

THE MULTINATIONAL ANDEAN GENETIC AND HEALTH PROGRAM: II. DISEASE AND DISABILITY AMONG THE AYMARA^{1,2,3}

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The subject of altitude-related disease and disability in high Andes towns and villages has interested the medical community for many years; but aside from information on risks associated with particular age or occupational groups, data on this subject has been rather limited. To help fill the gap, a number of academic and government institutions in Bolivia, Chile, Ecuador, Peru, and the United States have been collaborating on a broad research effort known as the Multinational Andean Genetic and Health Program. This article reports results of that program stemming from medical examination of 2,096 highland and coastal residents of the Chilean Department of Arica.

Introduction

Andean men and women are generally presumed to have adapted effectively to the lessened oxygen, rigorous temperatures, and low humidity which go with life in the highlands where they reside (1,2,3). However, some of their adaptations, which may enhance oxygen transport and utilization, may also have deleterious effects in the long run.

Thus, for example, increased hematopoiesis can lead to a higher frequency of

gall bladder and liver disease, and to an elevated serum uric acid level stemming from increased red cell destruction (4,5). Elevated serum uric acid, in turn, appears to be a coronary risk factor in some populations, although admittedly not a certain one (6,7,8,9); but see also, for example, Ciswicka-Sznajderman, et al. (10) or Allard and Goulet (11). Also, elevated hemoglobin and hematocrit, both characteristic of high-altitude dwellers, have been shown to be associated with an increased risk of coronary heart disease in Framingham, Massachusetts (12), an association confirmed by Heyden and colleagues (13) among white residents of Evans County, Georgia.

In addition, polycythemia is known to predispose to thrombus formation (14), and ample physiological evidence exists to suggest that increased blood viscosity, as measured by hematocrit levels, should increase the risk of coronary heart disease.

A high incidence of patent ductus arteriosus has also been observed at high altitude. In 1962 Marticorena, et al. (15) reported an incidence of 0.74 per cent among children living at 14,200 feet in Cerro de Pasco, Peru. The incidence at sea level in Lima, Peru, has been reported as 0.05 per cent (16). It is probable that chronic hypoxia and pulmonary hyperten-

¹Also appearing in Spanish in the *Boletín de la Oficina Sanitaria Panamericana*, 1979.

²Part I of this series, by W. J. Schull and F. Rothhammer, entitled "A Multinational Andean Genetic and Health Program: Rationale and Design of a Study of Adaptation to the Hypoxia of Altitude," appeared in: J. S. Weiner (Ed.), *Genetic and Nongenetic Components in Physiological Variability*, Vol. 18. Society for the Study of Human Biology, London, 1977, pp. 139-169.

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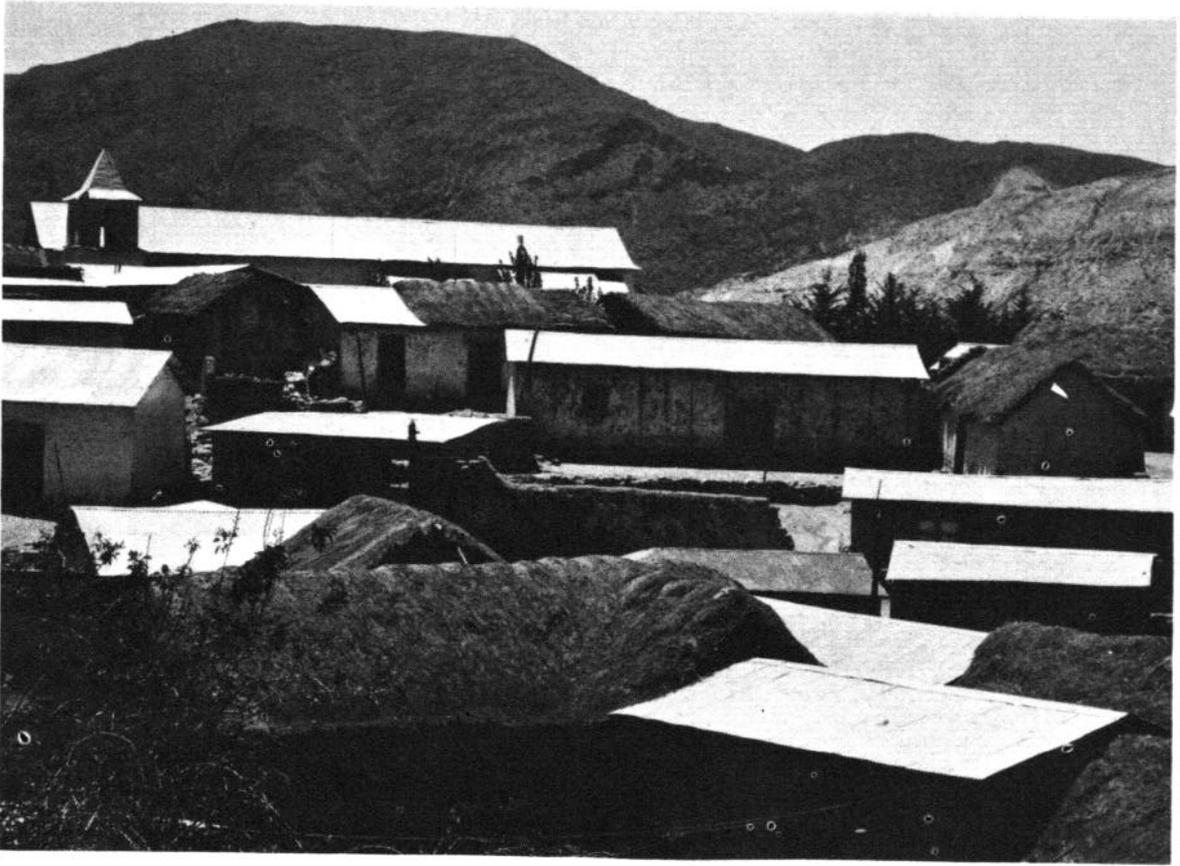
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The Chilean *sierra* town of Socoroma (above), one of those studied, and surrounding countryside (below). The altitude of both is around 10,000 feet (photo: Betsy Siegel, University of Texas).



sion are at least partly responsible for this patency at high altitude.

Pulmonary edema is also known to be a hazard for the high-altitude dweller upon his or her return to altitude after a stay at sea level (17), and the presently inexplicable, seemingly acute loss of adaptation known as Monge's disease, which appears to threaten all indigenous inhabitants, must add to the hazards of highland life (2).

Similarly, pneumoconiosis, the scourge of the miner, is a disease known to cause respiratory insufficiency at sea level, and its occurrence among miners at the higher altitudes would seem especially threatening. However, the functional effects of this disorder appear to be different at high altitudes than at sea level. Hurtado (18, see also Cosio (19)) reports no reduction in residual air among high-altitude miners with this disease (there is, of course, a reduction in vital capacity); this contrasts with the diminution seen at sea level. He believes a reduction in residual air would be incompatible with life at high altitude. Simple comparisons based solely upon altitude differences are hazardous, however, for it is now recognized that the impact of pneumoconiosis upon the miner depends on the nature of the dust which he inhales (20,21). Indeed, the risk of pneumoconiosis itself appears to be related to smoking as well as to other extraneous factors which may condition the symptomatology of the disease as well as its incidence and prevalence (20,22).

As our brief observations will indicate, most of what is known about high-altitude disease and disability involves risks associated with special occupations or age groups, and there is a paucity of information on disease and disability in the typical highland Aymara or Quechua village or town.

Some data are available, of course, from cities such as La Paz, Cuzco, and Arequipa, but these are generally based upon hospital admissions, an uncertain guide in com-

munities where the vast majority of people have limited access to such medical attention. These observations, often merely clinical impressions, appear nonetheless to confirm higher morbidity and mortality from respiratory, gall bladder, and liver disease. Hellriegel (23), for example, has reported relatively high rates of lung cancer among inhabitants of a mining and industrial community in the central Andes of Peru; it is unclear, however, whether the increased frequency in this instance stems from altitude, exposure to industrial pollutants, or both.

Numerous clinical impressions of differences in the frequency of specific diseases at high and low altitudes have been reported (24,25); however, most are nothing more than unquantifiable opinions. It is somewhat more difficult to discount differences in age-specific mortality rates for such specific disorders as arteriosclerotic heart disease; however, even here there are non-trivial sources of bias which can color conclusions (in the case of mortality from heart disease see (26) as an example). Infectious disorders such as tuberculosis might seem to present a simpler problem, but this is not so (27), since the factors that affect the dissemination of disease can and do differ widely from altitude to altitude, but not necessarily as a direct and proportionate consequence of changes in oxygen tension.

We are aware of few systematic, community-wide studies that would help provide a clearer perspective on acute and chronic disease and disability among people indigenous to altitudes of 4,000 meters or more. Morococha (4,500 meters) in Peru has been studied by the staff of San Marcos University's Institute of Andean Biology and by members of Cayetano Heredia University. Buck and colleagues (28) have studied four Peruvian villages, of which one (Pusi, population 500) was at an elevation of 3,500 meters. Finally, Omran, McEwen, and Zaki (29) have reported findings derived from study of eight Bolivian com-

munities, three of which (Compi, San Miguel, and Penas) are in the *altiplano*.

The Present Study

Northern Chile, specifically the Department of Arica, is divisible into three sharply distinct ecological niches—the *costa* (sea level to a few hundred meters), the *sierra* (generally 3,000 to 3,500 meters), and the *altiplano* (above 4,000 meters). The three differ strikingly with regard to air pressure, temperature, and humidity; and these physical parameters, in turn, are associated with biotic constraints that impose differing biological burdens and limit life-styles. In 1972 a multidisciplinary investigation, termed the Multinational Andean Genetic and Health Program, was initiated in Arica. Thus far it has involved members of the University of San Andrés (Bolivia), the University of Chile (Santiago), the Northern University (Arica, Chile), the Chilean National Health Service, the Central University of Ecuador, the University of San Marcos (Peru), the Mayo Clinic (United States), the University of Michigan, and the University of Texas Health Science Center at Houston. While this program has many objectives (31), the one that pertains here is evaluation of the burden of disease and disability among the indigenous Aymara people—both those living in the interior of Arica and their kinfolk along the coast.

Examinations Performed

In 1973 and 1974, during the months of October and November,¹⁰ 2,096 individuals ranging in age from 15 days to over 90 years, drawn from 12 coastal, sierran or *altiplano* communities or locales, were given a thorough medical examination. Selection of subjects was based on willing-

ness to participate. An open invitation was made to all village residents during town meetings, at which time a movie explaining the examination was shown. The medical examination entailed the following: (1) a physical examination and procurement of a complete medical history; (2) oral and dental examinations; (3) anthropometric measurements; (4) pulmonary function tests; (5) a resting electrocardiogram; (6) an ophthalmoscopic examination of visual acuity, color vision, tensiometry, and other variables; (7) a detailed appraisal of cardiovascular status; (8) simple performance tests, such as tapping; (9) procurement of nutritional, reproductive, and residential histories; and (10) the taking of an ACD preserved specimen of venous blood, a perchloric or trichloroacetic acid precipitated specimen, or both.

The standardized physical examination called for comments on (1) general appearance; (2) the skin; (3) the head (including the face, mouth and throat, nose, and ears—the latter including the eardrums, cerumen type, and general observations); (4) the neck (including venous engorgement and the thyroid); (5) the lymphatics; (6) the abdomen; (7) the bones and joints; (8) the spine and other parts of the musculoskeletal system; (9) the extremities; and (10) the nervous system (a neurological appraisal).

Special attention was given to the chest and lungs, since one of the program's other objectives was evaluation of pulmonary and cardiovascular changes and relationships between altitude and cardiopulmonary status. This portion of the examination required comments on the subject's respiratory rate, tachypnea, posterior-anterior diameters, decrease in diaphragm motion, percussion, breath sounds, adventitious sounds, pulse and apical rate, apical impulses (including character and location), thrills, heart tones, rhythm, systolic murmurs (both significant and insignificant), diastolic murmurs, and quality of arterial pulsations. Two blood pressure

¹⁰These months correspond to the dry season in the *sierra* and *altiplano*. It hardly ever rains along the coast.

measurements—made with a mercury sphygmomanometer having an appropriate size cuff—were recorded from the right arm with the subject sitting. (Korotkoff sounds I, IV, and V were recorded. Korotkoff IV was used for diastolic blood pressure.) Finally, a resting electrocardiogram was recorded with the subject supine.

All of the evaluations of the chest, lungs, and heart were made by one cardiologist; six physicians (four in 1973, two in 1974) conducted the remainder of the examinations.

Elsewhere (31) we have argued that these examinations—in the various villages within each ecological niche—were done on a broad enough base to make systematic biases in our evaluation of the prevalence of disease and disability unlikely. We accept, of course, that disorders limiting the mobility needed to participate in the examinations afford a basis for bias, insofar as such disorders are altitude-dependent.

Determination of Ethnic Background and Residence

Another basic consideration is the way in which the people examined were classified, first as to their Aymara or non-Aymara origins, and second as to their place of residence in the *costa*, *sierra*, or *altiplano*.

Racial ancestry. Aymara family names are recognizably different from Spanish ones, and this presumably makes individuals with such names readily classifiable. However, substantial numbers of these people have taken—or more frequently been given—Spanish surnames at baptism, and these persons pose classification problems if Aymara surnames are used as the sole criterion of Aymara origin. On the other hand, historical sources, as well as the distribution of certain Spanish names in this area, strongly suggest that the bearers of these particular names are actually Aymara. (In some instances it is even possible to show that the Spanish name is a translation of a

common Aymara surname.) Accordingly, through the use of known Aymara surnames and those Spanish names which most probably reflect Aymara origin, it is possible to classify a person's antecedents, and hence to classify the person as Aymara, non-Aymara, or mestizo (mixed ancestry).

Normally an individual inherits one family name from each of four grandparents, so in theory four names should be available for purposes of classification. But in practice the individual may not know or recollect all four names. To cope with these cases, we adopted the following procedure:

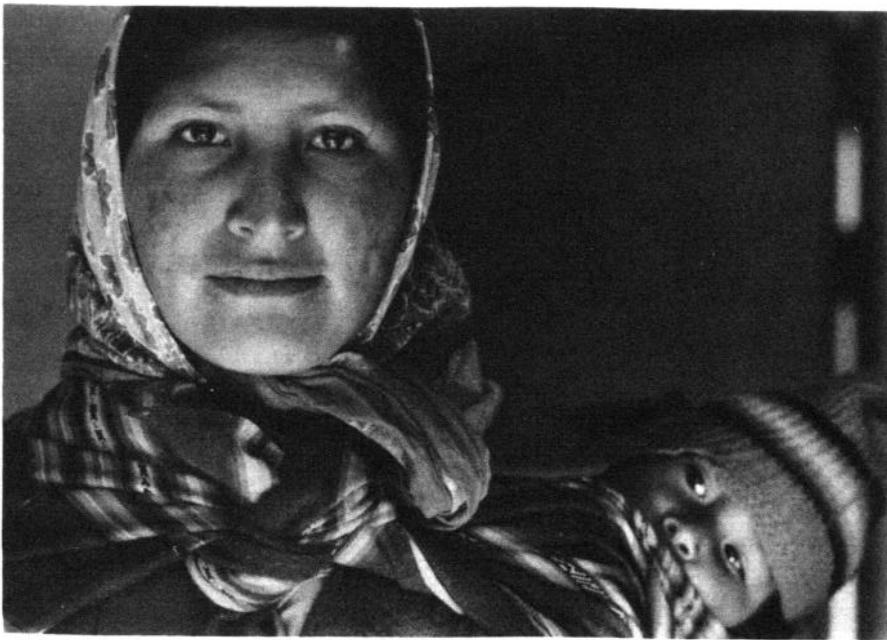
- If none of a person's known family surnames were Aymara or on the short list of Spanish names frequently encountered among the Aymara, that person was assumed to be non-Aymara.

- If all of a person's known family surnames were Aymara (or on the select Spanish list) when only two or three surnames were known, or if at least three names were in this category when all four names were known, the person was classified as Aymara.

- All persons falling into neither of these categories were classified as mestizo.

We believe this to have been a conservative procedure, in the sense that many Aymara were presumably classified as mestizo.

Area of Residence. Largely over the last three decades—as more roads have penetrated the *sierra* and *altiplano*, and as the city of Arica's economic attractions have grown, the population of the interior has become more mobile. Many people have moved to the city permanently; others have come to visit the coast for days, weeks, or even years, while continuing to consider themselves residents of the interior. No fully satisfactory method exists for assigning such individuals to residential groups. In seeking a satisfactory solution to the problem, we adopted a classification procedure based on a person's birthplace and the



An Aymara mother and child (photo: Betsy Siegel, University of Texas).

proportion of his or her life spent in the *costa*, *sierra*, or *altiplano*. A person was classed as a permanent resident of one of these regions if he had lived all his life in that region, while a person who had spent less than 90 per cent of his life in the region of current residence was considered a non-permanent resident. (Those who had spent at least 90 but less than 100 per cent of their lives in one region constituted only about 100 of the examinees.)

Diagnosis of Disease and Disability

Diagnostic Standards

Given the traditional metrics of clinical medicine, the capacity to recognize and properly describe the presence of disease can vary widely from physician to physician. So it is important in a study such as ours, which attempts to examine differences in the "burden" of disease and disability as a function of hypoxia, to be able to demonstrate that no systematic diagnostic biases exist. It will be noted that this is not equivalent to asserting that diagnostic errors do not occur, but merely that they are not systematic. The evidence overwhelmingly attests to "personal" diagnoses, that is,

to substantial differences of opinion or diagnostic acumen, whichever term happens to more accurately describe these interpersonal differences.

As previously noted, seven different physicians participated in the clinical evaluations; so there was clearly ample opportunity for systematic biases which might fortuitously affect the data so as to suggest altitude differences. We have therefore examined the general frequencies of disease and disability encountered at different altitudes (the *costa* and *sierra*) in the years 1973 and 1974. The results are set forth in Table 1; while individual diagnoses dif-

Table 1. Diseases and disabilities seen in the years 1973 and 1974 in the coast and sierra zones of the Department of Arica, by ICDA* classes.

| Disease category | Coast | | Sierra | | Total | |
|-----------------------------------|-------|------|--------|------|-------|------|
| | 1973 | 1974 | 1973 | 1974 | 1973 | 1974 |
| Infective and parasitic | 7 | 21 | 19 | 4 | 26 | 25 |
| Neoplasms | 2 | 6 | 9 | 0 | 11 | 6 |
| Endocrine, nutritional, metabolic | 16 | 45 | 30 | 4 | 46 | 49 |
| Blood, blood forming organs | 7 | 13 | 6 | 0 | 13 | 13 |
| Mental disorders | 2 | 5 | 17 | 0 | 19 | 5 |
| Nervous system | 7 | 35 | 100 | 9 | 107 | 44 |
| Circulatory system | 39 | 113 | 178 | 23 | 219 | 136 |
| Respiratory system | 9 | 70 | 117 | 68 | 126 | 138 |
| Digestive system | 2 | 39 | 30 | 6 | 32 | 45 |
| Genitourinary system | 3 | 11 | 7 | 6 | 10 | 17 |
| Skin | 11 | 91 | 137 | 73 | 148 | 164 |
| Musculoskeletal system | 9 | 49 | 40 | 13 | 49 | 62 |
| Congenital anomalies | 2 | 16 | 28 | 3 | 30 | 19 |
| Other | 23 | 103 | 245 | 51 | 268 | 154 |
| Total diseases and disabilities | 179 | 617 | 963 | 260 | 1,104 | 877 |
| People at risk | 116 | 520 | 671 | 136 | 787 | 656 |

*Eighth Revision, International Classification of Diseases (34).

ferred (but in a manner wholly explicable by chance), the overall rates in the two years were comparable. Thus in 1973 1.40 diagnoses were made for each individual examined; in 1974 this figure was 1.34. Within ecological niches, these values were 1.20 versus 1.19 for the coast, and 1.44 versus 1.92 for the *sierra*. It bears noting that the proportions of males seen in the years 1973 and 1974 did not differ significantly, nor did the proportions of children. Thus Tables 2a through 3c, which give only the overall rates, do not confound diagnostic differences ascribable to sex or age.

Many of the diagnoses set forth in Tables 2 and 3 are matters of clinical judgment, while others are matters of convention. Among the latter is the diagnosis of hypertension. In the latter connection we recorded two events, namely, "frank" and "borderline" hypertension. By convention (32) we defined borderline hypertension among individuals 15 years of age or older as indicated by a systolic pressure of 140-159 mm of mercury and/or a diastolic pressure of 90-94, while defining "frank" hypertension in this age group as indicated by a systolic pressure of 160 or greater and/or a diastolic pressure of 95 or more. Hypertension, frank or borderline, is less clearly defined in children (subjects under 15 years of age) and the definition is likely age-dependent; but convention, limited as it is, suggests that systolic pressures over 140 or diastolic pressures over 90 are abnormal. Though these standards do not adequately recognize cardiovascular disease at high altitude in our view, we accepted them for purposes of comparison. Since they are defined on the basis of experiences at lower altitudes, they are not calculatedly self-serving insofar as high-altitude observers are concerned. It warrants noting, however, that for individuals less than 15 years of age, even at sea level, these standards exceed the 90th percentile for ages 6 through 15 inclusive (33).

The diagnosis of anemia presents similar problems when the condition involves inadequate nutrition. Here one of the conventional metrics is the amount of hemoglobin in the blood. Again, we took as our standards those values normally viewed as indicative of anemia at sea level, namely, less than 12 gms per cent of hemoglobin in males and less than 10 gms per cent in females.

Specific Diagnoses

Some 419 different ICDA (34) codable diseases or "symptoms and ill-defined conditions" listed in the *International Classification of Diseases* (34) were encountered. Most of these involved only a few individuals at most, making diagnosis-specific comparisons for different altitudes, sexes, or age groups statistically meaningless. Accordingly, we have grouped our findings into broader diagnostic categories, but will in the paragraphs that follow call attention to the most frequently encountered problems in each category (in addition to those other specific diagnoses indicated in the tables).

Infective and parasitic diseases. The illnesses most commonly encountered in children were diarrhea, upper respiratory infection (including otitis media), tuberculosis, whooping cough, and bacterial infections of the skin. The illness most commonly encountered in adults was tuberculosis. Stools were not routinely examined; it can be surmised from the work of others (28) that had they been, parasites, mostly worms, would undoubtedly have been encountered.

Neoplasms. Only one malignancy was seen, and all of the benign tumors were essentially inconsequential as threats to health.

Endocrine, nutritional, and metabolic disorders. Obesity and undernutrition were the most common disorders of these types, both in adults and children; undernutrition was defined as being involved when a

Table 2a. Data for permanent Aymara residents. Distribution of diseases and disorders among the permanent Aymara residents examined in the population of the Department of Arica, by sex and ecological niche.

| Disease category | ICDA code | Coast | | Sierra | | | | Altiplano | | | | Total | | | | | |
|---|--------------|----------------|----------------|---------|---|-------|----|-----------|----|-------|-----|---------|-----|-------|-----|---------|-----|
| | | Males | | Females | | Males | | Females | | Males | | Females | | Males | | Females | |
| | | C ^a | A ^b | C | A | C | A | C | A | C | A | C | A | C | A | C | A |
| Infective and parasitic | 000-136 | - | - | - | - | 1 | 1 | - | 1 | 5 | 4 | 6 | 1 | 6 | 5 | 6 | 2 |
| Neoplasms | 140-239 | - | - | - | - | - | - | - | - | 1 | 3 | - | 2 | 1 | 3 | - | 2 |
| <i>Malignant</i> | 140-209 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <i>Benign or unspecified</i> | 210-239 | - | - | - | - | - | - | - | 1 | 3 | - | 2 | 1 | 3 | - | 2 | - |
| Endocrine, nutritional, metabolic | 240-279 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | - | 3 | 3 | 2 | 9 | 5 | 6 | 4 | 10 |
| <i>Diabetes mellitus</i> | 250 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Blood, blood forming organs | 280-289 | 1 | - | - | - | - | - | - | - | - | - | 1 | 1 | - | - | - | 1 |
| Mental disorders | 290-315 | - | - | - | - | 1 | 2 | 1 | - | - | - | - | - | 1 | 2 | 1 | 1 |
| Nervous system, sense organs | 320-389 | - | 1 | - | - | 1 | 7 | 4 | 10 | 7 | 14 | - | 5 | 8 | 22 | 4 | 15 |
| <i>Nervous system</i> | 320-358 | - | 1 | - | - | - | 1 | - | - | 2 | - | - | 2 | 2 | - | - | - |
| <i>Eye</i> | 360-379 | - | - | - | - | 1 | 1 | 1 | 3 | 3 | 5 | - | 2 | 4 | 6 | 1 | 5 |
| <i>Ear, mastoid process</i> | 380-389 | - | - | - | - | - | 5 | 3 | 7 | 2 | 9 | - | 3 | 2 | 14 | 3 | 10 |
| Circulatory system | 390-458 | 1 | 2 | - | - | 6 | 8 | - | 16 | - | 18 | 2 | 16 | 7 | 28 | 2 | 32 |
| <i>Acute hypertension (≥ 160/95)</i> | 401 | - | - | - | - | - | 2 | - | 2 | - | 3 | - | 1 | - | 5 | - | 3 |
| <i>Borderline hypertension (≥ 140/90)</i> | 401 0 | - | 1 | - | - | - | 2 | - | 5 | - | 8 | 1 | 4 | - | 11 | 1 | 9 |
| <i>Acute myocardial infarction</i> | 410 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <i>Other ischemic heart disease</i> | 411-414 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <i>All other heart disease</i> | 390-429 | 1 | 1 | - | - | 6 | 1 | - | 1 | - | 3 | 1 | 7 | 7 | 5 | 1 | 8 |
| <i>Cerebrovascular disease</i> | 430-438 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Respiratory system | 460-519 | - | - | 2 | - | 8 | 3 | 9 | 8 | 29 | 9 | 29 | 9 | 37 | 12 | 40 | 17 |
| <i>Acute resp. infect. except influenza, tonsillitis, sinusitis</i> | 460-466 | - | - | 1 | - | 5 | 1 | 5 | 2 | 19 | 3 | 22 | - | 24 | 4 | 28 | 2 |
| <i>Pneumonia</i> | 480-486 | - | - | - | - | 1 | - | 3 | - | - | - | 2 | 2 | - | 1 | 2 | 5 |
| <i>Acute tonsillitis, hypertrophy of tonsils and adenoids</i> | 463,500 | - | - | - | - | 3 | - | 2 | 1 | 8 | 2 | 5 | 4 | 11 | 2 | 7 | 5 |
| Digestive system | 520-577 | - | - | - | - | 3 | 1 | - | 6 | 2 | 8 | 4 | 11 | 5 | 9 | 4 | 17 |
| <i>Inguinal hernia</i> | 550,552 | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | - | - | - |
| <i>Cholelithiasis, cholecystitis</i> | 574,575 | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | 3 |
| Genitourinary system | 580-629 | - | - | - | - | - | - | - | 2 | 1 | 2 | - | 1 | 1 | 2 | - | 3 |
| <i>Urinary system</i> | 580-599 | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 |
| <i>Hyperplasia of prostate</i> | 600 | - | - | - | - | - | - | - | - | - | 1 | - | 1 | - | 1 | - | 1 |
| <i>Disorders of menstruation</i> | 626 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Skin, subcutaneous tissue | 680-709 | 1 | - | - | - | 11 | 7 | 14 | 9 | 12 | 16 | 12 | 18 | 24 | 23 | 26 | 27 |
| Musculoskeletal, connect. tissue | 710-738 | - | 2 | - | - | 2 | 3 | 1 | 5 | 1 | 8 | 2 | 8 | 3 | 13 | 3 | 13 |
| <i>Arthritis, all forms</i> | 710-718 | - | - | - | - | 1 | - | 2 | - | 1 | - | 2 | - | 2 | - | 4 | - |
| Congenital anomalies | 740-759 | - | 1 | 1 | - | 5 | 1 | - | 1 | 5 | 3 | 5 | 3 | 10 | 5 | 6 | 4 |
| Symptoms, ill-defined conditions | 780-796 | 1 | 2 | 1 | 1 | 10 | 11 | 4 | 19 | 20 | 28 | 13 | 27 | 31 | 41 | 18 | 47 |
| Accidents | 800-999 | - | - | - | - | 3 | 3 | 1 | 2 | 1 | 4 | - | 3 | 4 | 7 | 1 | 5 |
| Conditions, exams w/o sickness | 793, Y00-Y13 | - | - | - | - | - | - | - | - | - | 1 | 2 | 5 | - | 1 | 2 | 5 |
| Total, all diagnoses | | 5 | 9 | 5 | 2 | 51 | 48 | 36 | 80 | 87 | 121 | 77 | 119 | 143 | 178 | 118 | 201 |
| People examined | | 5 | 5 | 6 | 1 | 37 | 21 | 33 | 38 | 87 | 59 | 82 | 69 | 129 | 85 | 121 | 108 |

^aC = children

^bA = adults

- = 0

subject fell into the lowest one percentile of his or her age and sex class (based on Chilean standards.)

Diseases of the blood and blood-forming organs. Anemia, generally thought to be nutritional in origin, was found to be the most frequent disease of the blood. Detailed hematologic studies were not practicable in the field, and thus some of the "simple" anemias may have been due to causes other

than iron deficiency or a more generalized malnutrition.

Mental disorders. Neurosis in adults and mental retardation in children accounted for the bulk of mental problems.

Diseases of the nervous system and sense organs. Otitis media was seen often in children; and cataracts, otitis media, otosclerosis, and hearing impairments were frequently observed in adults. It warrants

Table 2b. Data for permanent mestizo residents. Distribution of diseases and disorders among the permanent mestizo residents examined in the population of the Department of Arica, by sex and ecological niche.

| Disease category | ICDA code | Coast | | | | Sierra | | | | Altiplano | | | | Total | | | |
|---|--------------|----------------|----------------|---------|----|--------|----|---------|----|-----------|----|---------|----|-------|-----|---------|-----|
| | | Males | | Females | | Males | | Females | | Males | | Females | | Males | | Females | |
| | | C ^a | A ^b | C | A | C | A | C | A | C | A | C | A | C | A | C | A |
| Infective and parasitic | 000-136 | 6 | - | 5 | 1 | 1 | 1 | 5 | 7 | 5 | 1 | 2 | 1 | 12 | 2 | 12 | 9 |
| Neoplasms | 140-239 | - | 1 | - | 2 | 1 | - | - | 2 | 2 | - | - | 1 | 3 | 1 | - | 5 |
| <i>Malignant</i> | 140-209 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <i>Benign or unspecified</i> | 210-239 | - | 1 | - | 2 | 1 | - | - | 2 | 2 | - | - | 1 | 3 | 1 | - | 5 |
| Endocrine, nutritional, metabolic | 240-279 | 4 | - | 3 | 5 | 5 | 2 | 2 | 2 | - | 1 | 1 | 4 | 9 | 3 | 6 | 11 |
| <i>Diabetes mellitus</i> | 250 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Blood, blood forming organs | 280-289 | 4 | 1 | - | 1 | - | - | - | - | - | - | 1 | 4 | 1 | - | 2 | 2 |
| Mental disorders | 290-315 | - | - | - | 1 | 1 | 2 | 2 | 1 | - | - | - | - | 1 | 2 | 2 | 2 |
| Nervous system, sense organs | 320-389 | 5 | 1 | 1 | - | 8 | 5 | 7 | 4 | 4 | 2 | 5 | 4 | 17 | 8 | 13 | 8 |
| <i>Nervous system</i> | 320-358 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | - |
| <i>Eye</i> | 360-379 | 2 | - | - | - | 3 | 2 | 1 | - | 4 | 1 | 4 | 2 | 9 | 3 | 5 | 2 |
| <i>Ear, mastoid process</i> | 380-389 | 3 | 1 | 1 | - | 5 | 3 | 5 | 4 | - | 1 | 1 | 2 | 8 | 5 | 7 | 6 |
| Circulatory system | 390-458 | 5 | 12 | 5 | 6 | 8 | 9 | 5 | 9 | 3 | 10 | - | 12 | 16 | 31 | 10 | 27 |
| <i>Acute hypertension (≥160/95)</i> | 401 | - | 1 | - | 2 | - | - | 3 | - | 2 | - | 1 | - | 3 | - | 6 | 6 |
| <i>Borderline hypertension (≥140/90)</i> | 401.0 | 1 | 5 | - | 3 | - | 3 | - | 1 | 1 | 1 | - | 2 | 2 | 9 | - | 6 |
| <i>Acute myocardial infarction</i> | 410 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <i>Other ischemic heart disease</i> | 411-414 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 |
| <i>All other heart disease</i> | 390-429 | 4 | 5 | 5 | 1 | 8 | 2 | 5 | 3 | 2 | 5 | - | 7 | 14 | 12 | 10 | 11 |
| <i>Cerebrovascular disease</i> | 430-438 | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | - |
| Respiratory system | 460-519 | 8 | - | 20 | 1 | 28 | 3 | 30 | 9 | 23 | 5 | 22 | 6 | 59 | 8 | 72 | 16 |
| <i>Acute resp. infect. except influenza, tonsillitis, sinusitis</i> | 460-466 | 6 | - | 12 | - | 16 | - | 16 | 3 | 14 | - | 13 | 1 | 36 | - | 41 | 4 |
| <i>Pneumonia</i> | 480-486 | - | - | 1 | - | - | 1 | 1 | 3 | 2 | - | - | - | 2 | 1 | 2 | 3 |
| <i>Acute tonsillitis, hypertrophy of tonsils and adenoids</i> | 463,500 | 1 | - | 5 | - | 10 | 2 | 11 | 3 | 6 | - | 9 | - | 17 | 2 | 25 | 3 |
| Digestive system | 520-577 | 1 | 4 | 3 | 1 | 2 | - | - | - | 2 | 2 | 1 | 4 | 5 | 6 | 4 | 5 |
| <i>Inguinal hernia</i> | 550,552 | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 | - | - | - |
| <i>Cholelithiasis, cholecystitis</i> | 574,575 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Genitourinary system | 580-629 | 1 | - | 1 | 1 | - | - | - | 2 | 1 | 1 | - | 2 | 2 | 1 | 1 | 5 |
| <i>Urinary system</i> | 580-599 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <i>Hyperplasia of prostate</i> | 600 | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 | - | - | - |
| <i>Disorders of menstruation</i> | 626 | - | - | 1 | 1 | - | - | - | 1 | - | - | - | - | - | - | 1 | 2 |
| Skin, subcutaneous tissue | 680-709 | 6 | 4 | 4 | 7 | 33 | 7 | 32 | 10 | 3 | 5 | 5 | 14 | 42 | 16 | 41 | 31 |
| Musculoskeletal, connect. tissue | 710-738 | 1 | 2 | 2 | 2 | - | 8 | 2 | 2 | 2 | 7 | 4 | 2 | 3 | 17 | 8 | 6 |
| <i>Arthritis, all forms</i> | 710-718 | - | - | - | - | 1 | - | 1 | - | - | - | - | - | 1 | - | 1 | 1 |
| Congenital anomalies | 740-759 | 3 | 1 | 2 | - | 2 | 3 | 7 | 3 | 5 | 1 | 4 | 3 | 10 | 5 | 13 | 6 |
| Symptoms, ill-defined conditions | 780-796 | 17 | 4 | 6 | 1 | 25 | 7 | 28 | 16 | 19 | 8 | 14 | 10 | 61 | 19 | 48 | 27 |
| Accidents | 800-999 | 1 | - | - | - | 2 | 2 | - | 1 | 1 | 3 | 1 | - | 4 | 5 | 1 | 1 |
| Conditions, exams w/o sickness | 793, Y00-Y13 | - | - | - | - | - | - | 1 | - | - | - | - | 2 | - | - | - | 3 |
| Total, all diagnoses | | 62 | 30 | 52 | 29 | 116 | 49 | 120 | 69 | 70 | 46 | 59 | 66 | 248 | 125 | 231 | 164 |
| People examined | | 78 | 30 | 73 | 23 | 96 | 30 | 104 | 33 | 59 | 22 | 69 | 30 | 233 | 82 | 246 | 86 |

^aC = children
^bA = parents
 - = 0

reiteration that the examinations were conducted in the spring (October and November), a season during which otitis media and respiratory diseases were presumably at neither a maximum nor a minimum.

Diseases of the circulatory system. Systemic hypertension in Aymara adults living permanently in the *sierra* or the *altiplano* was uncommon, but it occurred more frequently than the literature would sug-

gest. Eight of 187 adults who had resided permanently in the *sierra* or the *altiplano* had systolic blood pressures equal to or greater than 160, or diastolic pressures equal to or greater than 95. Nineteen additional individuals had blood pressures equalling or exceeding 140/90 but less than 160/95. None of the 6 Aymara adults examined who were permanent coastal residents had blood pressures equalling or exceeding 160/95, and only 1 had a blood pressure

Table 2c. Data for permanent non-Aymara residents. Distribution of diseases and disorders among the permanent non-Aymara residents examined in the population of the Department of Arica, by sex and ecological niche.

| Disease category | ICDA code | Coast | | Sierra | | | | Altiplano | | | | Total | | | | | |
|--|--------------|----------------|----------------|---------|----|-------|----|-----------|----|-------|----|---------|---|-------|-----|---------|-----|
| | | Males | | Females | | Males | | Females | | Males | | Females | | Males | | Females | |
| | | C ^a | A ^b | C | A | C | A | C | A | C | A | C | A | C | A | C | A |
| Infective and parasitic | 000-136 | 1 | - | 1 | - | - | - | - | - | - | - | - | - | 1 | - | 1 | - |
| Neoplasms | 140-239 | - | 2 | - | 1 | - | - | - | - | - | - | - | - | - | 2 | - | 1 |
| Malignant | 140-209 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Benign or unspecified | 210-239 | - | 2 | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| Endocrine, nutritional, metabolic | 240-279 | 2 | 3 | - | 13 | - | - | - | 1 | - | - | - | - | 2 | 3 | - | 14 |
| Diabetes mellitus | 250 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Blood, blood forming organs | 280-289 | - | 4 | - | 1 | - | - | - | - | - | - | - | 1 | 1 | 4 | - | 2 |
| Mental disorders | 290-315 | - | 2 | - | 3 | 1 | - | - | - | - | - | - | - | 1 | 2 | - | 3 |
| Nervous system, sense organs | 320-389 | - | 10 | 1 | 1 | - | 4 | 1 | 3 | - | - | - | - | - | 14 | 2 | 4 |
| Nervous system | 320-358 | - | 3 | - | - | - | - | 1 | - | - | - | - | - | - | 3 | 1 | - |
| Eye | 360-379 | - | 2 | - | - | - | 2 | 1 | - | - | - | - | - | - | 4 | - | 1 |
| Ear, mastoid process | 380-389 | - | 5 | 1 | 1 | - | 2 | - | 2 | - | - | - | - | - | 7 | 1 | 3 |
| Circulatory system | 390-458 | 4 | 20 | 2 | 28 | - | 3 | - | 1 | - | 3 | - | - | 4 | 26 | 2 | 29 |
| Acute hypertension (≥ 160/95) | 401 | - | 3 | - | 9 | - | - | - | - | 1 | - | - | - | - | 4 | - | 9 |
| Borderline hypertension (≥ 140/90) | 401.0 | - | 9 | 1 | 6 | - | 1 | - | 1 | - | - | - | - | 10 | 1 | 7 | |
| Acute myocardial infarction | 410 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Other ischemic heart disease | 411-414 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 |
| All other heart disease | 390-429 | 4 | 5 | 1 | 5 | - | - | - | - | - | - | - | - | 4 | 5 | 1 | 5 |
| Cerebrovascular disease | 430-438 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Respiratory system | 460-519 | 6 | 9 | 4 | 5 | 2 | 1 | 1 | 5 | - | - | - | - | 8 | 10 | 5 | 10 |
| Acute resp. infect. except influenza, tonsillitis, sinusitis | 460-466 | 2 | 4 | 2 | 3 | 2 | 1 | - | 2 | - | - | - | - | 4 | 5 | 2 | 5 |
| Pneumonia | 480-486 | - | 1 | - | - | - | - | - | 1 | - | - | - | - | - | 1 | - | 1 |
| Acute tonsillitis, hypertrophy of tonsils and adenoids | 463,500 | 3 | - | 2 | 1 | - | - | 1 | - | - | - | - | - | 3 | - | 3 | 1 |
| Digestive system | 520-577 | - | 5 | 1 | 5 | - | - | - | - | 2 | - | 1 | - | 7 | - | 6 | |
| Inguinal hernia | 550,552 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| Cholelithiasis, cholecystitis | 574, 575 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Genitourinary system | 580-629 | 1 | 2 | - | 1 | - | - | - | - | - | - | - | - | 1 | 2 | - | 1 |
| Urinary system | 580-599 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Hyperplasia of prostate | 600 | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Disorders of menstruation | 626 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Skin, subcutaneous tissue | 680-709 | 3 | 7 | 6 | 13 | - | 2 | - | 2 | - | - | - | - | 3 | 9 | 6 | 15 |
| Musculoskeletal, connect. tissue | 710-738 | - | 9 | - | 10 | - | 2 | - | 1 | - | 2 | - | - | 13 | - | 11 | |
| Arthritis, all forms | 710-718 | - | 2 | - | 2 | - | - | - | - | 1 | - | - | - | 3 | - | 2 | |
| Congenital anomalies | 740-759 | - | 1 | 2 | - | - | - | - | - | 1 | - | - | - | 2 | 2 | - | - |
| Symptoms, ill-defined conditions | 780-796 | 5 | 15 | 5 | 6 | 1 | 5 | - | 1 | - | 4 | - | - | 6 | 24 | 5 | 7 |
| Accidents | 800-999 | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 |
| Conditions, exams w/o sickness | 793, Y00-Y13 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| Total, all diagnoses | | 22 | 90 | 22 | 87 | 4 | 17 | 2 | 14 | - | 12 | - | 3 | 27 | 119 | 23 | 104 |
| People examined | | 29 | 49 | 40 | 52 | 1 | 7 | 4 | 6 | 1 | 3 | - | 1 | 31 | 59 | 44 | 59 |

^aC = children

^bA = adults

- = 0

between 140/90 and 160/95. Only 1 of 239 Aymara children living permanently in the *sierra* or *altiplano* had a blood pressure greater than 140/90, and none of the 11 living permanently along the coast had elevated blood pressure.

Among the 155 Aymara adults who were residing in the *sierra* or *altiplano* at the time of these examinations but acknowledged spending at least 10 per cent of their lives elsewhere, 6 had systolic blood pressures over 160 or diastolic pressures above

95. An additional 16 individuals had blood pressures in the range of either 140-159 (systolic) or 90-94 (diastolic) or both. These frequencies are very similar to those observed among permanent residents at these altitudes, and lower than those found among the coastal Aymara. None of the 33 Aymara children who had spent only part of their lives in the *sierra* or *altiplano* had elevated systolic or diastolic pressures.

Peripheral vascular disease was common among the more elderly adults.

Table 3a. Data for non-permanent Aymara residents. Distribution of diseases and disorders among the non-permanent Aymara residents examined in the population of the Department of Arica, by sex and ecological niche.

| Disease category | ICDA code | Coast | | Sierra | | | | Altiplano | | | | Total | | | | | |
|---|-----------|----------------|----------------|---------|----|-------|-----|-----------|----|-------|----|---------|----|-------|-----|---------|-----|
| | | Males | | Females | | Males | | Females | | Males | | Females | | Males | | Females | |
| | | C ^a | A ^b | C | A | C | A | C | A | C | A | C | A | C | A | C | A |
| Infective and parasitic | 000-136 | — | 2 | — | 1 | — | 1 | — | — | 2 | 1 | 2 | — | 5 | 2 | 3 | |
| Neoplasms | 140-239 | — | — | — | 1 | — | — | — | 2 | — | — | 1 | — | — | — | 4 | |
| <i>Malignant</i> | 140-209 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| <i>Benign or unspecified</i> | 210-239 | — | — | — | 1 | — | — | — | 2 | — | — | 1 | — | — | — | 4 | |
| Endocrine, nutritional, metabolic | 240-279 | — | 4 | — | 2 | 1 | 1 | — | 1 | — | — | — | — | 1 | 5 | — | 3 |
| <i>Diabetes mellitus</i> | 250 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| Blood, blood forming organs | 280-289 | — | — | — | 2 | — | 1 | — | 1 | — | — | — | — | — | 1 | — | 3 |
| Mental disorders | 290-315 | — | — | — | — | — | 2 | — | 1 | — | — | 1 | — | 2 | — | 2 | |
| Nervous system, sense organs | 320-389 | — | — | — | 3 | 1 | 12 | 1 | 5 | — | 3 | — | 1 | 1 | 15 | 1 | 9 |
| <i>Nervous system</i> | 320-358 | — | — | — | — | — | — | — | 2 | — | — | — | — | — | — | — | 2 |
| <i>Eye</i> | 360-379 | — | — | — | 2 | — | 3 | 1 | 1 | — | 1 | — | 1 | — | 4 | 1 | 4 |
| <i>Ear, mastoid process</i> | 380-389 | — | — | — | 1 | 1 | 9 | — | 2 | — | 2 | — | — | 1 | 11 | — | 3 |
| Circulatory system | 390-458 | — | 9 | — | 4 | 2 | 20 | — | 18 | — | 5 | — | 2 | 2 | 34 | — | 24 |
| <i>Acute hypertension (≥ 160/95)</i> | 401 | — | 3 | — | — | — | 2 | — | 4 | — | — | — | — | — | 5 | — | 4 |
| <i>Borderline hypertension (≥ 140/90)</i> | 401.0 | — | 2 | — | 3 | — | 8 | — | 5 | — | 3 | — | — | — | 13 | — | 8 |
| <i>Acute myocardial infarction</i> | 410 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| <i>Other ischemic heart disease</i> | 411-414 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| <i>All other heart disease</i> | 390-429 | — | 2 | — | — | 2 | 4 | — | 5 | — | 2 | — | 1 | 2 | 8 | — | 6 |
| <i>Cerebrovascular disease</i> | 430-438 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Respiratory system | 460-519 | — | — | — | 1 | 1 | 15 | 1 | 10 | 4 | 2 | 1 | 3 | 5 | 17 | 2 | 14 |
| <i>Acute resp. infect. except influenza, tonsillitis, sinusitis</i> | 460-466 | — | — | — | 1 | 1 | 7 | 1 | 5 | 1 | 2 | 1 | 1 | 2 | 9 | 2 | 7 |
| <i>Pneumonia</i> | 480-486 | — | — | — | — | — | 1 | — | 3 | — | — | — | — | — | 1 | — | 3 |
| <i>Acute tonsillitis, hypertrophy of tonsils and adenoids</i> | 463, 500 | — | — | — | — | — | 2 | — | — | 3 | — | — | 2 | 3 | 2 | — | 2 |
| Digestive system | 520-577 | — | 3 | — | 4 | — | — | — | 3 | — | 2 | — | 1 | — | 5 | — | 8 |
| <i>Inguinal hernia</i> | 550, 552 | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | 1 |
| <i>Cholelithiasis, cholecystitis</i> | 574, 575 | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | 1 |
| Genitourinary system | 580-629 | — | — | — | — | — | 2 | — | 2 | — | — | — | 1 | — | 2 | — | 3 |
| <i>Urinary system</i> | 580-599 | — | — | — | — | — | 1 | — | — | — | — | — | — | — | 1 | — | — |
| <i>Hyperplasia of prostate</i> | 600 | — | — | — | — | — | 1 | — | — | — | — | — | — | — | 1 | — | — |
| <i>Disorders of menstruation</i> | 626 | — | — | — | — | — | — | — | 1 | — | — | — | 1 | — | — | — | 2 |
| Skin, subcutaneous tissue | 680-709 | — | 6 | 1 | 5 | 1 | 9 | 3 | 16 | 1 | 9 | 1 | 3 | 2 | 24 | 5 | 24 |
| Musculoskeletal, connect. tissue | 710-738 | — | 5 | — | 4 | — | 5 | — | 7 | — | 2 | — | 2 | — | 12 | — | 13 |
| <i>Arthritis, all forms</i> | 710-718 | — | 2 | — | 1 | — | 1 | — | 2 | — | 1 | — | — | — | 4 | — | 5 |
| Congenital anomalies | 740-759 | — | — | — | 1 | — | — | — | 1 | 1 | 2 | — | 3 | 1 | 2 | — | 5 |
| Symptoms, ill-defined conditions | 780-796 | — | 2 | — | 5 | 3 | 32 | — | 15 | 1 | 15 | 1 | 9 | 4 | 49 | 1 | 29 |
| Accidents | 800-999 | — | — | — | 1 | — | — | — | — | — | 1 | — | — | — | 1 | — | 1 |
| Conditions, exams w/o sickness | 793 | — | — | — | 3 | — | — | — | 1 | — | 2 | — | 2 | — | 2 | — | 6 |
| | Y00-Y13 | | | | | | | | | | | | | | | | |
| Total, all diagnoses | | — | 31 | 1 | 37 | 9 | 100 | 6 | 83 | 7 | 45 | 4 | 31 | 16 | 176 | 11 | 151 |
| People examined | | 2 | 26 | 4 | 22 | 13 | 55 | 6 | 47 | 9 | 31 | 5 | 22 | 24 | 112 | 15 | 91 |

^aC = children
^bA = adults
 — = 0

Cardiac auscultatory findings were of interest and surprising. The most common finding among adults was premature contractions, the vast majority of which were supraventricular in origin.

Rheumatic fever is a significant health problem in many Central and South American countries, and it came as a surprise that none of the Aymara adults or children living at altitude or sea level had murmurs of mitral insufficiency, mitral

stenosis, or aortic insufficiency that would suggest previous attacks of rheumatic fever.

It is unlikely that all hemolytic streptococcal infections in the Aymara are treated adequately. So it must be assumed that the hemolytic streptococcus is not a common pathogen among the Aymara, or else that for some reason the Aymara either do not have acute rheumatic fever or are resistant to carditis. It is improbable that altitude itself is protective, since a 1964 survey in the

Table 3b. Data for non-permanent mestizo residents. Distribution of diseases and disorders among the non-permanent mestizo residents examined in the population of the Department of Arica, by sex and ecological niche.

| Disease category | ICDA code | Coast | | Sierra | | | | Altiplano | | | | Total | | | | | |
|---|--------------|----------------|----------------|---------|----|-------|----|-----------|----|-------|----|---------|----|-------|-----|---------|-----|
| | | Males | | Females | | Males | | Females | | Males | | Females | | Males | | Females | |
| | | C ^a | A ^b | C | A | C | A | C | A | C | A | C | A | C | A | C | A |
| Infective and parasitic | 000-136 | 1 | 4 | 1 | 3 | - | 1 | - | - | - | 3 | 1 | 1 | 1 | 8 | 2 | 4 |
| Neoplasms | 140-239 | - | - | - | 1 | - | 1 | - | 2 | - | - | - | - | - | 1 | - | 3 |
| <i>Malignant</i> | 140-209 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <i>Benign or unspecified</i> | 210-239 | - | - | - | 1 | - | 1 | - | 2 | - | - | - | - | - | 1 | - | 3 |
| Endocrine, nutritional, metabolic | 240-279 | 1 | 2 | - | 8 | - | 4 | - | 3 | 1 | 2 | - | 3 | 2 | 8 | - | 14 |
| <i>Diabetes mellitus</i> | 250 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Blood, blood forming organs | 280-289 | 1 | - | - | 2 | - | - | - | 2 | - | - | - | - | 1 | - | - | 4 |
| Mental disorders | 290-315 | - | - | - | - | - | 1 | - | - | 1 | - | - | - | - | 2 | - | - |
| Nervous system, sense organs | 320-389 | 1 | 7 | 1 | 4 | 2 | 8 | 2 | 4 | 1 | 2 | 2 | 1 | 4 | 17 | 5 | 9 |
| <i>Nervous system</i> | 320-358 | - | - | - | 1 | - | 1 | - | 1 | - | - | - | - | 1 | - | 2 | - |
| <i>Eye</i> | 360-379 | - | 3 | - | - | 2 | 1 | - | 1 | - | - | - | - | 2 | 5 | - | 1 |
| <i>Ear, mastoid process</i> | 380-389 | 1 | 4 | 1 | 3 | - | 6 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 11 | 5 | 6 |
| Circulatory system | 390-458 | 4 | 15 | 2 | 7 | 4 | 17 | 5 | 22 | - | 7 | - | 3 | 8 | 39 | 7 | 33 |
| <i>Acute hypertension (≥160/95)</i> | 401 | - | 6 | - | - | - | 6 | - | 5 | - | 2 | - | - | - | 14 | - | 5 |
| <i>Borderline hypertension (≥140/90)</i> | 401.0 | - | 3 | - | 4 | - | 5 | - | 1 | - | 3 | - | 1 | - | 11 | - | 6 |
| <i>Acute myocardial infarction</i> | 410 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <i>Other ischemic heart disease</i> | 411-414 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| <i>All other heart disease</i> | 390-429 | 4 | 2 | 2 | 1 | 4 | 4 | 5 | 5 | - | 2 | - | 1 | 8 | 8 | 7 | 8 |
| <i>Cerebrovascular disease</i> | 430-438 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Respiratory system | 460-519 | 3 | 4 | 6 | 6 | 6 | 10 | 9 | 5 | 7 | 4 | 3 | 3 | 16 | 18 | 18 | 14 |
| <i>Acute resp. infect. except influenza, tonsillitis, sinusitis</i> | 460-466 | 1 | 2 | 3 | 1 | 3 | 5 | 6 | 3 | 4 | 1 | 2 | - | 8 | 8 | 11 | 4 |
| <i>Pneumonia</i> | 480-486 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| <i>Acute tonsillitis, hypertrophy of tonsils and adenoids</i> | 463,500 | 1 | 1 | 3 | 1 | 2 | - | 2 | 1 | 3 | 1 | 1 | - | 6 | 2 | 6 | 2 |
| Digestive system | 520-577 | - | 3 | - | 8 | 1 | 5 | - | 5 | - | 1 | - | 1 | 1 | 9 | - | 14 |
| <i>Inguinal hernia</i> | 550,552 | - | - | - | - | - | 1 | - | - | - | - | - | 1 | - | 1 | - | 1 |
| <i>Cholelithiasis, cholecystitis</i> | 574,575 | - | - | - | 3 | - | - | - | - | - | - | - | - | - | - | - | 3 |
| Genitourinary system | 580-629 | - | 2 | - | 2 | - | 1 | - | 3 | - | - | - | - | 3 | - | 5 | - |
| <i>Urinary system</i> | 580-599 | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 |
| <i>Hyperplasia of prostate</i> | 600 | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | - | - | - |
| <i>Disorders of menstruation</i> | 626 | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 |
| Skin, subcutaneous tissue | 680-709 | - | 12 | - | 18 | 9 | 3 | 12 | 9 | 3 | 5 | 1 | 7 | 12 | 20 | 13 | 34 |
| Musculoskeletal, connect. tissue | 710-738 | 1 | 9 | - | 3 | - | 1 | - | 3 | 1 | 2 | - | 1 | 2 | 12 | - | 7 |
| <i>Arthritis, all forms</i> | 710-718 | - | 3 | - | 1 | - | - | - | 2 | - | - | - | - | 3 | - | 3 | - |
| <i>Congenital anomalies</i> | 740-759 | 2 | - | 1 | 1 | 1 | 3 | 1 | - | 2 | - | - | - | 3 | 5 | 2 | 1 |
| Symptoms, ill-defined conditions | 780-796 | 2 | 16 | 2 | 14 | 6 | 30 | 7 | 10 | 6 | 9 | 2 | 2 | 14 | 55 | 11 | 26 |
| Accidents | 800-999 | - | 1 | - | - | - | 1 | - | - | - | 1 | - | - | - | 3 | - | - |
| Conditions, exams w/o sickness | 793, Y00-Y13 | - | - | - | 5 | - | - | - | 3 | - | - | - | 1 | - | - | - | 9 |
| Total, all diagnoses | | 16 | 75 | 13 | 82 | 29 | 86 | 36 | 71 | 19 | 39 | 9 | 23 | 64 | 200 | 58 | 177 |
| People examined | | 20 | 55 | 21 | 46 | 26 | 55 | 28 | 52 | 11 | 17 | 8 | 12 | 57 | 127 | 57 | 110 |

^aC = children

^bA = adults

- = 0

United States showed high rates of rheumatic fever in the Rocky Mountain area (35). The lack of crowding in the areas studied—both the villages at altitude and the two valleys at sea level—could have been at least partially responsible for the apparent low incidence of rheumatic fever.

Virtually all of the murmurs were insignificant, being either soft ejection murmurs over the upper left sternal border or vibratory short systolic murmurs over the lower left sternal border. The few significant

murmurs were found in five patients with pulmonary stenosis, four with aortic stenosis, two with small ventricular septal defects, one with a common ventricle, and one with a partial atrioventricular canal. Although the occurrence of patent ductus arteriosus is reportedly more common (15 times) at high altitude, only one child yielded auscultatory findings of a patent ductus arteriosus. It is unlikely that the examiner (an experienced pediatric cardiologist) would have overlooked the murmur

Table 3c. Data for non-permanent non-Aymara residents. Distribution of diseases and disorders among the non-permanent non-Aymara residents examined in the population of the Department of Arica, by sex and ecological niche.

| Disease category | ICDA code | Coast | | | | Sierra | | | | Altiplano | | | | Total | | | |
|---|--------------|----------------|----------------|---------|----|--------|----|---------|----|-----------|----|---------|----|-------|-----|---------|---|
| | | Males | | Females | | Males | | Females | | Males | | Females | | Males | | Females | |
| | | C ^a | A ^b | C | A | C | A | C | A | C | A | C | A | C | A | C | A |
| Infective and parasitic | 000-136 | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - | 1 | - | 1 |
| Neoplasms | 140-239 | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | - | - |
| <i>Malignant</i> | 140-209 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <i>Benign or unspecified</i> | 210-239 | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | - | - |
| Endocrine, nutritional, metabolic | 240-279 | - | 5 | - | 5 | 2 | - | 1 | - | - | - | - | - | 7 | - | 6 | |
| <i>Diabetes mellitus</i> | 250 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| Blood, blood forming organs | 280-289 | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | 2 | |
| Mental disorders | 290-315 | - | - | 1 | - | 2 | - | - | 1 | - | - | - | - | 3 | - | 1 | |
| Nervous system, sense organs | 320-389 | - | 3 | - | 2 | 5 | - | - | 3 | - | 1 | - | 11 | - | 3 | | |
| <i>Nervous system</i> | 320-358 | - | 2 | - | - | 1 | - | - | - | - | - | - | 3 | - | - | | |
| <i>Eye</i> | 360-379 | - | - | - | - | - | - | - | 2 | - | - | - | 2 | - | - | | |
| <i>Ear, mastoid process</i> | 380-389 | - | 1 | - | 2 | 4 | - | - | 1 | - | 1 | - | 6 | - | 3 | | |
| Circulatory system | 390-458 | - | 17 | - | 8 | 27 | 2 | 2 | 6 | - | 1 | 1 | 50 | 2 | 11 | | |
| <i>Acute hypertension (≥ 160/95)</i> | 401 | - | 5 | - | 3 | 7 | - | - | 5 | - | - | - | 17 | - | 3 | | |
| <i>Borderline hypertension (≥ 140/90)</i> | 401.0 | - | 5 | - | 1 | 11 | - | - | 1 | - | 1 | - | 17 | - | 2 | | |
| <i>Acute myocardial infarction</i> | 410 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | |
| <i>Other ischemic heart disease</i> | 411-414 | - | 4 | - | - | 2 | - | - | - | - | - | - | 6 | - | - | | |
| <i>All other heart disease</i> | 390-429 | - | 2 | - | 2 | 3 | 2 | - | - | - | - | - | 1 | 5 | 2 | | |
| <i>Cerebrovascular disease</i> | 430-438 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | |
| Respiratory system | 460-519 | - | 2 | - | 1 | 2 | 3 | 5 | - | 2 | 1 | 1 | 2 | 7 | 6 | | |
| <i>Acute resp. infect. except influenza, tonsillitis, sinusitis</i> | 460-466 | - | 1 | - | 1 | 1 | - | 2 | - | - | 1 | 1 | 1 | 1 | 3 | | |
| <i>Pneumonia</i> | 480-486 | - | - | - | - | - | - | - | 1 | - | - | - | 1 | - | - | | |
| <i>Acute tonsillitis, hypertrophy of tonsils and adenoids</i> | 463,500 | - | - | - | - | 1 | 3 | 3 | - | - | - | - | 1 | 3 | 3 | | |
| Digestive system | 520-577 | - | 1 | - | 3 | 1 | - | - | - | - | - | - | 2 | - | 3 | | |
| <i>Inguinal hernia</i> | 550,552 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | |
| <i>Cholelithiasis, cholecystitis</i> | 574,575 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | |
| Genitourinary system | 580-629 | - | 1 | - | 2 | - | - | - | - | 1 | - | - | 1 | - | 3 | | |
| <i>Urinary system</i> | 580-599 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | | |
| <i>Hyperplasia of prostate</i> | 600 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | |
| <i>Disorders of menstruation</i> | 626 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | |
| Skin, subcutaneous tissue | 680-709 | - | 3 | - | 6 | 2 | 4 | 1 | 1 | - | 2 | - | 3 | 2 | 9 | | |
| Musculoskeletal, connect. tissue | 710-738 | - | 3 | - | 4 | 3 | - | - | 1 | - | - | - | 7 | - | 4 | | |
| <i>Arthritis, all forms</i> | 710-718 | - | - | - | - | 2 | - | - | - | - | - | - | 2 | - | - | | |
| Congenital anomalies | 740-759 | - | 2 | - | - | - | - | - | 2 | - | - | - | 4 | - | - | | |
| Symptoms, ill-defined conditions | 780-796 | - | 3 | - | 5 | 2 | 17 | 1 | 2 | - | 5 | 2 | 2 | 25 | 3 | | |
| Accidents | 800-999 | - | 1 | - | - | 1 | 1 | - | - | - | - | - | 2 | 1 | - | | |
| Conditions, exams w/o sickness | 793, Y00-Y13 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | |
| Total, all diagnoses | | - | 42 | - | 40 | 6 | 66 | 10 | 6 | - | 22 | 3 | 7 | 7 | 130 | | |
| People examined | | 3 | 16 | 1 | 24 | 7 | 39 | 6 | 10 | - | 10 | 1 | 3 | 10 | 65 | | |

^aC = children
^bA = adults
 - = 0

of patent ductus arteriosus, particularly since it was expected that the incidence would be high. It is possible, but not probable, that most of the infants with patent ductus arteriosus had died.

Diseases of the respiratory system. Common cold, bronchitis, tonsillitis, and pneumonia were the more common diagnoses in this disease category among both adults and children. Auscultatory findings suggesting asthma were not noted; but the older Aymara living at altitude commonly had

symptoms and auscultatory findings suggesting pulmonary tuberculosis.

Diseases of the digestive system. Severe dental caries and ill-defined gastrointestinal disorders constituted the bulk of adult problems; no single diagnosis stood out among children. Dental caries were often so severe that extraction was necessary.

Diseases of the genitourinary system. Prostate and menstrual disorders, in the latter case those associated with menopause, were relatively common.

Diseases of the skin and subcutaneous tissue. Cicatrix, keloids, and acquired keratoderma were the commonest of the skin diseases observed in adults and children.

Diseases of the musculoskeletal system and connective tissue. Among children deformities of the leg, most often as a result of trauma, constituted the principal pathology; among adults deformities were also common, but so too were arthritis and rheumatism.

Congenital anomalies. Ogival palate and deformities of the chest (pectus excavatum and pectus carinatum) predominated among the Aymara. The diagnosis of 14 congenital heart defect cases revealed an incidence among the Aymara similar to that found in the United States (7 per 1,000 population).

Symptoms and ill-defined conditions. Among children, enlarged lymph nodes and hemoptysis were the most frequent findings in this category; among adults, enlarged lymph nodes, hemoptysis, abdominal and/or joint pain, and senility were the predominant findings.

Accidents. Perforated eardrums, one or both, was the most common finding normally recorded in this category.

Concluding Remarks

Tables 2 and 3 indicate the numbers of male and female adults and children with observed diseases and disabilities, the nature of these diseases and disabilities, and the ecological niche and ethnic origins of those examined. Table 2 includes only people who said they had never lived outside their present area of residence (*costa, sierra, or altiplano*), while Table 3 includes only those who said they had spent at least 10 per cent of their lives in other regions. (As noted earlier, approximately 100 individuals were seen whose residential status placed them between the two groups described.)

We note that findings varied significantly for different regions and ethnic groupings, as well as for the same ethnic grouping in

different regions. For example, taking all altitudes together, systemic hypertension was more commonly observed among adult non-Aymara (in 33 of 220 subjects) than among mestizos (28 of 405), and was more often found among mestizos than among the Aymara (17 of 396). It is also interesting to note that the frequency of hypertension increased with increasing altitude among adult non-Aymara, decreased among the Aymara, and remained more or less constant among the mestizos. This increase among the non-Aymara cannot be accounted for solely in terms of the transitory increase in blood pressure which frequently accompanies migration to high altitude during the acclimatization process.

Many of the other altitude-related diagnoses seem to directly reflect differences in the rigors of life. Thus respiratory diseases increased with altitude, presumably because of colder temperatures and ill-heated homes; the rate of skin diseases reflecting the diminished moisture and increased cold was also elevated; and otitis media was more common. More evidence of past traumatic accidents was also seen at higher altitudes; this must reflect in part the limited health care available to people in these regions. Fractures often went unset. However, we did not see increased rates of arthritic or rheumatoid disorders, gall bladder disease, or other conditions which might be ascribable to differences in adaptation to altitude. We did not encounter clinically recognizable diabetes or obvious nutritional disorders. Obese as well as undernourished individuals were encountered in all groups and at all altitudes; however, obesity was rarer among the Aymara and undernourished individuals were somewhat more common.

Interesting contrasts were also observed between "permanent" and "non-permanent" residents within given ethnic groups. Overall, it appears that migrants to a new region tended to experience the diseases and disorders associated with the region they

had entered rather than the one they had left behind. But this statement requires immediate qualification. In particular, the result is heavily influenced by infectious and parasitic disorders—respiratory diseases and the like—which undoubtedly account for the bulk of the disability prevalent in any population such as the one under discussion. It is also true that the three broad ecological zones in the Department of Arica differ so markedly in temperature, humidity, and atmospheric pressure that diseases or conditions which relate directly to these physical parameters can and do differ—as in the case of the acquired keratoderma resulting from the chill and desiccation which occur at high altitude. However, as we have pointed out in the case of hypertension, there are also real differences between migrants and non-migrants which suggest some more fundamental biological response to environmental stress. Unfortunately, rather than elucidating the nature of this stress response, our data merely serve to indicate its existence.

Viewed in terms of public health needs, some consolation may be obtained from this general observation, for it implies that public health authorities need not anti-

cipate two totally different sets of health care requirements, one for “immigrants” and the other for permanent residents. Some acute problems will differ in frequency, however, and provision must be made for their occurrence. Such provision must include an awareness—by both professionals and the lay public—of those disorders which may be virtually unique or which may occur with elevated frequency among immigrants.

Our observations suggest a need for other more specific public health activities. Steps should be taken to promote improved dental care, particularly preventive work, and also—if needed—reconstructive work capable of obviating severe tooth loss. The current school health programs are clearly beneficial, but do not reach the older individuals requiring some reinforcement of earlier education. A program in the *sierra* and *altiplano* to improve skin hygiene would have immediate rewards. Continuation of the use of BCG in children is clearly indicated. And, finally, the routine use of chloramphenicol, largely by the *practicantes*,¹¹ should be discouraged; penicillin involves significantly less risk, is less expensive, and is usually more effective.

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¹¹Members of the police force (Carabineros) who have had two years of paramedical training.

SUMMARY

During the Multinational Andean Genetic Health Program initiated in the Chilean Department of Arica in 1972, some 2,096 Arica residents were given thorough medical examinations. This article reports data obtained from these examinations, which were conducted in the months of October and November of 1973 and 1974.

All of those examined were classified in terms of their area of residence (the *costa*, *sierra*, or *altiplano*); whether they had always resided in

the same area; their ethnic origins; and their age and sex. Differences were observed in the incidence of particular diseases and disabilities among diverse ethnic groups—those occupying similar ecological niches as well as those occupying different niches. It was also found that “migrants” tended to experience the health problems of their new, as opposed to their old, places of residence. Some of the public health implications of these and other findings are discussed briefly.

REFERENCES

- (1) Hurtado, A. Acclimatization to high altitudes. In: W.H. Weihe (ed.). *Physiological Effects of High Altitude*. Pergamon Press, Oxford, England, 1964.
- (2) Monge M., Carlos, and Carlos Monge C. *High Altitude Disease: Mechanism and Management*. Charles C. Thomas, Springfield, 1966.
- (3) Frisancho, A. R. Functional adaptation to high altitude hypoxia. *Science* 187:313-319, 1975.
- (4) Lewis, J. G., and J. E. Gardner. The relation of serum uric acid to haemoglobin level in patients with cardiac and respiratory disease. *J Clin Pathol* 13:502-505, 1960.
- (5) Page, L. B., A. Damon, and R. C. Moellering. Antecedents of cardiovascular disease in six Solomon Islands societies. *Circulation* 49:1132-1146, 1974.
- (6) Hall, A. P. Correlations among hyperuricemia, hypercholesterolemia, coronary disease and hypertension. *Arthritis Rheum* 8:846-852, 1965.
- (7) Jacobs, D. Hyperuricaemia and myocardial infarction. *S Afr Med J* 46:367-369, 1972.
- (8) McEwin, R., K. McEwin, and B. Loudon. Raised serum uric acid levels with myocardial infarction. *Med J Aust* 1:530-532, 1974.
- (9) Klein, R., B. E. Klein, J. C. Cornoni, J. Maready, J. C. Cassel, and H. A. Tyroler. Serum uric acid: Its relationship to coronary heart disease risk factors and cardiovascular disease, Evans County, Georgia. *Arch Intern Med* 132:401-410, 1973.
- (10) Ciswicka-Sznajderman, M., H. Ignatowska-Switalska, and M. Sznajderman. Uric acid level, coronary heart disease and serum lipids. *Pol Med J*. 11:233-237, 1972.
- (11) Allard, C., and C. Goulet. Serum uric acid: Not a discriminator of coronary heart disease in men and women. *Can Med Assoc J* 109: 986-988, 1973.
- (12) Dawber, T. R. Coronary heart disease. *Bibl Cardiol* (Basel) 13:9-24, 1963.
- (13) Heyden, S., L. Walker, C.G. Hames, and H. A. Tyroler. Decrease of serum cholesterol level and blood pressure in the community: Seven to nine years of observations in the Evans County study. *Arch Intern Med* 128:982-986, 1971.
- (14) Erf, L. A. Radioactive phosphorus in the treatment of primary polycythemia (Vera). In: L. M. Tocantins (ed.). *Progress in Hematology*. Grune and Stratton, New York, 1956.
- (15) Marticorena, E., D. Penalosa, J. Severino, and K. Hellriegel. Frequency of patent ductus arteriosus at high altitude. Fourth World Congress of Cardiology, Mexico, 1962.
- (16) Rossena, H. Unpublished observations.
- (17) Hurtado, A. *Aspectos fisiológicos y patológicos de la vida en la altura*. Imprenta Rimac, Lima, 1937.
- (18) Hurtado, A. Relación de los estudios de altura con la clínica y la fisiología en general. *Gaceta Médica* (Lima) 1:57-59, 1944.
- (19) Cosio, G., Z. Hematic and cardiopulmonary characteristics of the Andean miner. *Bull Pan Am Health Organ* 7(1):26-33, 1973.
- (20) Morgan, W.K.C., N. L. Lapp, and A. Seaton. Respiratory impairment in simple coal workers' pneumoconiosis. *J Occup Med* 14:839-844, 1972.
- (21) Marek, K., and A. Kujawska. L'influence des lésions pneumoconiotiques précoces sur la fonction respiratoire. *Bull Physio-Path Resp* 9:1173-1187.
- (22) Morgan, W.K.C., R. Reger, D. B. Burgess, and E. Shoub. A comparison of the prevalence of coal workers' pneumoconiosis and respiratory impairment in Pennsylvania bituminous and anthracite miners. *Ann NY Acad Sci* 200:252-259, 1972.
- (23) Hellriegel, K. Incidencia del cáncer

pulmonar en un centro minero-industrial de los Andes del Perú central. *Revista Médica de Yauli* (Oroya, Peru) 1-2:16, 1962.

(24) Hurtado, A. Pathological aspects of life at high altitudes. *Milit Med* 117:272-284, 1955.

(25) Hurtado A. Some clinical aspects of life at high altitude. *Ann Intern Med* 53:247-258, 1960.

(26) Morton, W. E., D. J. Davids, and J. A. Lichty. Mortality from heart disease at high altitude. *Arch Environ Health* 9:21-24, 1964.

(27) Keck, C. W., R. K. St. John, T. M. Daniel, M. Pantoja, D. Danielson, and W. W. Fox. Tuberculosis in the Yungas area of Bolivia. *Health Serv Rep* 88:499-507, 1973.

(28) Buck, A. A., T. T. Sasaki, and R. I. Anderson. *Health and Disease in Four Peruvian Villages: Contrasts in Epidemiology*. The Johns Hopkins Press, Baltimore, 1968.

(29) Omran, A. R., W. J. McEwen, and M. H. Zaki. *Epidemiological Studies in Bolivia*. Research Institute for the Study of Man, New York, 1967.

(30) Cruz-Coke, R., A. P. Cristoffanini, M. Aspillaga, and F. Biancani. Evolutionary forces in human populations in an environmental gradient in Arica, Chile. *Hum Biol* 38:421-438, 1966.

(31) Schull, W. J., and F. Rothhammer. A multinational Andean genetic and health program: Rationale and design of a study of adaptation to the hypoxia of altitude. In: J. S. Weiner (ed.). *Genetic and Non-Genetic Components in Physiological Variability*, Vol. 18. Society for the Study of Human Biology, London, 1977.

(32) Gordon, T., and B. Devine. Hypertension and hypertensive heart disease in adults: United States, 1960-1962. In: *Vital and Health Statistics*. U.S. Public Health Service, Publication No. 1,000, Series 11 (No. 13), p. 62; Washington, D.C., 1966.

(33) Lauer, R., and W. H. Weidman. Unpublished data from SCOR, University of Iowa and Mayo Clinic, Rochester, Minnesota.

(34) U.S. Department of Health, Education, and Welfare, Public Health Service, National Center for Health Statistics. *Eighth Revision, International Classification of Diseases*. U.S. Government Printing Office, Washington, D. C., 1968.

(35) Marienfeld, C. J., M. Robins, R. P. Sandridge, and C. Findlan. Rheumatic fever and rheumatic heart disease among U.S. college freshmen, 1956-1960. *Public Health Rep* 79:789-811, 1964.