

Original Research Article

Behavioral Changes Associated with Economic Development in the South Pacific: Health Transition in Vanuatu

KELSEY NEEDHAM DANCAUSE,^{1,2*} CHRISTA DEHUFF,² LAURA E. SOLOWAY,^{2,3} MIGUEL VILAR,^{2,4} CHIM CHAN,² MICHELLE WILSON,^{2,5} LEN TARIVONDA,⁶ RALPH REGENVANU,⁷ AKIRA KANEKO,^{8,9,10} RALPH M. GARRUTO,² AND J. KOJI LUM²

¹Department of Psychiatry, McGill University, Montreal, Quebec, Canada H4H1R3

²Department of Anthropology, Binghamton University, Binghamton, New York 13902

³New York State Department of Health, New York State Cancer Registry, Albany, New York 12204

⁴Department of Anthropology, University of Pennsylvania, Philadelphia, Pennsylvania 19104

⁵Department of Anthropology, Henry Ford Community College, Dearborn, Michigan 48128

⁶Department of Public Health, Ministry of Health, Port Vila PMB 009, Vanuatu

⁷Vanuatu National Cultural Council, Port Vila, Vanuatu

⁸Global COE, Nagasaki University Institute of Tropical Medicine, Nagasaki 852-8501, Japan

⁹Unit of Parasitology, Osaka City University Graduate School of Medicine, Osaka 545-8585, Japan

¹⁰Island Malaria Group, Karolinska Institute, Stockholm SE-171 77, Sweden

ABSTRACT Health patterns are changing in developing countries; as diet and activity patterns change with economic development, chronic disease prevalence increases, which is a characteristic of health transition. The islands of Vanuatu (South Pacific) have varying rates of economic development and provide a natural experimental model of health transition.

Objectives: To characterize behavioral changes associated with modernization.

Methods: We surveyed 425 children and 559 adults on three islands varying in degree of economic development. We assessed diet (24-h dietary recall), physical activity (mode of transport, work activities, and recreation), substance use, and other behavioral patterns.

Results: Spending patterns and access to Western foods followed modernization gradients in our sample, whereas occupational patterns and ownership of technological goods were poor markers of modernization. With increasing economic development, participants consumed more animal proteins and simple carbohydrates. Physical activity levels were high; most participants were active in gardening, and sports were popular, especially in urban areas. However, urban participants spent more time in sedentary recreation. Men's use of alcohol and tobacco increased with economic development, but we observed marked differences in substance use patterns between two rural islands—one with and one without tourism.

Conclusions: Economic development in Vanuatu is accompanied by nutrition transition and increased sedentary recreation, although physical activity levels remain high. Differences in substance use patterns between rural islands with and without tourism indicate a need for more research in rural areas. These findings might inform research in other communities in the early stages of health transition. *Am. J. Hum. Biol.* 23:366–376, 2011. © 2011 Wiley-Liss, Inc.

Health burdens are changing in developing countries around the globe. Prevalence of noncommunicable diseases such as cardiovascular disease (CVD) and Type II Diabetes Mellitus—previously, diseases of developed nations—are increasing rapidly (Boutayeb and Boutayeb, 2005; McMichael, 2000). Populations in developing countries also suffer persisting infectious diseases, maternal and child undernutrition, and psychosocial illnesses such as alcoholism and depression that are exacerbated by rapid cultural change (Amuna and Zotor, 2008; WHO, 2010). Many Pacific Island nations are experiencing these multiple burdens characteristic of health transition (Baker and Bindon, 1993; Baker and Garruto, 1992a,b; Ohtsuka and Ulijaszek, 2007), especially as diets begin to include fewer traditional foods (nutrition transition) and participation in sedentary wage labor increases. Because the health care systems in many developing countries lack resources to treat costly chronic diseases (Prentice, 2006), efforts to monitor and prevent chronic diseases, before they reach overwhelming rates, are imperative.

Countries in the early phases of health transition represent natural experimental models (Garruto et al., 1999) in which the contributions of behavioral, biological, and environmental variables on chronic disease risk can be examined before chronic diseases have become widespread.

Such studies often benefit from relatively high degrees of genetic and cultural homogeneity, which provide natural internal controls. The South Pacific archipelago of Vanuatu (see Fig. 1) provides such a model. Level of economic development and patterns of health and illness are currently changing, and at varying rates among islands. For example, a review of hypertension in developing countries from 1980 to 1998 found that rural populations of Vanuatu had the lowest prevalence in the world (2% among men and women), but in urban areas prevalence reached 5% among men and 12% among women by the end of the study period (Fuentes et al., 2000). Similarly, surveys in 1984 (Finlayson et al., 1988) and 1985 (Taylor

Contract grant sponsors: Binghamton University Laboratory of Evolutionary Anthropology and Health, the Graduate Program in Biomedical Anthropology; Contract grant sponsor: NSF Doctoral Dissertation Improvement Award; Contract grant number: BCS-0925664.

*Correspondence to: Kelsey Needham Dancause, McGill University, Douglas Hospital Research Center, 6875 LaSalle Blvd., Verdun, Quebec, Canada H4H1R3. E-mail: kelseydancause@gmail.com

Received 7 December 2009; Revision received 31 October 2010; Accepted 1 December 2010

DOI 10.1002/ajhb.21146

Published online 8 March 2011 in Wiley Online Library (wileyonlinelibrary.com).

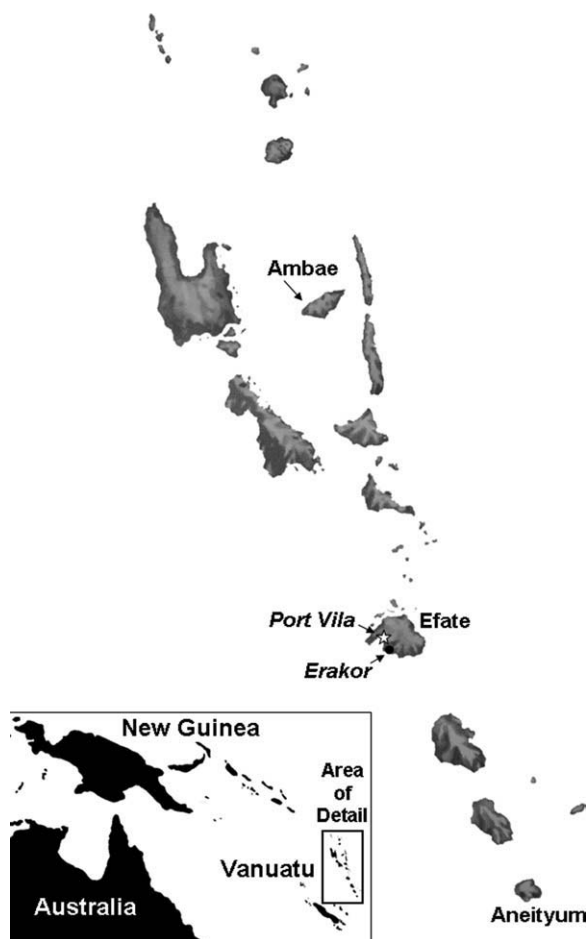


Fig. 1. Map of Vanuatu, with study locations.

et al., 1991) found that blood pressure, prevalence of hypertension, overweight, and obesity were higher in Port Vila, the urban capital, compared with rural areas. By 1998, 46% of men in Vanuatu and 52% of women were overweight and 12 and 20%, respectively, were obese (Prentice, 2006). These figures are consistent with increasing urbanization. Between 1965 and 2000, the percentage of Vanuatu's population in urban areas increased from 10.9% to 20.0% (FAO, 2003).

At the same time that chronic diseases are increasing, undernutrition and malaria and other infectious diseases represent continuing health burdens in the archipelago. In 2005, ~20% of children in Vanuatu were underweight (UNICEF, 2005) and almost 10,000 cases of malaria were reported (WHO Regional Office for the Western Pacific, 2010). These combined health burdens are characteristic of early phases of health transition.

Numerous Pacific studies suggest that increasing rates of chronic diseases are associated with migration to urban areas (Joseph et al., 1983; Ostbye et al., 1989; Pawson and Janes, 1982; Prior et al., 1974; Salmond et al., 1985), urbanization (Baker et al., 1986; Benjamin, 2006; Coyne et al., 1984; DiBello et al., 2009; Ezeamama et al., 2006; Friedlaender, 1987; Harvey and Heywood, 1983; Hodge et al., 1995; Kende, 2001; King et al., 1994; Lindeberg et al., 1999; McGarvey et al., 1989; McGarvey, 1991; Norgan, 1995; Rus-

sell-Jones et al., 1990; Saweri, 2001; Taylor et al., 1991, 1992; Ulijaszek, 2003; Zimmet et al., 1978), and having relatives in urban areas, who send remittances and influence attitudes about cultural change (Ulijaszek, 2005). However, identifying specific behavioral changes associated with modernization is difficult. Studies characterizing modernization through measures of employment, housing, and education help to identify populations experiencing change that might be at risk of increased chronic diseases, but do not necessarily illuminate behaviors to target for prevention. Many studies focus on only adults, highlighting already-adopted behaviors but ignoring patterns that youth might be only beginning adopt. Finally, remote areas that are difficult to sample are often neglected. Thus, while numerous invaluable studies have shown a link between modernization and chronic disease risk, there remains a need for studies that assess behaviors of people of all ages in areas with differing levels of economic development.

The gradient of economic development and differences in health burdens among islands make Vanuatu a good natural experimental model of health transition. Data collected from each island represent a cross-sectional "snapshot" of the life cycle of a population experiencing health transition. We analyzed behavioral differences within and among islands to characterize how behaviors change with economic development. This forms the first component of a study to identify behaviors associated with increased chronic disease risk, which could be useful for designing prevention measures.

MATERIALS AND METHODS

Field methods

Fieldwork was completed in June and July 2007. We sampled six villages on three islands. Surveys on the islands of Ambae and Aneityum were organized in collaboration with annual malarionometric screenings conducted by the Karolinska Institute Infectious Disease Unit and the Vanuatu Ministry of Health. Aneityum was originally chosen for malarionometric surveys in 1991, because its small size (about 160 km²) and population (< 1,000 residents) made it an ideal site to examine the feasibility of malaria eradication programs. Ambae was surveyed beginning in 2002 to provide a (mesoendemic) comparison to Aneityum. Most residents of sampled villages voluntarily attend these screenings, and of the participants ages seven and above who attended in 2007, 89.9% in Ambae and 87.7% in Aneityum chose to complete the health transition survey afterwards. Our sample in the village of Erakor on the island of Efate differed from these because no malarionometric surveys were conducted there. Rather, members of the Vanuatu Ministry of Health and the research team contacted local church leaders and presented the details of the study, and church leaders invited community members to attend.

Key demographic characteristics of the sampled regions, and for Vanuatu as a whole, are summarized in Tables 1 and 2. These figures are from the 1999 census (VNSO, 1999), the most detailed source of demographic data on the regions sampled until analysis of the 2009 census is complete. Our convenience sample was intended to represent a wide range of ages and lifestyle patterns. The sex ratio (men/100 women) of our adult participants (104.8) was similar to the nationwide figures in urban (107.9) and rural (104.4) areas (VNSO, 2009). Similarly,

the percentage of participants in rural areas (77%) mirrored the nationwide figure of 76% (VNSO, 2009). However, ~43% of our participants were aged 7–17, whereas this age group accounted for only about 35% of the national population in 1999 (VNSO, 1999). All participants were “Ni-Vanuatu” (Melanesians from Vanuatu).

The villages of Redcliff and Sakau, in South Ambae, are rural; access to the nearest urban center, about 60 km away, is by small plane or boat, and the rugged roads on the island make vehicle travel very difficult (see Fig. 2). There is little involvement in the tourism industry. The villages of Port Patrick, Umej, and Anelcauhat, in Aneityum, are also rural. However, Aneityum has a thriving tourism industry, particularly since malaria was eradicated in 1991 (Kaneko et al., 2000). The Aneityum Tourism Committee estimates that 38 ships (paying docking fees of ~\$5,000 each) and 58,000 tourists, on average, visited Aneityum each year in 2005 and 2006. Ships dock, and most tourism activities are centered, at tiny nearby “Mystery Island” (where residents returning from travel and visitors to the main island are also screened for malaria). Residents of Anelcauhat are only minutes by boat from Mystery Island, while those in Umej and Port Patrick must travel by boat around the island or walk the hilly trails to Anelcauhat—about 12 km from Umej and 26 km from Port Patrick. Erakor, in Efate, is a suburb of the country’s bustling urban capital, Port Vila, which its residents can access easily by boat or vehicle—ferries and buses are numerous and relatively inexpensive—or in just over an hour by foot.

Behavioral survey

We designed a survey to ascertain participants’ ancestry; number of liveborn biological and adopted children; education; an index of selected household and technological goods; number and relationships of family members with hypertension, CVD, and obesity; work and leisure

TABLE 1. Rural and urban demographic characteristics (all inhabited islands) based on 1999 Vanuatu census

	Urban	Rural	Total population
Population <15 yrs	14,205	63,204	77,409
Population 15–59 yrs	23,135	71,564	94,699
Population ≥60 yrs	880	8,291	9,172
Median age	21.0	18.1	18.8
Life expectancy at birth: Males	69.5	64.4	65.6
Life expectancy at birth: Females	74.2	67.4	69.0

activities; dietary patterns; food expenditures; and substance use patterns. The survey was written in English, and members of the Vanuatu Ministry of Health translated it into Bislama, the lingua franca of Vanuatu. We included open-ended questions to facilitate discussion.

Dietary patterns were assessed using 24-h dietary recall. We also assessed frequency of fresh meat, tinned meat, fresh fish, and tinned fish consumption, because animal protein intake typically increases during nutrition transition (Popkin, 2009). Frequency responses were coded as “daily or almost daily,” “weekly,” “monthly,” and “yearly.” To assess activity patterns, we asked participants their mode of transportation to work, the store, and their gardens (walking, bicycle, car/truck/bus, boat) and, if they walked, how many minutes and how often. We asked participants if they played sports, watched TV or videos, and listened to the radio or cassette tapes; how often (“daily,” “weekly,” “monthly,” “yearly”); and for how long, on average. Finally, we asked participants if they smoked, drank alcohol, and drank kava (a traditional extract made from the root of *Piper methysticum* with mostly sedative effects); if so, how often (“daily,” “weekly,” “monthly,” “yearly”); and how many times, on average, each day, week, month, or year.

Statistical methods

Survey responses were entered into a database and descriptive statistics were analyzed for each island and village. One-way ANOVA was used to test differences of means among villages and islands. Categorical variables were analyzed using Chi-square test for independence. Statistical analyses were completed using Microsoft Excel Statistical Package and Statistica version 6. Statistical significance was defined as $P < 0.05$.

RESULTS

Sample characteristics

Total number of biological and adopted children per adult participant did not differ within or among islands, averaging 4.2 in Ambae (rural), 4.2 in Aneityum (rural with tourism), and 3.6 in Efate (urban). For women age 45 and over, total number of liveborn biological children averaged 5.5 in Ambae, 5.9 in Aneityum, and 4.3 in Efate. Women’s reports likely exclude some children who were born alive but died early in life; however, these figures are comparable to the national fertility rate of 4.8 measured in the 1999 census (VNSO, 1999).

TABLE 2. Sample and island characteristics of the present study

Sample Characteristics	Island (villages)			
	Ambae (Redcliff, Sakau)	Aneityum (Anelcauhat, Port Patrick, Umej)	Efate (Erakor)	
Children (ages 7–17)	Male	42	106	53
	Female	43	105	76
	Total	85	211	129
Adults (≥ age 18)	Male	51	166	69
	Female	77	172	24
	Total	128	338	93
Island sample size	213	549	222	
Malaria endemicity	Mesoendemic	Eradicated in 1991	Low in urban areas	
Level of economic development in 2007	Low	Moderate	High	
Area population size based on 1999 census	South Ambae 967	Aneityum (all villages) 821	Erakor 977	

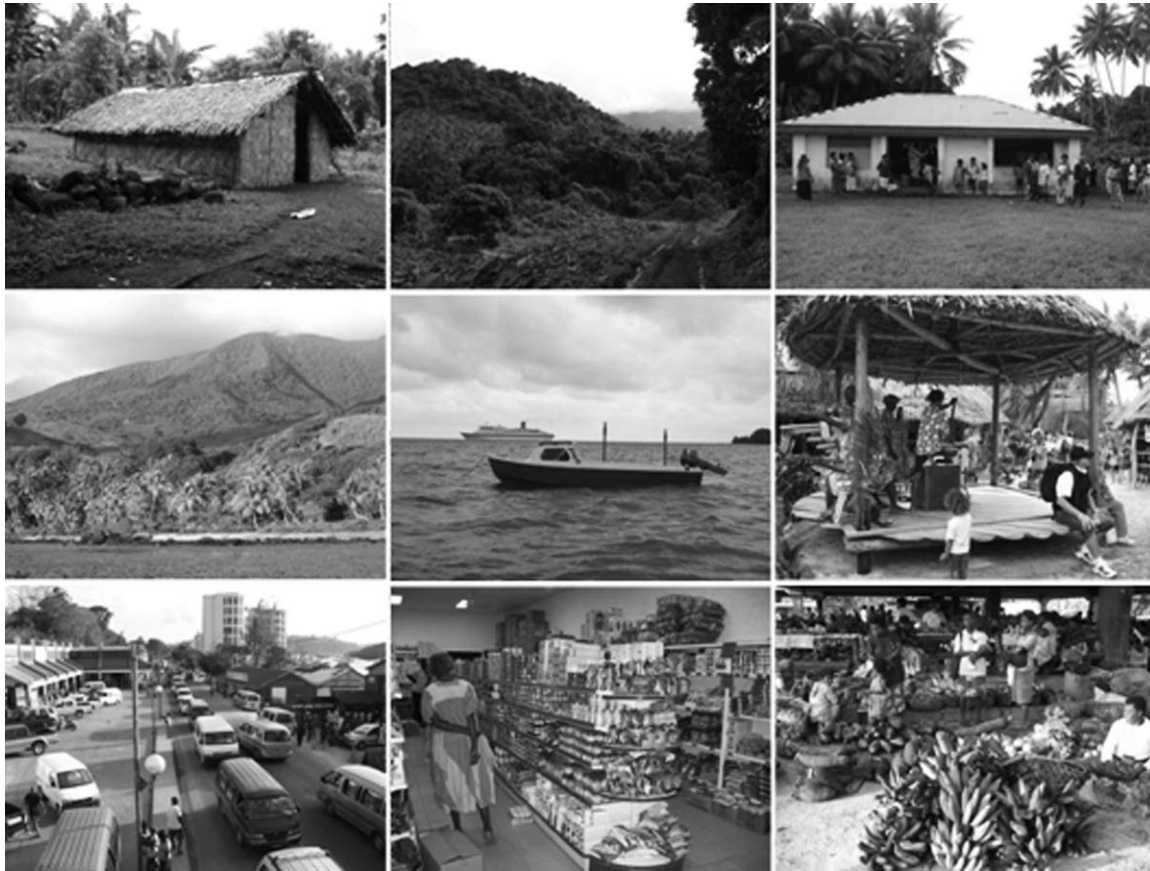


Fig. 2. Island characteristics. Top: Ambae. A traditional thatched home; one of the rugged roads of Southern Ambae; grass landing field and air terminal. Middle: Aneityum. The terrain is hilly and people might walk several hours to traditional gardens. A cruise ship arrives toward tiny Mystery Island, offshore from the main island. Many families participate in string bands and selling items to tourists. Bottom: Efate. Residents of Erakor, a suburb of the capital, can access the city center easily by bus. Families buy food both at grocery stores and at the local open-air market.

Mean years of education did not differ significantly between men and women, but differed significantly among islands, averaging, among men, 5.9 in Ambae, 6.7 in Aneityum, and 7.6 in Efate ($P = 0.015$); and, among women, 5.2 in Ambae, 6.1 in Aneityum, and 7.1 in Efate ($P = 0.021$). The percentage of men and women, respectively, with no formal education was 8.0 and 6.0 in Ambae and 6.4 and 6.9 in Aneityum; only one participant in Efate had no formal education. Most adult men and women had traveled outside of their home island (78.5% in Ambae, 97.3% in Aneityum, and 88.8% in Efate), although fewer traveled at least once each year (18.9% in Ambae, 29.7% in Aneityum, and 45.9% in Efate) or outside of Vanuatu (9.1% in Ambae, 10.7% in Aneityum, and 57.3% in Efate).

Summary of household possessions

Ownership of selected technological goods was higher in Efate than in Ambae and Aneityum, but did not follow a general increasing trend with modernization. Significantly more participants in Efate had cars or trucks (12.0% of participants), computers (7.6%), microwaves (8.7%), refrigerators (53.3%), televisions (79.3%), and mobile phones (56.5%) compared with Ambae and Aneityum where, in the five villages, ownership of trucks (used

mostly for logging) ranged from 0% to 5.9%, computers 0% to 2.8%, refrigerators 0% to 3.2%, televisions 0% to 4.2%, and mobile phones 0% to 7.4%. We expected that fewer participants in Efate would own livestock, but in fact, more participants in Umej, Aneityum had no livestock (24.4%), followed by Efate (23.3%). Radios were the only technological goods that followed a modernization gradient, and were owned by 23.0% of participants in Ambae, 44.0% in Aneityum, and 81.5% in Efate.

Reported illnesses and obesity

The percentage of participants who reported having blood relatives with hypertension or CVD, or who appeared overweight or obese, differed among ($P < 0.001$) but not within islands. Hypertension or CVD among family members was reported by 19.7% of participants in Ambae, 35.3% in Aneityum, and 45.1% in Efate. Overweight or obesity among family members was reported by 24.8% of participants in Ambae, 48.0% in Aneityum, and 39.6% in Efate.

Work activities

Gardening and housekeeping were the main work activities on all islands, even in the urban sample, reported by

90.2% of men and all but one woman (a full-time student) in Ambae, 84.0% of men and 88.8% of women in Aneityum, and 60.9% of men and 78.3% of women in Efate. The other main occupations in Ambae and Aneityum included teaching (for both men and women) and logging (men only). In Efate, the other main occupations were in the tourism industry—11.6% of men and 8.7% of women worked as receptionists, security guards, masseuses, and cooks at hotels and resorts, and 7.2% of men drove taxis or ferries, often for resorts. Participants from Aneityum also worked in tourism, playing in string bands, guiding tours, and selling hand-made crafts, food, and T-shirts or trinkets manufactured elsewhere and sold at “Duty Free” stands. Of the adult participants, 14.2% of men and 21.7% of women reported working regularly at Mystery Island, though many more were observed to participate. A further 12.3% of men worked for the Aneityum Tourism Project as managers, security guards, and boat drivers. Only five children or teenagers, all from Anelcauhat (2.9% of that sample) reported working at Mystery Island, but many more children were observed selling things to tourists, playing in string bands, and posing for photos for a donation.

Diet

Twenty-four-hour dietary recall patterns were compared among islands for 123 adults from Ambae, 328 from Aneityum, and 93 from Efate. One of the most striking differences was variation in animal protein consumption (see Fig. 3). Only 7.5% of Efate adults consumed neither meat nor fish the day before, compared with 30.7% in Aneityum and 41.4% in Ambae ($P < 0.001$). Furthermore, 32.3% of Efate adults ate multiple meat or fish dishes the day before, compared to only 7.3% in Aneityum and 2.4% in Ambae ($P < 0.001$). Other major differences among islands included consumption of rice or noodles, and bread or biscuits, both of which were significantly higher ($P < 0.001$) in Efate than in Ambae or Aneityum. Traditional vegetable (such as island cabbage) and starch (such as taro and yam) consumption was high on all islands.

Differences within islands were not statistically significant, but some trends on Aneityum were noteworthy. Consumption of multiple meats and fish, fresh meat, tinned meat, tinned fish, and rice or noodles was highest in Anelcauhat, the village closest to the tourism center. The most striking was tinned fish, reported by 2.7 times as many participants in Anelcauhat (39 of 210, or 18.6%, of adults) as in Port Patrick and Umej (8 of 118, or 6.7%, of adults).

We analyzed dietary recalls for 48 children from Ambae, 180 from Aneityum, and 121 from Efate. To analyze the validity of reports, we compared responses of siblings, who might be expected to share similar diets, and we observed consistency in reports. In general, children's patterns matched those of adults (see Fig. 3). Compared with adults, children were more likely to consume tinned fish in Aneityum ($P < 0.001$) and bread/biscuits ($P < 0.001$) in Efate, and were less likely to eat traditional vegetables and starches in Aneityum ($P = 0.002$) and Efate ($P = 0.003$). Mirroring the trend of adults, all of the Aneityum children who reported eating tinned fish the day before were from the village closest to the tourism center (Anelcauhat).

We analyzed frequency of fresh meat, tinned meat, fresh fish, and tinned fish consumption for 58 adults from Ambae, 125 from Aneityum, and 60 from Efate. Differences were statistically significant among islands ($P <$

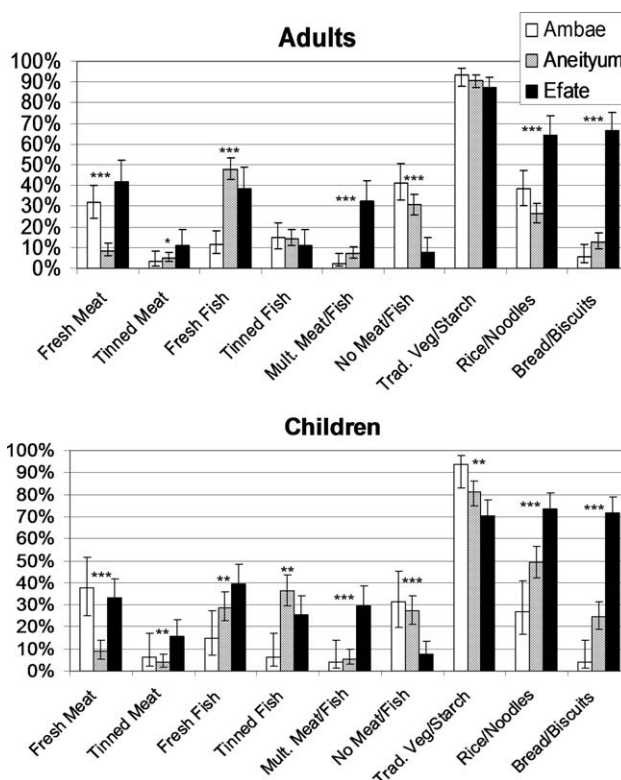


Fig. 3. Twenty-four hour dietary recalls by island. Bars indicate 95% confidence intervals. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

0.001) except for tinned fish, which approached statistical significance ($P = 0.058$) (see Fig. 4). Tinned meat was consumed only monthly or yearly by 73.5% of participants in Ambae and 55.1% in Aneityum, whereas over 80% of Efate participants ate tinned meat on a daily or weekly basis. Efate participants were also more likely to consume fresh meat daily. Similarly, more participants in Efate and Aneityum ate fresh fish daily compared with Ambae, where fish was more often consumed weekly. Children's patterns were similar to adults (data not shown).

While subject to a number of methodological problems associated with children's dietary recalls, the foods children listed taking to school (for those children who did not go home to eat) is perhaps telling. The top ten foods reported were: in Ambae ($n = 47$), bananas (74%), manioc (45%), taro (36%), chicken (32%), island cabbage (30%), rice (30%), yam (21%), laplap (15%), fresh fish (15%), and tinned fish (15%); in Aneityum ($n = 127$), manioc (51%), island cabbage (39%), fresh fish (34%), taro (33%), rice (28%), bananas (20%), tinned fish (18%), sugarcane (14%), yam (11%), and fruit (including grapefruit, oranges, pineapple, and pawpaw—10%); and in Efate ($n = 112$), fried bread (donuts—43%), bread (35%), cookies (30%), chips (23%), lemonade (20%), candy (18%), fruit (including grapefruit, mango, pawpaw, and oranges—13%), rice (11%), popsicles (10%), and bananas (8%).

Spending patterns

Table 3 summarizes mean and median weekly expenditures on “store-bought” foods in vatu, the currency of

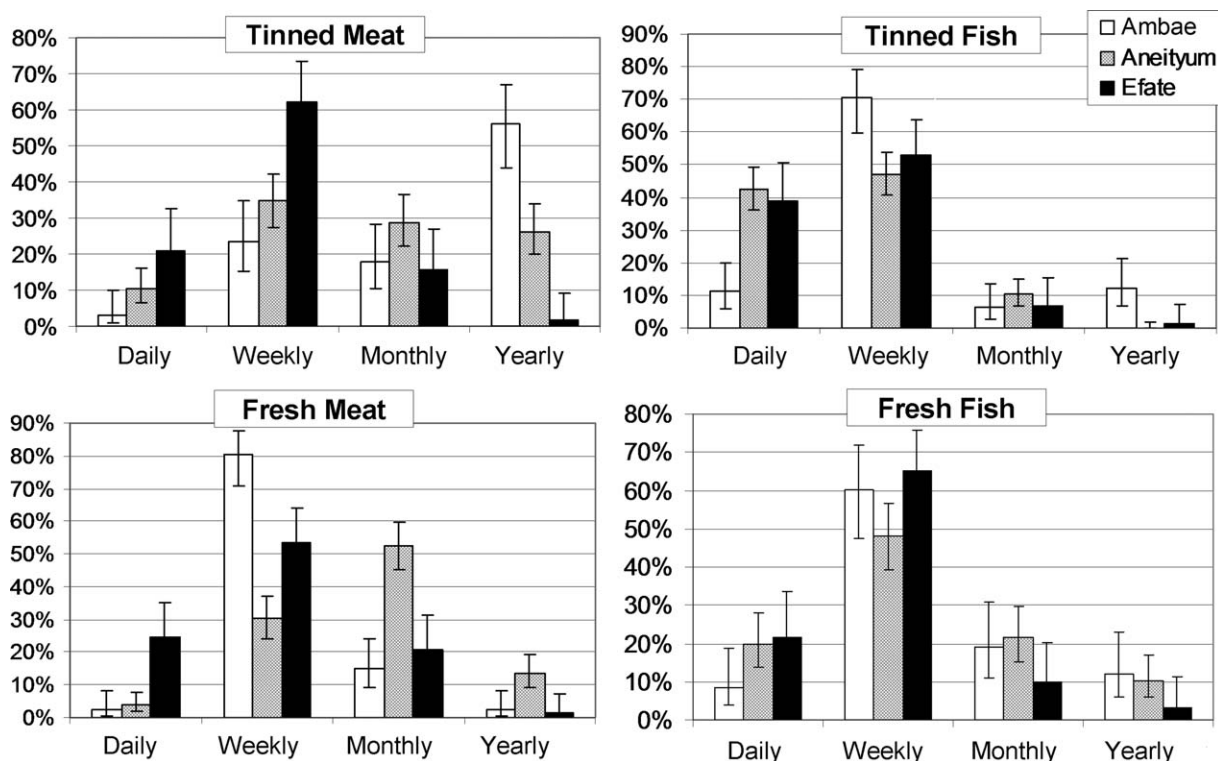


Fig. 4. Frequency of adult fish and meat consumption by island. Bars indicate 95% confidence intervals.

Vanuatu, for 86 adults from Ambae, 106 from Aneityum, and 56 from Efate. These expenditures do not include traditional fruits and vegetables purchased from neighbors or open-air markets. Mean expenditures differed significantly ($P < 0.001$) among islands. We did not adjust amounts for family size because total family size was similar among islands and because family size might not reflect the number of individuals eating in the home, especially where extended families live in close proximity. Although mean amounts did not differ significantly within islands, in Aneityum participants in Port Patrick, the village furthest from the tourism center, spent less on average than those in Umej and Anelcauhat, which are closer to the tourism center (1,015 vatu compared with 1,241 and 1,264 vatu, respectively). The wide range of weekly expenditures illustrates the great variability in spending patterns observed.

Our survey did not specifically address children's and teenagers' purchasing patterns, but a few volunteered information about their purchases of, in the words of one 11-year-old boy, "junk foods." In Ambae, only one child (ages 7–12) out of 27 who discussed purchases, and no teenagers (ages 13–17), reported buying snacks such as chips, candy, and fried bread. In Aneityum, by contrast, 13 out of 51 children (25.5%) and 38 out of 90 teenagers (42.2%) reported buying these foods. Only three Efate children and 12 teenagers discussed purchases; two of the three children and one of the 12 teenagers reported buying "junk foods." Patterns were similar between boys and girls.

Most participants in Ambae and Aneityum (89.8% and 79.4%, respectively) had never eaten in a restaurant. Among those who had, the mean number of visits (during the life-

TABLE 3. Adult weekly expenditures on food from stores by island, in vatu

	Ambae ($n = 86$)	Aneityum ($n = 106$)	Efate ($n = 56$)
Mean	867	1,187	3,586
Median	500	1,000	3,000
Range	50–5,000	100–5,000	300–12,000

In 2007, 100 vatu \approx \$1 USD.

time) was 2.6 in Ambae and 5.2 in Aneityum. In Efate, by contrast, 10% of participants ate in restaurants daily, 17.8% weekly, 35.6% monthly, and 36.7% yearly or less.

Physical activity

Seven of 280 adult participants in Aneityum (2.5%, including four men and three women), and seven of 93 adult participants in Efate (7.5%, all men) had jobs requiring little physical activity, such as working in an office or driving a bus. All but one adult (a man in Efate) maintained gardens, usually one or two nearby and one or more farther away. Nearby gardens were usually in the yard of the home or within less than 10 min walk. Farther gardens ranged from 30 min to four hours away by foot. In Ambae and Efate, participants walked 40 min to their farther gardens, on average, multiple times each week. In Aneityum, participants walked about 2 h 15 min, on average, once each week. While all participants in Ambae and Aneityum walked to their gardens, 25.0% of women and 17.1% of men in Efate reported taking a truck to those that were far.

Similarly, all participants in Ambae and Aneityum who had jobs outside the home walked to work except nine

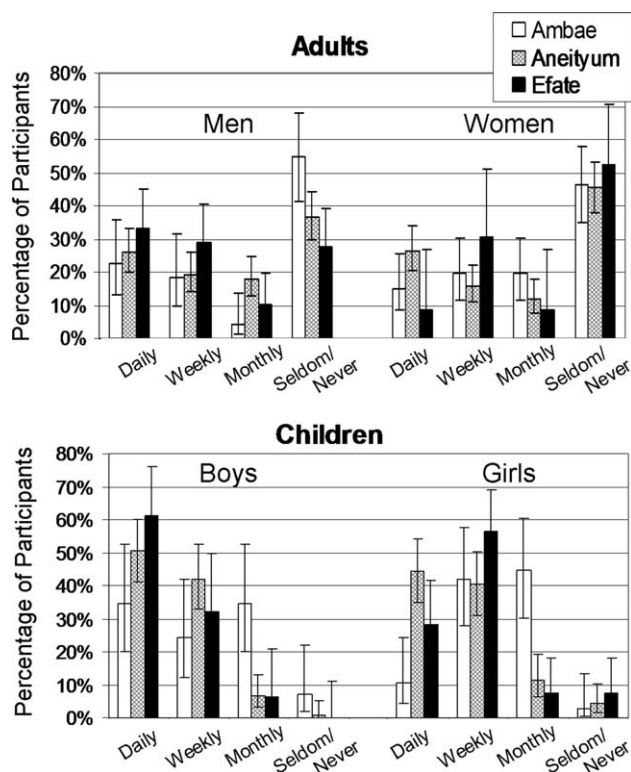


Fig. 5. Frequency of sports participation by island. Bars indicate 95% confidence intervals.

men who worked in forestry and rode to the logging site. In contrast, 69.0% of the men in Efate reported taking a car, bus, or ferry to work. Only four women in our Efate sample worked regularly outside the home, and all took the bus to work. All participants in Ambae and Aneityum and 91.3% of men and 91.7% of women in Efate walked to the store. Most walked less than five minutes (70.1% in Ambae, 63.5% in Aneityum, and 59.0% in Efate). In Ambae and Aneityum, the store was more than 30 min away by foot for 10.3% and 5.6% of participants, respectively; these participants usually walked to the store once a week or less. Considering these figures, participants averaged roughly 22 min each week walking to and from the store in Ambae, 30 min in Aneityum, and 34 min in Efate.

We compared sports participation among islands for 105 adults in Ambae, 282 in Aneityum, and 79 in Efate. Volleyball and soccer were popular on all three islands. Frequency differed significantly among islands for adult men ($P = 0.015$) and boys and girls ($P < 0.001$), but not for adult women (see Fig. 5). About half of the women from all islands, and more than half of the men in Ambae, reported seldom or never playing sports. Similarly, children were less likely to play sports regularly in Ambae compared to Aneityum and Efate. Although sports participation was lower among adults than children, many adults were still regularly active in sports, especially in Efate. Between 34.3% and 42.4% of women played sports daily or weekly, and between 40.8% and 62.3% of men. In general, sex differences were less pronounced in Aneityum than the other islands.

Mean amount of time spent in sedentary recreation, including watching television or videos and listening to

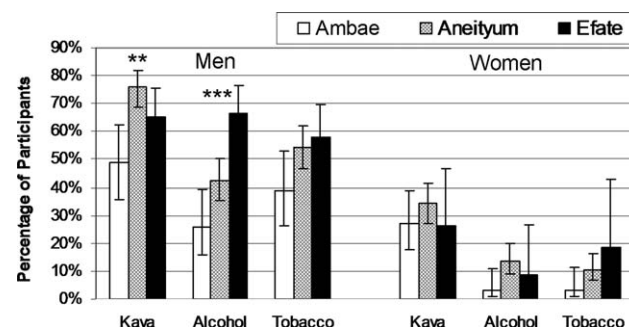


Fig. 6. Adult substance use by island: Prevalence of any use. Bars indicate 95% confidence intervals. $**P < 0.01$; $***P < 0.001$. Substance use frequency patterns differed among islands. See Results: Substance Use.

radio or cassette tapes, differed significantly among islands for adults ($P < 0.001$) and children ($P = 0.024$). In Aneityum, men spent more time in sedentary recreation than women ($P = 0.040$). Daily sedentary recreation for adult men and women, respectively, averaged 48 and 32 min in Ambae; 57 and 38 min in Aneityum; and 3.7 and 3.2 h in Efate. Figures for boys and girls, respectively, averaged 37 and 57 min in Ambae; 55 and 52 min in Aneityum; and 2 h and 1.6 h in Efate. Many more participants in Ambae and Aneityum reported seldom or never watching television or listening to the radio than in Efate (45.4%, 34.1%, and 1.1% of adults, respectively, and 32.1%, 29.1%, and 0% of children). Few children reported spending ≥ 4 h each day in these activities (1.8% in Ambae, 2.4% in Aneityum, and 0 in Efate), and few adults in Ambae (2.1%) and Aneityum (2.9%), whereas 36.7% of Efate adults spent ≥ 4 h each day in sedentary recreation. These patterns did not differ by sex.

Substance use

We analyzed substance use patterns for 50 men and 64 women from Ambae, 162 men and 161 women from Aneityum, and 69 men and 23 women from Efate. The percentage of participants who used kava, alcohol, and tobacco is shown in Figure 6. Use of kava and alcohol varied significantly among islands for men ($P = 0.0014$ and $P < 0.001$, respectively). Differences in alcohol use among islands approached statistical significance for women ($P = 0.064$). In general, use of all three substances was lowest in Ambae, and was lower among women than among men. Betel nut was used by only five participants, all young men from Anelcauhat, Aneityum.

Most differences in substance use frequency were not statistically significant, but some trends were observed. For example, whereas 81.8% of those men in Ambae and 90.9% in Aneityum who drank alcohol did so only monthly or yearly, 52.2% of Efate men who drank did so on a daily or weekly basis. Smoking frequencies presented different patterns. While Efate had the greatest percentage of smokers, Aneityum had the heaviest smokers: the percentage of men who smoked 10 or more times daily was 11.1 in Ambae, 42.0 in Aneityum, and 18.2 in Efate ($P = 0.074$), and men averaged 5.9 cigarettes per day in Ambae, 11.7 in Aneityum (after removing one outlier, a report of four packs per day), and 4.8 in Efate ($P = 0.001$). Differences were not statistically significant among women, but

followed the same pattern: women averaged 0.5 cigarettes per day in Ambae, 5.5 in Aneityum, and 3.4 in Efate. Most men and women who drank kava did so on a daily or weekly basis with the exception of Aneityum, where most women (73.1%) who drank kava did so only monthly or yearly.

Our survey did not specifically address youth substance use patterns, though some teenagers volunteered this information. In Ambae, two 17-year-old boys reported using alcohol, kava, and tobacco, one 12-year-old reported chewing betel nut, and one 6-year-old reported drinking kava. We cannot verify the younger boys' reports, although children in the Solomon Islands Project (Friedlaender, 1987) began smoking tobacco and chewing betel nut at age five, so perhaps these reports from Vanuatu are valid. Three 17-year-old boys in Efate reported using beer, kava, and tobacco. Finally, alcohol use was reported by five boys in Anelcauhat, kava by six, and tobacco by nine, all ages 14–17. One 16-year-old boy in Anelcauhat reported using betel nut. While these data do little to characterize youth substance use patterns, they do indicate that alcohol, kava, and tobacco are available to teenagers in both rural and urban areas.

DISCUSSION

Assessing the progress of and the behaviors associated with modernization is important if we are to identify communities at risk of increased chronic disease burdens and implement timely interventions. In Vanuatu, some indices of modernization that have been used in other studies, such as ownership of technological goods (see, for example, Soloway et al., 2009), did not follow a modernization gradient, owing to little variation in rural areas. Similarly, urban participants were still primarily involved in gardening, and occupation alone thus did not reflect modernization gradients. Here and in similar early transitional areas, modernization might be best reflected through education, and consumption of and expenditures on Western foods, indices that have been used successfully in the Solomon Islands Project (Page et al., 1977).

Similarly, patterns of reported illnesses and obesity did not necessarily follow a modernization gradient, although reports show that increasing obesity and chronic disease risk are associated with modernization in Vanuatu (Carlot-Tary, 2000). Reports of hypertension and CVD among family members were lowest in Ambae, intermediate in Aneityum, and highest in Efate, as expected; but reports of overweight/obese family members were higher in rural Aneityum than in urban Efate. Reports of hypertension and CVD in Efate might reflect greater awareness due to greater health care access than in rural areas. In contrast, reports of obesity are based on perceptions of ideal weight, which might change over time as cultural attitudes change (Becker et al., 2005; Brewis et al., 1998), especially among populations that have never experienced obesity epidemics before (Candib, 2007). Perhaps the perceived “healthy” body weight is lighter in Aneityum, where obesity prevalence is lower than in urban areas and most elements of modernization are increasing only recently. In contrast, fewer participants in Efate reported having obese family members despite the higher prevalence of obesity in the area. These results might suggest that where body weights have been increasing for several decades, the population has accepted a larger body size as

“healthy.” More research on this issue in Vanuatu (and in other early transitional areas) is necessary, since perceptions about healthy bodies can impact people's body satisfaction and health. For example, comparisons of body size and satisfaction between 1989 and 1998 in rural Fiji suggested that women in 1998 were less satisfied with their bodies and more likely to endorse efforts to lose weight, yet obesity prevalence continued to rise, perhaps reflecting associations between body dissatisfaction and binge eating (Becker et al., 2005). This highlights the importance of educating populations about healthy weights during transition (Prentice, 2006).

Dietary patterns

Diets can change remarkably rapidly during health transition, and analyses at the early stages of transition might reveal modest but important dietary differences with modernization. We used dietary recalls, which do not allow us to estimate individual energy and nutrient intake, but provide reasonable reflections of population-wide dietary patterns. With increasing modernization, participants incorporated more meat and fish into their diets, and more refined carbohydrate products such as bread, crackers, and instant noodles. They also consumed more rice, which is cheaper per calorie than traditional starches in urban areas and is preferred because it is quicker to prepare and easier to store (Foy, 1992). Similar dietary changes have been observed in Papua New Guinea, but whereas in those samples consumption of starchy roots decreased over time with increased reliance on rice (Harvey and Heywood, 1983; Saweri, 2001), traditional starch consumption remains high in Vanuatu. Between 1965 and 2000, the amount of daily excess energy intake increased 62% in Vanuatu (FAO, 2003). The consumption of more animal proteins and refined carbohydrates likely contributes to this trend.

Although children's patterns were, in general, similar to adults', more youth in Aneityum reported eating tinned fish, rice, noodles, bread, and biscuits compared with adults—dietary patterns that are associated with chronic disease risk (Carlot-Tary, 2000). Thus although children's dietary recalls can be difficult to conduct and interpret (Baxter, 2009), they might reflect subtle changes that would not be apparent in adults' reports and are a useful tool in early transitional areas.

The dietary differences we observed were reflected in spending patterns. In Aneityum, increased spending might be an important risk factor even at early ages; children and teenagers could earn their own money at Mystery Island to spend on snacks (and on tobacco and alcohol). Spending patterns might provide a way to predict which populations are at risk of increasing chronic diseases, since store-bought foods are usually more energy-dense and less nutrient-dense than traditional foods (Popkin, 2004).

Physical activity

Although self-reported activity surveys might not accurately reflect individual patterns or allow for quantification of energy expenditure, they can provide an overview of population-wide activity patterns which is useful in assessing differences between populations or over time. Whereas physical activity levels often decline with

increasing modernization (Katzmarzyk and Mason, 2009), physical activity levels differed less among islands than we expected. Participants in Efate were more likely than those on other islands to drive to their gardens that were far away, were less likely to walk to work, and spent more time in sedentary recreation, but they also had high levels of occupational and recreational physical activity. We expected that more adults in Efate would have sedentary occupations, but for most participants, gardening was the main occupation. This might reflect sampling bias, because attending the survey might have been inconvenient for people working in wage labor; but our results mirror those of the 1998 Vanuatu NCD survey, which found that only 13.6% of the total sample did not garden on a regular basis (Carlot-Tary, 2000). Sports were also popular, especially in Efate where, as in many urban areas, residents have more organized spaces to play (Katzmarzyk and Mason, 2009). In areas in the early stages of health transition, where overall physical activity levels remain high, differences between populations might be subtle and using accelerometers or pedometers to quantify estimated physical activity levels would help to distinguish these differences.

Substance use

Urbanization is associated with increasing availability of alcohol, tobacco, and other drugs, and with psychosocial stresses that might contribute to substance use (Boutayeb and Boutayeb, 2005). Among men in our sample, use of alcohol, kava, and tobacco was lowest in rural Ambae, and use of alcohol increased with modernization. However, men's use of kava and tobacco was almost as high or higher in rural Aneityum compared with that of urban Efate. Furthermore, women's use of kava and alcohol, although low in general, was higher in Aneityum than on the other two islands. The difference in use between rural Ambae and rural Aneityum suggests that slight differences in level of economic development might be associated with large differences in substance use.

Patterns of alcohol and tobacco use in Aneityum might reflect changes in access largely related to tourism. About one-third of Aneityum adults smoked and one-third of these smoked at least ten times each day. Participants said they bought cigarettes "whenever they had money" which, for most, is dependent on participation in Mystery Island tourism activities. Furthermore, chiefs in Aneityum have prohibited alcohol [as observed on other islands—see (Gregory et al., 1981)], but it is available at Mystery Island. Other interview reports might suggest changes in kava use in the future. Several young men in Aneityum said they preferred to grow marijuana than kava because it matures more quickly, and in Efate, several young adults reported avoiding kava because it is bad for the skin. Indeed, dry, scaly rashes are observed among long-term users (Gounder, 2006). A notable difference between kava and alcohol is energy content. One hundred grams of kava extract contains only about 6 kcal (Dignan et al., 2004), and drinking kava suppresses appetite (Lebot et al., 1997), whereas the high energy content of alcohol might contribute to adiposity.

Global implications of health transition

The health and behavioral patterns observed in Vanuatu mirror those of transitional areas across the

Asia-Pacific region and globally. For example, populations in Papua New Guinea suffer continuing undernutrition and infection (Ulijaszek, 2000), along with increasing BMI, prevalence of overweight (Benjamin, 2007; Ulijaszek, 1993), and central fat distribution (Norgan, 1987) largely associated with modernization since the 1950s. During this period, intake of protein, energy, and store-bought foods increased (Harvey and Heywood, 1983), just as observed in Vanuatu and across the Pacific, including in Fiji (Collins et al., 1996; Taylor et al., 1992), Guam (Guerrero et al., 2008), Kiribati (King et al., 1984a; Taylor et al., 1992), Nauru (King et al., 1984b; Ringrose and Zimmet, 1979; Sicree et al., 1987; Zimmet et al., 1978), New Caledonia (Papoz et al., 1996), Samoa (Baker et al., 1986; Dibello et al., 2009; Galanis et al., 1999), the Solomon Islands (Eason et al., 1987; Friedlaender, 1987), and Tuvulu (Wicking et al., 1981).

In fact, these patterns are observed in developing and transitional countries worldwide. For example, in rural Oaxaca, Mexico, prevalence of adult overweight/obesity increased about 46% among men and about 38% among women from 1978 to 2000, during which time participation in full-time farming dropped and participation in wage labor increased (Malina et al., 2007). In India, where urban areas already have high prevalence of obesity (Garg et al., 2010), rural areas are now also beginning to suffer rapid increases with increasing intake of animal fats and refined sugars, despite the continued burden of undernutrition among children (Balarajan and Villamor, 2009). In The Gambia, West Africa, obesity prevalence is increasing rapidly among women who depend heavily on vegetable oil and other nontraditional foods, and who accept large body size as an indicator of health, a perception reinforced by the association of thinness with HIV/AIDS (Prentice, 2006). And in the Seychelles, where a booming tourism and fishing industry have contributed to rapid increases in gross domestic product, prevalence of overweight/obesity more than doubled in only 7 years (Bovet et al., 2006).

Our survey indicates that the risk behaviors observed in transitional areas can change rapidly with relatively minor differences in level of economic development. For example, although both islands are rural, substance use patterns differ markedly between Aneityum, which has a thriving tourism industry, and Ambae, which does not. Even if their current levels of chronic diseases and obesity are lower than in urban areas, rural communities must not be neglected in early prevention efforts.

Common themes arise in effective intervention strategies. First, there is an increased focus on the dual burden of underweight and obesity. For example, recent interventions to reduce chronic disease risk in India have placed less emphasis on weight loss and more on improving diet quality in general: avoiding sugared drinks, improving fiber and protein intake, and focusing on local food sources (Balagopal et al., 2008). Second, rather than focusing on specific groups (such as obese women) or settings (such as schools), interventions are increasingly incorporating the entire community in their design, implementation, and assessment (Sanigorski et al., 2008). This is particularly important where body fatness might have positive connotations, such as in China, where the elder generation is likely to view a fat child as a healthy child (Gao et al., 2008). Educational campaigns teaching the message that excess body fat is unhealthy might be the most that many

developing countries can afford—a simple, yet critical message (Prentice, 2006). Focusing on modifiable behaviors and preventable risk now, for both adults and children, in both urban and rural areas, is critical to help populations enjoy the benefits of economic development while minimizing its potentially widespread health burdens.

ACKNOWLEDGMENTS

The authors would like to thank the local councils of chiefs and participants who welcomed them into their communities.

LITERATURE CITED

- Amuna P, Zotor FB. 2008. Epidemiological and nutrition transition in developing countries: impact on human health and development. *Proc Nutr Soc* 67:82–90.
- Baker PT, Bindon JR. 1993. Health transition in the Pacific Islands. *Am J Hum Biol* 5:5–7.
- Baker PT, Hanna JM, Baker TS, editors. 1986. *The changing Samoans: behavior and health in transition*. New York: Oxford University Press.
- Baker PT, Garruto RM. 1992a. Health transition: examples from the Western Pacific. *Hum Biol* 64:785–798.
- Baker PT, Garruto RM, editors. 1992b. Symposium on changes in disease patterns in the Western Pacific and Southeast Asia. *Hum Biol* 64:783–867.
- Balagopal P, Kamalamma N, Patel TG, Misra R. 2008. A community-based diabetes prevention and management education program in a rural village in India. *Diabetes Care* 31:1097–1104.
- Balarajan Y, Villamor E. 2009. Nationally representative surveys show recent increases in the prevalence of overweight and obesity among women of reproductive age in Bangladesh, Nepal, and India. *J Nutr* 139:2139–2144.
- Baxter SD. 2009. Cognitive processes in children's dietary recalls: insight from methodological studies. *Eur J Clin Nutr* 63:S19–S32.
- Becker AE, Gilman SE, Burwell RA. 2005. Changes in prevalence of overweight and in body image among Fijian women between 1989 and 1998. *Obes Res* 13:110–117.
- Benjamin AL. 2006. Community screening for high blood pressure among adults in urban and rural Papua New Guinea. *P N G Med J* 49:137–146.
- Benjamin AL. 2007. Body size of Papua New Guineans: a comparison of the body mass index of adults in selected urban and rural areas of Papua New Guinea. *P N G Med J* 50:163–171.
- Boutayeb A, Boutayeb S. 2005. The burden of non communicable diseases in developing countries. *Int J Equity Health* 4:2.
- Bovet P, Chiolerio A, Madeleine G, Gabriel A, Stettler N. 2006. Marked increase in the prevalence of obesity in children of the Seychelles, a rapidly developing country, between 1998 and 2004. *Int J Pediatr Obes* 1:120–128.
- Brewis AA, McGarvey ST, Jones J, Swinburn BA. 1998. Perceptions of body size in Pacific Islanders. *Int J Obes Relat Metab Disord* 22:185–189.
- Candib LM. 2007. Obesity and diabetes in vulnerable populations: reflection on proximal and distal causes. *Ann Fam Med* 5:547–556.
- Carlot-Tary M. 2000. 1998 Vanuatu non-communicable disease survey report. Noumea: Multipress.
- Collins VR, Dowse GK, Cabealawa S, Ram P, Zimmet PZ. 1996. High mortality from cardiovascular disease and analysis of risk factors in Indian and Melanesian Fijians. *Int J Epidemiol* 25:59–69.
- Coyne T, Badcock J, Taylor R. 1984. The effect of urbanization and Western diet on the health of Pacific Island populations. South Pacific commission technical paper 186. Noumea: South Pacific Commission.
- DiBello JR, McGarvey ST, Kraft P, Goldberg R, Campos H, Qusted C, Laumoli TS, Baylin A. 2009. Dietary patterns are associated with metabolic syndrome in adult Samoans. *J Nutr* 139:1933–1943.
- Dignan C, Burlingame B, Kumar S, Aalbersberg W. 2004. *The Pacific Islands food composition tables*, 2nd ed. Rome: Food and Agriculture Organization of the United States.
- Eason RJ, Pada J, Wallace R, Henry A, Thornton R. 1987. Changing patterns of hypertension, diabetes, obesity and diet among Melanesians and Micronesians in the Solomon Islands. *Med J Aust* 146:465–469, 473.
- Ezeamama AE, Viali S, Tuitele J, McGarvey ST. 2006. The influence of socio-economic factors on cardiovascular disease risk factors in the context of economic development in the Samoan archipelago. *Soc Sci Med* 63:2533–2545.
- FAO (Food and Agriculture Organization of the United States). 2003. *Nutrition country profiles: Vanuatu*. Rome, Italy: FAO. Available at: <ftp://ftp.fao.org/esn/nutrition/ncp/van.pdf>.
- Finlayson PJ, Caterson ID, Rhodes KM, Plehwe WE, Hannelley T, Silink M. 1988. Diabetes, obesity and hypertension in Vanuatu. *P N G Med J* 31:9–18.
- Foy T. 1992. Food security in a South Pacific context: the case of rice in Vanuatu. *Pac Econ Bull* 7:32–40.
- Friedlaender JS, editor. 1987. *The Solomon Islands project: a long-term study of health, human biology, and culture change*. Oxford: Clarendon Press.
- Fuentes R, Imaniemmi N, Laurikainen E, Tuomilehto J, Nissinen A. 2000. Hypertension in developing economies: a review of population-based studies carried out from 1980 to 1998. *J Hypertens* 18:521–529.
- Galanis DJ, McGarvey ST, Qusted C, Sio B, Afele-Fa'amuli SA. 1999. Dietary intake of modernizing Samoans: implications for risk of cardiovascular disease. *J Am Diet Assoc* 99:184–190.
- Gao Y, Griffiths S, Chan EY. 2008. Community-based interventions to reduce overweight and obesity in China: a systematic review of the Chinese and English literature. *J Public Health (Oxf)* 30:436–448.
- Garg C, Khan SA, Ansari SH, Garg M. 2010. Prevalence of obesity in Indian women. *Obes Rev* 11:105–108.
- Garruto RM, Little MA, James GD, Brown DE. 1999. Natural experimental models: the global search for biomedical paradigms among traditional, modernizing, and modern populations. *Proc Natl Acad Sci U S A* 96:10536–10543.
- Gounder R. 2006. Kava consumption and its health effects. *Pac Health Dialog* 13:131–135.
- Gregory RJ, Gregory JE, Peck JG. 1981. Kava and prohibition in Tanna, Vanuatu. *Br J Addict* 76:299–313.
- Guerrero RT, Paulino YC, Novotny R, Murphy SP. 2008. Diet and obesity among Chamorro and Filipino adults on Guam. *Asia Pac J Clin Nutr* 17:216–222.
- Harvey PW, Heywood PF. 1983. Twenty-five years of dietary change in Simbu Province, Papua New Guinea. *Ecol Food Nutr* 13:27–35.
- Hodge AM, Dowse GK, Koki G, Mavo B, Alpers MP, Zimmet PZ. 1995. Modernity and obesity in coastal and Highland Papua New Guinea. *Int J Obes Relat Metab Disord* 19:154–161.
- Joseph JG, Prior IA, Salmund CE, Stanley D. 1983. Elevation of systolic and diastolic blood pressure associated with migration: the Tokelau island migrant study. *J Chronic Dis* 36:507–516.
- Kaneko A, Taleo G, Kalkoa M, Yamar S, Kobayakawa T, Björkman A. 2000. Malaria eradication on islands. *Lancet* 356:1560–1564.
- Katzmarzyk PT, Mason C. 2009. The physical activity transition. *J Phys Act Health* 6:269–280.
- Kende M. 2001. Superiority of traditional village diet and lifestyle in minimizing cardiovascular disease risk in Papua New Guineans. *P N G Med J* 44:135–150.
- King H, Collins V, King LF, Finch C, Alpers MP. 1994. Blood pressure, hypertension and other cardiovascular risk factors in six communities in Papua New Guinea, 1985–1986. *P N G Med J* 37:100–109.
- King H, Taylor R, Zimmet P, Pargeter K, Raper LR, Beriki T, Tekanene J. 1984a. Noninsulin-dependent diabetes (NIDDM) in a newly independent Pacific nation: the Republic of Kiribati. *Diabetes Care* 7:409–415.
- King H, Zimmet P, Pargeter K, Raper LR, Collins V. 1984b. Ethnic differences in susceptibility to non-insulin-dependent diabetes. A comparative study of two urbanized Micronesian populations. *Diabetes* 33:1002–1007.
- Lebot V, Merlin M, Lindstrom L. 1997. *Kava—the Pacific elixir: the definitive guide to its ethnobotany, history, and chemistry*. Rochester: Healing Arts Press.
- Lindeberg S, Eliasson M, Lindahl B, Åhrén B. 1999. Low serum insulin in traditional Pacific Islanders: the Kitava study. *Metabolism* 48:1216–1219.
- Malina RM, Reyes ME, Tan SK, Buschang PH, Little BB. 2007. Overweight and obesity in a rural Amerindian population in Oaxaca, Southern Mexico, 1968–2000. *Am J Hum Biol* 19:711–721.
- McGarvey ST. 1991. Obesity in Samoans and a perspective on its etiology in Polynesians. *Am J Clin Nutr* 53(6 Suppl):1586S–1594S.
- McGarvey ST, Bindon JR, Crews DE, Schendel DE. 1989. *Modernization and adiposity: causes and consequences*. In: Little MA, Haas JD, editors. *Human population biology*. New York: Oxford University Press. pp 263–279.
- McMichael AJ. 2000. The urban environment and health in a world of increasing globalization: issues for developing countries. *Bull World Health Organ* 78:1117–1126. Review.
- Norgan NG. 1987. Fat patterning in Papua New Guineans: effects of age, sex and acculturation. *Am J Phys Anthropol* 74:385–392.
- Norgan NG. 1995. Changes in patterns of growth and nutritional anthropometry in two rural modernizing Papua New Guinea communities. *Ann Hum Biol* 22:491–513.
- Ostbye T, Welby TJ, Prior IA, Salmund CE, Stokes YM. 1989. Type 2 (non-insulin-dependent) diabetes mellitus, migration and westernisation: the Tokelau Island migrant study. *Diabetologia* 32:585–590.
- Ohtsuka R, Ulijaszek SJ, editors. 2007. *Health change in the Asia-Pacific region: biocultural and epidemiological approaches*. Cambridge: Cambridge University Press.

- Page LB, Friedlaender JS, Moellering R. 1977. Culture, human biology and disease in the Solomon Islands. In: Harrison GA, editor. Population structure and human variation. London: Cambridge University Press. pp 143–156.
- Papoz L, Barny S, Simon D. 1996. Prevalence of diabetes mellitus in New Caledonia: ethnic and urban-rural differences. CALDIA Study Group. Caledonia diabetes mellitus Study. *Am J Epidemiol* 143:1018–1024.
- Pawson IG, Janes G. 1982. Biocultural risks in longevity: Samoans in California. *Soc Sci Med* 16:183–190.
- Popkin BM. 2004. The nutrition transition: an overview of world patterns of change. *Nutr Rev* 2004; 62:S140–S143.
- Popkin BM. 2009. Global changes in diet and activity patterns as drivers of the nutrition transition. *Nestle Nutr Workshop Ser Pediatr Program* 63:1–10; discussion 10–14, 259–268.
- Prentice AM. 2006. The emerging epidemic of obesity in developing countries. *Int J Epidemiol* 35:93–99.
- Prior IA, Stanhope JM, Evans JG, Salmond CE. 1974. The Tokelau Island migrant study. *Int J Epidemiol* 3:225–232.
- Ringrose H, Zimmet P. 1979. Nutrient intakes in an urbanized Micronesian population with a high diabetes prevalence. *Am J Clin Nutr* 32:1334–1341.
- Russell-Jones DL, Hoskins P, Kearney E, Morris R, Katoaga S, Slavin B, Turtle JR. 1990. Rural/urban differences of diabetes—impaired glucose tolerance, hypertension, obesity, glycosylated haemoglobin, nutritional proteins, fasting cholesterol and apolipoproteins in Fijian Melanesians over 40. *Q J Med* 74:75–81.
- Salmond CE, Joseph JG, Prior IA, Stanley DG, Wessen AF. 1985. Longitudinal analysis of the relationship between blood pressure and migration: the Tokelau Island migrant study. *Am J Epidemiol* 122:291–301.
- Sanigorski AM, Bell AC, Kremer PJ, Cuttler R, Swinburn BA. 2008. Reducing unhealthy weight gain in children through community capacity-building: results of a quasiexperimental intervention program, be active eat well. *Int J Obes (Lond)* 32:1060–1067.
- Sicree RA, Zimmet PZ, King H, Coventry JS. 1987. Weight change amongst Nauruans over 6.5 years: extent, and association with glucose intolerance. *Diabetes Res Clin Pract* 3:327–336.
- Saweri W. 2001. The rocky road from roots to rice: a review of the changing food and nutrition situation in Papua New Guinea. *P N G Med J* 44:151–163.
- Soloway LE, Demerath EW, Ochs N, James GD, Little MA, Bindon JR, Garruto RM. 2009. Blood pressure and lifestyle on Saba, Netherlands Antilles. *Am J Hum Biol* 21:319–325.
- Taylor R, Jalaludin B, Levy S, Montaville B, Gee K, Sladden T. 1991. Prevalence of diabetes, hypertension and obesity at different levels of urbanisation in Vanuatu. *Med J Aust* 155:86–90.
- Taylor R, Badcock J, King H, Pargeter K, Zimmet P, Fred T, Lund M, Ringrose H, Bach F, Wang R, Sladden T. 1992. Dietary intake, exercise, obesity and noncommunicable disease in rural and urban populations of three Pacific Island countries. *J Am Coll Nutr* 11:283–293.
- Ulijaszek SJ. 1993. Evidence for a secular trend in heights and weights of adults in Papua New Guinea. *Ann Hum Biol* 20:349–355.
- Ulijaszek SJ. 2000. Nutrition, infection and child growth in Papua New Guinea. *Coll Antropol* 24:423–429.
- Ulijaszek SJ. 2003. Socio-economic factors associated with physique of adults of the Purari delta of the Gulf Province, Papua New Guinea. *Ann Hum Biol* 30:316–328.
- Ulijaszek S. 2005. Modernisation, migration and nutritional health of Pacific Island populations. *Environ Sci* 12:167–176.
- UNICEF (United Nations Children's Fund). 2005. Vanuatu: a situation analysis of children, women and youth. Suva: UNICEF Pacific Office.
- VNSO (Vanuatu National Statistics Office). 1999. Demographic analysis report—1999 population census. Port Vila: Statistics Office.
- VNSO (Vanuatu National Statistics Office). 2009. Official release of 2009 census household listing counts. Available at: <http://www.spc.int/prism/country/vu/stats/>. Last Accessed on: April 21, 2010.
- WHO (The World Health Organization). 2010. Programmes and Projects: Glossary of globalization, trade and health terms, health transition. Available at: <http://www.who.int/trade/glossary/story050/en/index.html>. Last Accessed on: January 7, 2010.
- WHO (The World Health Organization). Regional Office for the Western Pacific. 2010. Malaria epidemiology, Vanuatu. Available at: http://www.wpro.who.int/sites/mvp/epidemiology/malaria/van_profile.htm. Last Accessed on: April 22, 2010.
- Wicking J, Ringrose H, Whitehouse S, Zimmet P. 1981. Nutrient intake in a partly westernized isolated Polynesian population: the Funafuti survey. *Diabetes Care* 4:92–95.
- Zimmet P, Arblaster M, Thoma K. 1978. The effect of westernization on native populations. Studies on a Micronesian community with a high diabetes prevalence. *Aust N Z J Med* 8:141–146.