

virtue of aide visits. A design that would have allowed agreement to participate prior to randomization was not deemed feasible in the City-Hospital clinic environment, but is an obvious further research step.

#### REFERENCES

1. Trager B: Homemaker/home health aide services in the United States. Public Health Service, Health Services Administration, Bureau of Community Health Services, DHEW pub. no. (HSM) 73-6407, 1973.
2. Hallowitz E, Riesman F: The role of the indigenous nonprofessional in a community mental health neighborhood service center program. *Am J Orthopsychiatry* 1967; 378:766.
3. Wise HB, Terry E, Fuller M, *et al*: The family health worker. *Am J Public Health* 1968; 58:1828.
4. Knittel RE, Child RC, Hobgood MA: Role and training of health education aides. *Am J Public Health* 1971; 61:8.
5. Budner S, Arnold I, Goodman L: The plan and the reality: training and utilization of paraprofessionals for service to retarded. *Am J Public Health* 1971; 61:297.
6. Young MM, Hamlin CP: People workers: a local health department's experience with health education aides. *Am J Public Health* 1969; 59:1845.
7. Nielson M, Blenkner M, Bloom M: Home Aide Service and the Aged: A Controlled Study. Part I: Design and Findings. Cleveland: Benjamin Rose Institute, 1970.
8. Wang VL, Ephross PH, Green LW: The point of diminishing returns in nutrition education through home visits by aides: an evaluation of EPNEP. *Health Education Monographs* 1975; 3:30.
9. Metz R: Objectives of therapy. Sussman & Metz (eds): *Diabetes Mellitus* (4th ed). New York: American Diabetes Association, 1975.
10. Colvez A, Blanchet M: Disability trends in the United States population 1966-76: analysis of reported causes. *Am J Public Health* 1981; 71:464.
11. American Diabetes Association: Principles of nutrition and dietary recommendations for individuals with diabetes mellitus. *Diabetes* 1979; 28:1027.
12. Cobb S: Social support as a moderator of life stress. *Psychosom Med* 1976; 38:300.
13. Kaplan BH, Cassel J, Gore S: Social support and health. *Med Care* 1977; 5:47.
14. Bray G (ed): Standards for definition of overweight and obesity. *In: Obesity in Perspective. A conference sponsored by the Fogarty International Center for Advanced Study in the Health Sciences.* NIH Pub. No. (NIH) 75-7085. Bethesda, MD: NIH, 1975.
15. Davidson JK, Alogna M, Goldsmith M, *et al*: Assessment of program effectiveness at Grady Memorial Hospital, Atlanta. *In: Steiner G, Lawrence PA (eds): Educating Diabetic Patients.* New York: Springer, 1981.
16. Miller LV, Goldstein J, Kumar D, *et al*: Assessment of program effectiveness at the Los Angeles County, University of Southern California Medical Center. *In: Steiner G, Lawrence PA (eds): Educating Diabetic Patients.* New York: Springer, 1981.
17. University Group Diabetes Program: *Diabetes (Suppl 2)* 1970; 19:789.

#### ACKNOWLEDGMENTS

The research for this paper was supported by the NIAMDK, Grant No. 20579, through the Diabetes Research and Training Center, Department of Internal Medicine, Washington University School of Medicine, W. H. Daughaday, Principal Investigator.

## Waterborne Giardiasis at a Mountain Resort: Evidence for Acquired Immunity

GREGORY R. ISTRE, MD, THOMAS S. DUNLOP, G. BARRY GASPARD, AND RICHARD S. HOPKINS, MD

**Abstract:** In November 1981, an outbreak of waterborne giardiasis occurred at a popular ski resort in Colorado. Stratification of illness by consumption of municipal tap water showed a striking dose-response, with an attack rate of 42 per cent among persons who drank six or more glasses of water per day. Filtered water samples revealed *Giardia* cysts in specimens both before and after treatment, and several deficiencies were found in the water treatment facility. Residents who had lived in the area >2 years had a lower attack rate for illness than short-term residents. (*Am J Public Health* 1984; 74:602-604.)

#### Introduction

One of the first recognized waterborne outbreaks of giardiasis in the United States occurred in Aspen, Colorado, in 1965<sup>1</sup>; since then, other communities have reported similar outbreaks.<sup>2-4</sup> In Colorado, outbreaks of waterborne giardiasis have been reported with increasing frequency in the past several years.

Acquired immunity to *Giardia* has been postulated for

humans,<sup>5,6</sup> but epidemiologic evidence for immunity has been scarce. We recently had the opportunity to investigate an outbreak of giardiasis at a mountain resort in Colorado with evidence suggesting possible acquired immunity to *Giardia*.

#### Background

Aspen Highlands, a community of about 165 persons, is situated near the base of the Aspen Highlands ski area in the White River National Forest approximately 4 km north of the city of Aspen. The community water supply was taken from a creek passing near the base of the ski area.

In early December 1981, the Aspen-Pitkin Environmental Health Department received several telephone reports of diarrhea among residents of Aspen Highlands. There were no reports of illness among town of Aspen residents. A team of local and state health department investigators began an epidemiologic study of the problem in Aspen Highlands.

#### Methods

After initial interviews with ill persons had revealed no common meals or exposures, we administered questionnaires by telephone on December 2-5 to Aspen Highlands residents, and questioned a small sample of Aspen city residents who lived in the nearby area.\*

Stool specimens preserved in 10 per cent formalin-saline and in polyvinyl alcohol were obtained from a sample of ill and of well persons interviewed and were examined micro-

Address reprint requests to Gregory R. Istre, MD, Epidemiology Service, Oklahoma State Department of Health, 1000 NE 10th, Oklahoma City, OK 73152. Dr. Istre, was with the Field Services Division, Epidemiology Program Office, Centers for Disease Control, assigned to the Colorado Department of Health, Denver; Mr. Dunlop is with the Aspen-Pitkin Environmental Health Department; and Mr. Gaspard and Dr. Hopkins are with the Communicable Disease Control Section, Colorado Department of Health, Denver. This paper, submitted to the *Journal* July 14, 1983, was revised and accepted for publication January 3, 1984.

\*City residents were served by a city water supply.

**TABLE 1—Attack Rate for Diarrhea of  $\geq 7$  days, by Average Daily Water Consumption, Colorado, 1981**

Water consumption (glasses/day)	Diarrhea/Total	Per Cent Attack rate
0	0/6	0
1	1/12	8.3
2	4/22	18.2
3	3/15	20.0
4	2/7	28.6
5	0/9	0
6	3/7	42.9
$\geq 7$	5/12	41.9
Unknown	2/20	10.0
TOTAL	20/110	18.2

Chi square for trend = 5.7,  $p < 0.01$ .

scopically for parasites by standard technique.<sup>7</sup> Five persons with diarrhea at the time of the survey also had specimens taken for culture for *Salmonella*, *Shigella*, and *Campylobacter*, collected 4-10 days after onset of diarrhea.

During the epidemiologic investigation and while the water treatment facility was still in operation, specimens of raw creek water and post-treatment water were filtered through 1-micron filters and examined for cysts of *G. lamblia*; this analysis was performed with modifications of a standard technique.<sup>8\*\*</sup>

In January 1982, a team of state and Environmental Protection Agency (EPA) engineers dismantled the Aspen Highlands water-treatment facility to determine flaws in the operation and design of the system.

Analysis of the relationship between water consumption and illness was done using the calculator program for linear trend of Rothman and Boice.<sup>9</sup>

## Results

Of the estimated 165 persons living in Aspen Highlands, we were able to locate and interview 110 (67 per cent). Twenty (18.6 per cent) fit the case definition of diarrhea (three or more unformed stools/day, lasting seven days or more). By comparison, none of 16 city of Aspen residents interviewed had been ill. Onsets of illness peaked in early November and had subsided by early December. All cases had diarrhea; 35 per cent had abdominal cramps, 30 per cent had vomiting, 25 per cent had excessive gas, and 20 per cent had bloating. Stool examinations showed that eight of nine ill persons who were tested were positive for *G. lamblia*, compared with four of 17 non-ill persons from Aspen Highlands ( $p < 0.01$  by Fisher's exact test). None of seven persons from the city of Aspen had a positive stool examination for *Giardia*. All bacterial cultures were negative for *Salmonella*, *Shigella*, and *Campylobacter*.

Analysis of water consumption history among Aspen Highlands residents showed a striking dose-response relationship (Table 1) with no illness among those who did not drink town water, and an attack rate of over 40 per cent in persons who drank six or more glasses of tap water per day.

Short-term residents (less than two years) had a significantly higher attack rate for illness than longer-term residents (Table 2, relative risk = 4.5; 95% C.I., 1.3 to 16.2). In addition, the low attack rate for long-term residents did not

\*\*Charles Hibler, Colorado State University, personal communication.

**TABLE 2—Attack Rates for Diarrhea of  $\geq 7$  days, Stratified by Water Consumption and Length of Residence at Aspen Highlands, Colorado, 1981**

Water Consumption*	Residence (years)	Ill (%)	Well	Total
0-2 glasses/day	$\leq 2$	4 (18)	18	22
	$> 2$	1 (6)	17	18
$\geq 3$ glasses/day	$\leq 2$	12 (34)	23	35
	$> 2$	1 (7)	14	15

Overall Mantel-Haentzel Chi = 2.33,  $p < 0.01$  (one-tailed test), Relative Risk of illness in short-term residents compared to long-term residents = 4.54 (95% C.I., 1.3 to 16.2).

\*Information concerning water consumption not available for two ill persons and 18 well persons.

vary with amount of water consumed, while it did in short-term residents.

Review of plant records showed that a pump transferring finished water to the holding tank had malfunctioned during the last week of October 1981, resulting in a drop in water pressure, a subsequent increase demand on the system, and much shorter chlorine contact times. Our calculations (based upon the probable waterflow and the fixed rate of chlorination available) estimate that chlorine residual had dropped below 0.5 ppm during this time.

Examination of the water treatment plant revealed several deficiencies, including a fixed-rate chlorinator that could not keep pace during times of increased demand, lack of pre-treatment by chemical coagulation, erosion of the dual-media filter by water falling from the incoming settling tank, and the presence of fine sand medium in the clear-well of the plant (a holding station for post-treatment water). A detailed report of these findings will appear elsewhere.<sup>\*\*\*</sup>

Two beaver dams were present 3 km upstream from the water intake for the treatment plant. Filter specimens of raw and finished water both contained numerous cysts of *Giardia*.

## Discussion

Beavers may have been the source of *Giardia* for this stream, but we were unable to trap beaver at the damsites due to the heavy snowfall which preceded this investigation. During a survey in 1978 performed by the Wildlife Division, US Department of Agriculture, beaver captured in Maroon Creek upstream from Aspen Highlands were shown to be excreting cysts of *Giardia*.<sup>10</sup> Other outbreaks have been linked to streams probably contaminated by beavers shedding *Giardia*.<sup>2,11</sup>

This outbreak is one of the few in which a clear dose-response exists for water consumption and attack rates for clinical illness. While it is possible that ill persons could have given biased responses for water consumption, falsely inflating their actual intake, we attempted to minimize this bias by limiting the question to the period before the onset of diarrhea for those who had been ill. Based upon our calculations, for the trend to have been due to bias in reports of water consumption, ill persons would have had to overestimate their water consumption by 1½-2 glasses per day, while well persons gave accurate estimates.<sup>12</sup>

The lower attack rate among long-term residents of the area suggests that those residents had some degree of acquired immunity to *Giardia*. Animal studies have shown

\*\*\*Karlin R: Unpublished data.

evidence for acquired immunity to *Giardia*.<sup>13,14</sup> An investigation of an outbreak of giardiasis in Vail, Colorado in 1978 showed findings similar to those of this study, with clinical attack rates for giardia-like illness inversely related to length of residence in that community.† Among campers involved in an outbreak in Utah in 1974, persons who had had previous exposure to mountain stream water had a significantly lower attack rate for giardiasis than persons who had not drunk stream water.<sup>6</sup> Some of the deficiencies in the Aspen Highlands water treatment facility were probably present in the months or years preceding the outbreak, allowing ample exposure for *Giardia* infection among residents using this water supply in the past.

Chemical addition to induce flocculation is necessary to remove particles the size of *Giardia*.†† Proper filter maintenance might have decreased the magnitude of this outbreak, but probably would not have prevented it, since, without chemical addition and flocculation, the dual-media filter would not have been adequate to trap *Giardia* cysts.

#### REFERENCES

1. Moore GT, Cross M, McGuire D, *et al*: Epidemic giardiasis at a ski resort. *N Engl J Med* 1969; 281:402-407.
2. Lopez CE, Dykes AC, Juranek DD, *et al*: Waterborne giardiasis: a communitywide outbreak of disease and a high rate of asymptomatic infection. *Am J Epidemiol* 1980; 112:495-507.
3. Craun GF: Waterborne giardiasis in the United States: a review. *Am J Public Health* 1979; 69:817-819.
4. Weniger BG, Blaser MJ, Gedrose J, Lippy EC, Juranek DD: An outbreak of waterborne giardiasis associated with heavy water runoff due to warm weather and volcanic ashfall 1983; 73:868-872.
5. Wolfe MS: Giardiasis. *N Engl J Med* 1978; 298:319-321.

†Centers for Disease Control: unpublished data.

††Logsdon GS, Fox KR: Paper presented at Pacific Northwest Section Annual Meeting, American Waterworks Association, Spokane, Washington, May 8, 1981.

6. Barbour AG, Nichols CR, Fukushima T: An outbreak of giardiasis in a group of campers. *Am J Trop Med Hyg* 1976; 25:384-389.
7. Melvin DM, Brooke MM: Laboratory procedures for the diagnosis of intestinal parasites, 2nd Ed. DHEW Pub. No. (CDC)76-8282.
8. Jakubowski W, Erickson TH: Methods for detection of *Giardia* cysts in water supplies. In: Jakubowski W, Hoff JC (eds): *Waterborne Transmission of Giardiasis*. Proceedings of a Symposium, September 18-20, 1978. Cincinnati, OH: US Environmental Protection Agency, Office of Research and Development, Environmental Research Center, EPA-600/9-79-001, June 1979.
9. Rothman KJ, Boice JD: *Epidemiologic Analysis with a Programmable Calculator*. NIH Pub. No. 79-1649; 1979: pp 36-37.
10. Davies RB, Hibler CP: Animal reservoirs and cross-species transmission of *Giardia*. In: Jakubowski W, Hoff JC (eds): *Waterborne Transmission of Giardiasis*. Proceedings of a Symposium, September 18-20, 1978. Cincinnati, OH: US Environmental Protection Agency, Office of Research and Development, Environmental Research Center, EPA-600/9-79-001, June, 1979.
11. Dykes AC, Juranek DD, Lorenz RA, Sinclair S, Jakubowski W, Davies R: Municipal water borne giardiasis: an epidemiologic investigation. Beavers implicated as a possible reservoir. *Ann Int Med* 1980; 92:165-170.
12. Marshall JR, Priore R, Graham S, Brasure J: On the distortion of risk estimates in multiple exposure level case-control studies. *Am J Epidemiol* 1981; 113:464-473.
13. Roberts-Thomson IC, Stevens DP, Mahmoud AH, Warren KS: Acquired resistance to infection in an animal model of giardiasis. *J Immunol* 1976; 117:2036.
14. Stevens DP, Frank DM, Mahmoud AH: Thymus dependency of host resistance to *Giardia muris* infection: studies in nude mice. *J Immunol* 1978; 120:680-682.

#### ACKNOWLEDGEMENTS

We thank the following people who provided valuable assistance in this investigation: Dr. Charles Hibler and his staff examined water filters for *Giardia* cysts; Lee Cassin and Robert Nelson assisted in the epidemiologic investigation; Rick Karlin, Tom Braidech, John Blair, and Jerry Beberstein analyzed the water-treatment facility; Edward Lippy provided technical advice; and Phyllis Wasson typed the manuscript. Funding for this investigation was provided in part by the Environmental Protection Agency, contract no. 68-03-2927, and by EPA cooperative agreement no. CR-8088010. This investigation was presented in part at the Epidemic Intelligence Service 31st Annual Conference, April 20, 1982, Atlanta, GA.

## The Relationship between Weight-Height Indices And the Triceps Skinfold Measure among Children Age 5 to 12

ROBERT MICHIELUTTE, PHD, ROBERT A. DISEKER, DRPH, WAYNE T. CORBETT, VMD, DRPH,  
HARRY M. SCHEY, PHD, AND JOHN R. UREDA, DRPH

**Abstract:** This study examines several weight for height indices—Quetelet's index  $W/H^2$ ,  $W/H$ , and Rohrer's index  $W/H^3$ —for their appropriateness in estimating adiposity among young children. Data were obtained for a sample of 1,668 children age 5-12 residing in Forsyth County, North Carolina. Although  $W/H^2$  was found to be the most useful of these indices, the results suggest that no index, including the tricep skinfold measure, can be considered completely satisfactory in estimating adiposity among children. (*Am J Public Health* 1984; 74:604-606.)

Address reprint requests to Robert Michielutte, PhD, Section on Community Medicine, Bowman Gray School of Medicine, Winston-Salem, NC 27103. Drs. Diseker and Schey are also with that Section at the School of Medicine; Dr. Corbett is with North Carolina State University, School of Veterinary Medicine; Dr. Ureda is with the University of South Carolina, Department of Health Education. This paper, submitted to the Journal August 18, 1983, was revised and accepted for publication December 1, 1983.

Relative weight and skinfold measurements have been used frequently among adults and children to estimate adiposity. Both classes of measures have limitations,<sup>1-5</sup> but the research to date has suggested that skinfold measurements are the best of the non-laboratory methods currently in use.<sup>1,6-14</sup> Measures of relative weight cannot distinguish between adiposity, muscularity, or oedema.<sup>15</sup> Skinfold measurements are frequently used as one criterion for testing the usefulness of various measures of relative weight in estimating adiposity among children and adults.<sup>16-20</sup>

Despite the overall superiority of skinfolds when applied to adults, the best of the relative weight measures Quetelet's Index ( $W/H^2$ ) generally correlates highly with skinfold thicknesses and laboratory measurements of body fat.<sup>15,17-23</sup> Indices of relative weight are simpler to obtain and appear to be useful in providing a general assessment of obesity among groups in field studies, and in estimating obesity for individuals in the clinical setting.

The potential usefulness of weight for height indices among children is not clear, however, since they have not