41	36.5	2.5	9.7	0.8
Maasai	16	44.9	4.7	12.1	1.8
Mossi	11	27.7	4.1	14.7	3.6
Pacaãs Novos	38	37.1	2.0	14.3	1.3

*ng/mg creatinine.

Source: Jenner et al. (1982).

TABLE 8. *Problems and prospects for the study of health and disease among South American Indians*

Sampling strategies			
	Random samples		
	Whole communities	Cross sectional	
		Longitudinal	
	Pooling of data from several tribes		
Study feasibility			
	Bureaucratic requirements		
	Geographic remoteness		
	Language barriers		
	Cooperativeness		
	Absence of written records		
Definition of problems			
	Special foci		
	Differential susceptibility to disease		
		Effects of	Physical environment
			Population structure
			Culture
			Genetic factors
			Physiological factors
Analytical strategies			
	Correlation between	Antibody levels	
		Genetic markers (isolated or in groups)	
	Genetic dissection of the region responsible for the immune process		

APPENDIX

MEDICAL STUDIES PERFORMED IN SOUTH AMERICAN INDIANS*

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