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DIARRHEA AND SCHOOL TOILET HYGIENE IN CALI, COLOMBIA

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Koopman, J. S. (Department of Epidemiology, School of Public Health, the University of Michigan, Ann Arbor, MI 48109). Diarrhea and school toilet hygiene in Cali, Colombia. *Am J Epidemiol* 107:412–420, 1978.

In a 4-week period in early 1976 in a poor, working class area of Cali, Colombia, the prevalences of diarrhea, vomiting, common cold, and head lice in schoolchildren were measured in relation to classroom size and to the condition of the school toilets. The study found that unhygienic toilet conditions were related to diarrhea, and it was estimated that if all schools could reach the modest level of hygiene of the two schools with the relatively best facilities, diarrhea would be reduced by 44% and vomiting by 34%. Toilet hygiene was found to be unrelated to colds or head lice, which have similar social class distributions to diarrhea and vomiting. Crowding was found to be related to a small percentage of the prevalences of vomiting, head lice and colds.

diarrhea; hygiene; pediatrics; toilet facilities

Despite the availability of potable water and a sewage system for 90 per cent of the population of Cali, Colombia, diarrheal disease continues to be a frequent scourge. A network of health centers has been established to care for persons affected; however, mortality continues at a high level.

A surveillance system has been initiated in Cali in an attempt to ascertain those personal habits and environmental contaminations which cause the high level of diarrheal disease. Initial surveillance focused on small outbreaks (1).

In outbreaks investigated in schools, we invariably found person to person transmission to be acting alone or in conjunction with other sources of infection. In a pilot area of the city, a visit to all the schools revealed the deplorable condition of most toilet facilities. A campaign to correct these deficiencies was envisaged, and the present study was planned as a first step in evaluating the work to be done.

Although there is considerable bacteriologic literature on the spread of enteropathogens by toilets, we believe that this is the first epidemiologic study to measure the importance of toilets in causing endemic diarrhea.

Materials and methods

The population. The pilot area contains about 84,000 persons in a poor, working class area in Cali and approximately 6000 just outside the city limits. In the Cali area the vast majority of the homes have treated, piped water. Intradomiciliary connections of this water to sinks are, however, often inadequate or non-existent. The area is served by sewers, although in certain areas a heavy rainfall may cause the sewers to overflow. There are 14 municipal schools and 17 private elementary schools, grades 1–5, in this area. Of the 4967 female students and 5376 male stu-

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dents in these grades in the municipal schools, we interviewed 8219, without recording their sex. Although we also interviewed kindergarten and secondary school classes in some elementary schools, these data were not used in the present analysis. The private schools, which had an enrollment of 2189 females and 2776 males, were also not included in this study. In one municipal school outside Cali, we interviewed 225 students, out of a total of 163 females and 114 males, again without recording their sex. This area outside Cali has untreated water piped to homes.

Hygienic survey of the schools. In a four-week period in February and March, 1976, during an unannounced visit we noted the following in each of the schools:

a) Total number of toilets for each sex (the toilets were invariably of the tank type with a manual evacuation mechanism); b) number of toilets in which the manual evacuation mechanism was non-functional; c) number of toilets with water on the floor; d) number of toilets with used paper on the floor; e) number of toilets with feces in the bowl; f) number of toilets with feces outside of the bowl; g) number of functioning water faucets for washing hands; and h) size of the classrooms.

The following data were obtained from the school principal:

1) Provision of toilet paper, soap and towel: A value of 1 was given for each item provided in the classroom or in the bathroom; a value of 0.5 was given if provided elsewhere; and a value of 0 when the item was not provided.
2) Water flow: A value of 1 was given if the supply of piped water to the school was permanent and adequate; a value of 0.5 was given if the flow was inadequate; and the proportion of hours with water was recorded if the flow was only for certain hours.
3) Number of desks accomodating two or more students.

Symptom prevalence survey. During the same visit at which conditions in the lavoratories were observed, we made a symptom-prevalence survey. Some classes were missed because they did not meet on the days the school was visited. The survey was performed by the author and his four assistants who had six-month's experience in similar investigations.

In each classroom the number of enrolled students and the number present were determined. We made a presentation to the assembled students as to the survey on diarrhea, vomiting, colds, and head lice, using various local synonyms of diarrhea and stool and defining diarrhea as "Diarrhea is when you have to go three or more times to the bathroom and your stool is watery, liquid or slimy."

The older children, without identifying themselves, answered a written questionnaire on whether they had had each of the four signs or symptoms in the past week. Kindergarten and first grade children were interviewed individually.

Data analysis. The frequency by grade was determined by summing data from all the study schools. Confidence intervals were determined with the normal approximation $p \pm 1.96\sqrt{pq/n}$. Prevalence rates for each school were adjusted by the direct method to the overall distribution by grades.

Prior to analysis the various hygienic factors measured were combined into a single arbitrarily determined scale by a formula wherein weights were assigned according to a judgment of the relative importance of the factors. Multiplicative relationships were assigned in this formula for factors which might be interacting and additive relationships were assigned factors we thought might not be interacting but rather might be different measurements of a single factor.

Hygiene score =

$$\left\{\frac{F+M}{M^2/Y_m + F^2/Y_f} + \frac{1/3\,N}{F+M}\right\} \times \frac{Q(3+T+P+V)}{6} \times 100.$$

Where F = number of females enrolled per shift; M = number of males enrolled per shift; N = number of water faucets for handwashing; Q = water flow; T = towel; V = soap; P = toilet paper; and

$$Y_m = A_m - 1/2\,B_m - (1/10)\,C_m - (1/5)\,(D_m + E_m + F_m);$$

$$Y_f = A_f - 1/2\,B_f - (1/10)\,C_f - (1/5)\,(D_f + E_f + F_f).$$

Where A = number of toilets; B = number of toilets in which the evacuation mechanism did not work; C = number of toilets with water on the floor; D = number of toilets with used paper on the floor; E = number of toilets with feces in the bowl; F = number of toilets with feces outside the bowl; m = subscript indicating males; and f = subscript indicating females.

We did not gather data on sex, and therefore had to average the overall hygienic status for males and females. Two schools had different hygienic conditions for different shifts of students and so there are 17 rather than 15 different hygienic scores.

The linear regression between the adjusted prevalence rates and the hygiene scores was determined by assigning values of 1 to each adjusted case and 0 to the adjusted number of well students and then applying a standard regression formula. The significance of this relationship was tested with the Chi square test for trend in proportions (2). Our limited technical resources permitted no more sophisticated analysis. The regression between individual toilet hygiene factors and prevalence was determined and tested by the same means. The sum of squares due to regression divided by the total sum of squares is used as an estimate of the per cent of variation explained by this relationship.

The change in disease levels that one could expect with hygienic improvements (the attributable risk or etiologic fraction) was determined by selecting a tolerable level that was within the range of the observed levels and comparing the disease level corresponding to it in the observed regression to the total level of disease observed. For diarrhea, this resulted in the value that would be obtained by assuming that other schools could reach the same disease level as the two most hygienic schools.

Results

Hygiene levels. The mean and range of the various factors measured are presented in table 1. The average water flow value was 0.85 and the average sum of soap, towel and toilet paper was 1.68. The average number of students per desk was 2.3 and the average number of students per square meter of classroom was 1.04.

Prevalence by grade. In figures 1–4, a very regular decrease in prevalences of diarrhea, vomiting and head lice can be seen with increased number of years in school. This is not the case for cold symptoms. The total observed prevalence rates for grades 1–5 were: diarrhea, 18.9 per cent; vomiting, 14.3 per cent; colds, 50.6 per cent; and head lice, 39.1 per cent.

Table 1

Mean (and range) of factors relating to toilets and water faucets, measured in schools in Cali, Colombia, in February–March, 1976

Factors measured	Boys' toilets	Girls' toilets
No. of toilets per 100 students	1.67 (0.89–2.81)	2.43 (1.42–5.74)
% of toilets malfunctioning	63% (0–100%)	53% (0–100%)
% of toilets with water on the floor	84% (25%–100%)	36% (0–100%)
% of toilets with used paper on the floor	43% (0–83%)	27% (0–75%)
% of toilets with feces in the bowl	43% (0–90%)	38% (0–90%)
% of toilets with feces outside the bowl	11% (0–67%)	21% (0–100%)
No. of water faucets in lavatory per 100 students	1.59 (0–5.26)	

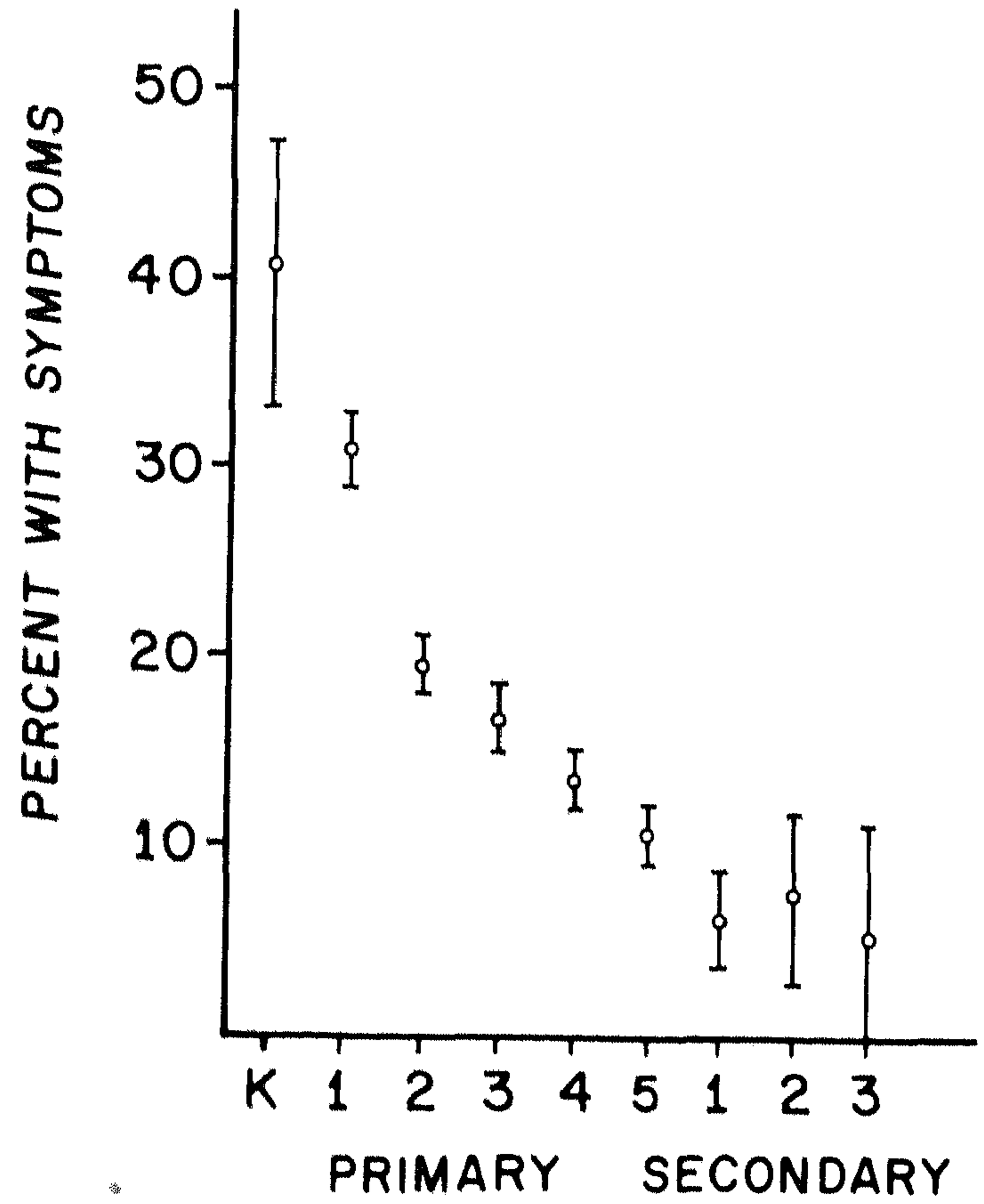

FIGURE 1. Weekly prevalence of diarrhea and 95 per cent confidence intervals by grade (kindergarten, primary school grades 1 to 5, and secondary school grades 1 to 3) for all schools of the study area, Cali, Colombia.

Relationship with environmental factors. Only the data from first to fifth primary grades were used to examine relationships between toilet hygiene or crowding and symptom prevalences because many schools did not have other grades and the data needed to be adjusted for grade due to the strong relationship to this factor. Table 2 shows the statistical significance of the relationships found, the ratio of the sum of squares due to regression to the total sum of squares and the improvements to be expected by making all schools reach the levels of the best in terms of the hygiene scale, the number of students per square meter of classroom and the number of students per desk. The only relationships with practical significance for the control of disease seen in this table are the relationships between the toilet hygiene scale and diarrhea and vomiting. The relationship between prevalence of diarrhea by school and the composite hygiene score is presented in figure 5, which shows the calculated linear regression together with hand drawn curvilinear regression suggesting that there is probably a better regression for these data than a linear regression.

For diarrhea we proceeded to analyze each of the components in the hygiene scale in terms of its relationship to diarrhea prevalence. The results are shown in table 3. The most objective measure of a direct source of contamination, feces in the bowl, was the measure that best explained diarrhea prevalence. Feces outside the bowl, which must be even more of a risk, were only rarely observed. The provision of toilet paper, soap and towels might have helped students avoid contamination from toilets, and their lack or inadequacy explained more cases than did the number of toilets per student.

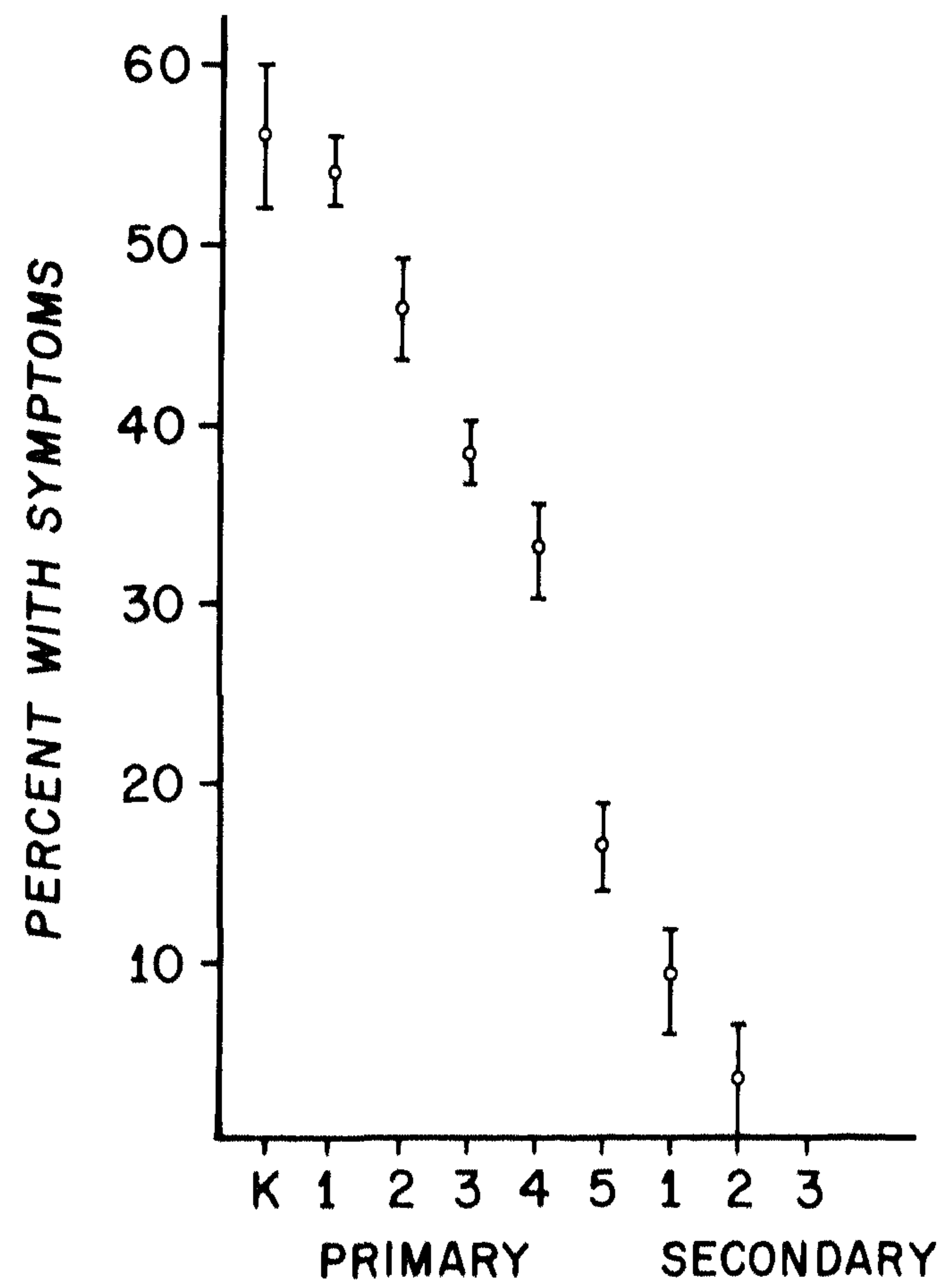

FIGURE 2. Weekly prevalence of head lice and 95 per cent confidence intervals by grade (kindergarten, primary school grades 1 to 5, and secondary school grades 1 to 3) for all schools of the study area, Cali, Colombia.

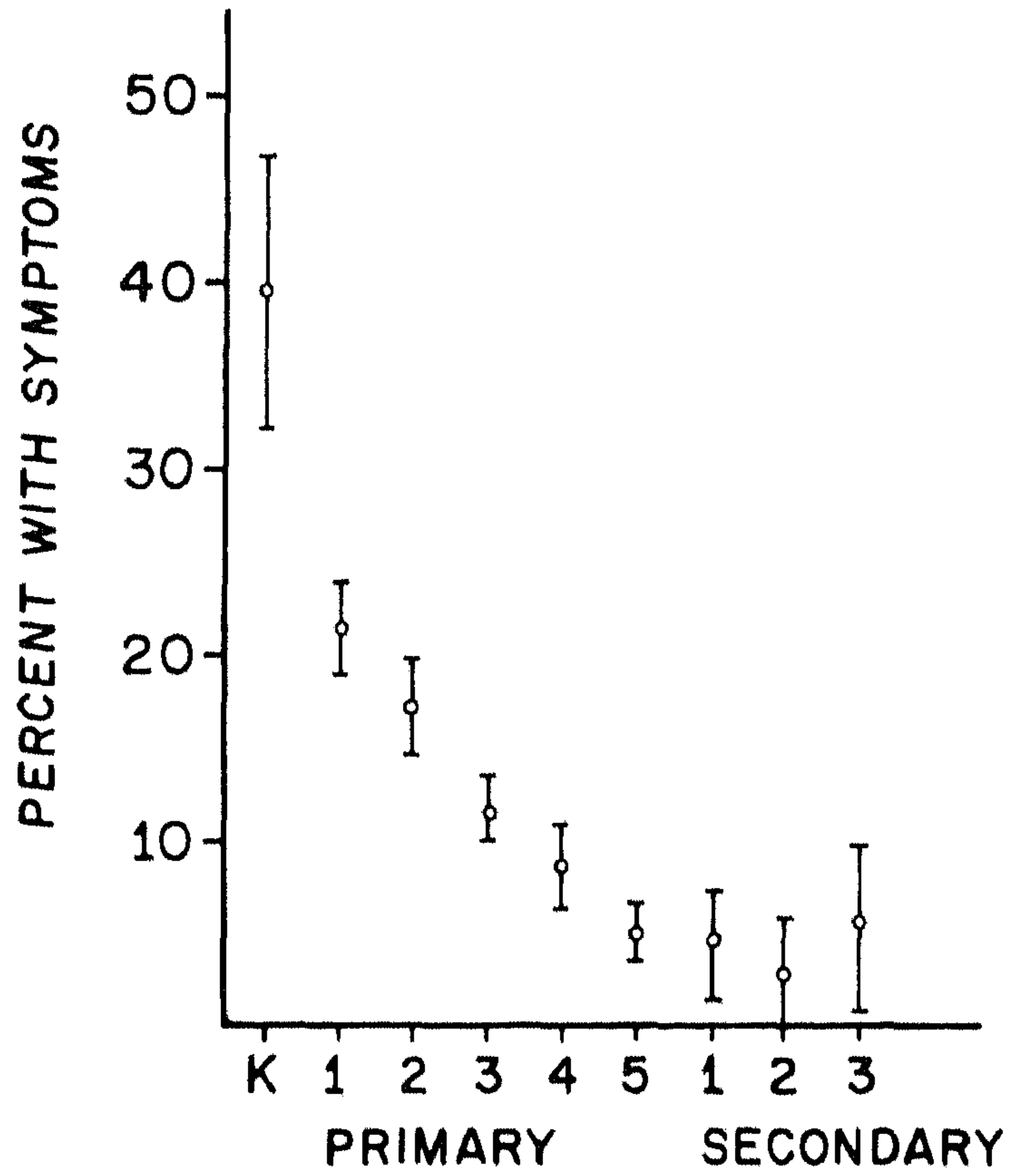

FIGURE 3. Weekly prevalence of vomiting and 95 per cent confidence intervals by grade (kindergarten, primary school grades 1 to 5, and secondary school grades 1 to 3) for all schools of the study area, Cali, Colombia.

DISCUSSION

Of the various relationships found in this study, those with immediate practical implications are the relationships between diarrhea and vomiting and unhygienic toilet conditions. Toilet hygiene was found to be unrelated to colds or head lice. Crowding was found to be related to only a small percentage of the prevalences of vomiting, head lice, and colds.

The data obtained from first graders are probably unreliable, but they were included because they fit the age incidence curves and because a cursory examination of the data indicated that they do not affect the strength of the relationships found.

The data represent observations during one month. Although there is no seasonal variation to diarrhea prevalence in Cali, the variety and pathogenicity of microbial agents involved during the study might differ in respect to toilet transmissibility from agents present at other times. We have no way of knowing this, but the likelihood does not appear great.

If the relationship between hygienic conditions in the schools and diarrhea or vomiting is causal, significant reduction in disease levels should be achieved by modest investments in: 1) toilet facilities that will not be so easily damaged by the students, 2) water storage tanks for low flow periods, 3) janitorial service, and 4) provision of toilet paper, soap and towels.

There is much reason to believe that the relationship between the hygienic factors measured and diarrhea or vomiting is causal. Except for the one school outside of Cali the populations are homogeneously lower class. The population outside Cali lives in the poorest conditions. If the variation in diarrhea and vomiting observed were due to socioeconomic factors outside of the school rather than to the factors measured, there would have to be a corre-

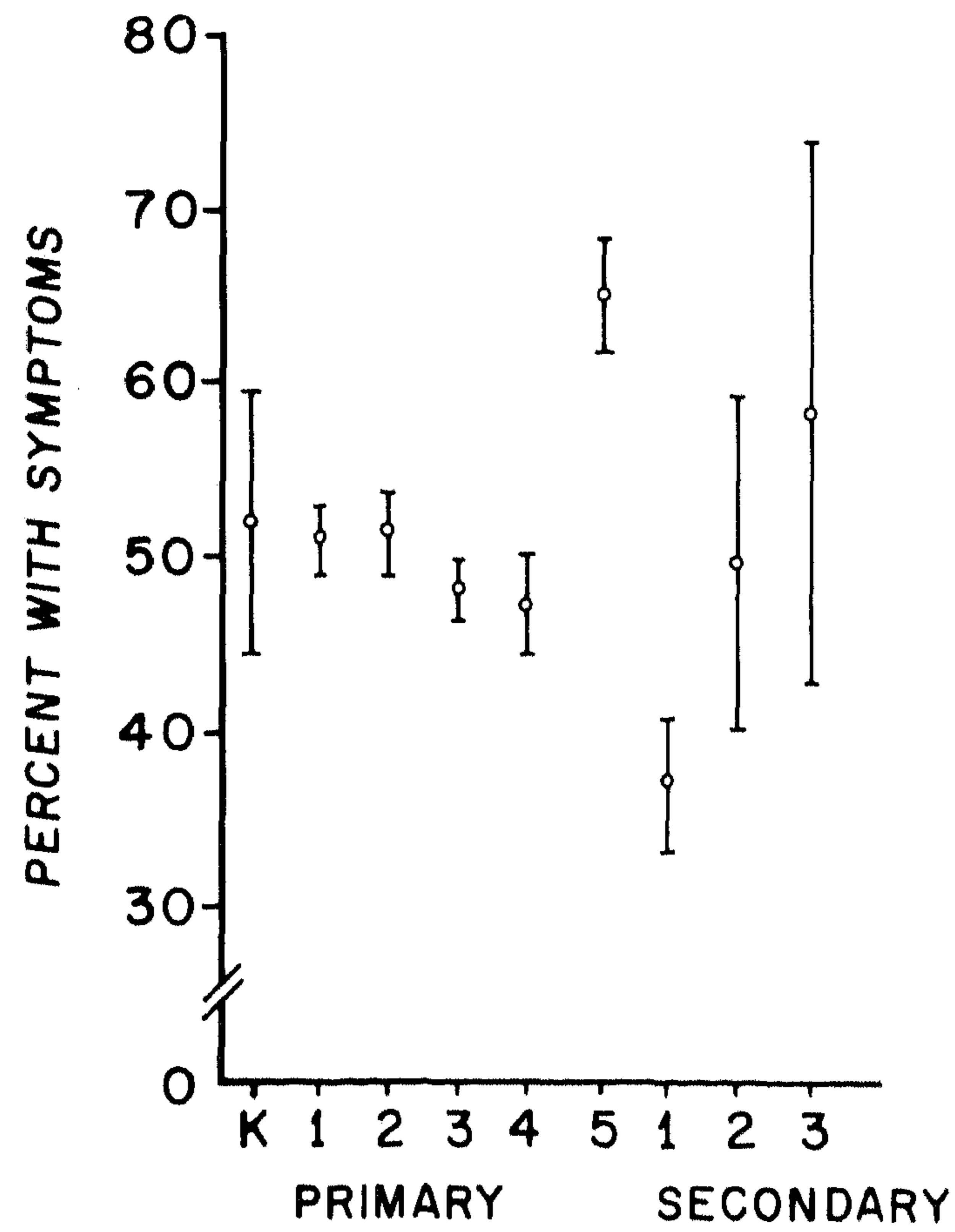

FIGURE 4. Weekly prevalence of cold symptoms and 95 per cent confidence intervals by grade (kindergarten, primary school grades 1 to 5, and secondary school grades 1 to 3) for all schools of the study area, Cali, Colombia.

TABLE 2

Relationships between adjusted symptom prevalence of crowding or toilet hygiene in schools studied in Cali, Colombia, in February–March, 1976

Type of calculation	Diarrhea and vomiting			Colds and head lice		
	Hygiene scale	Students per square meter	Students per desk	Hygiene scale	Students per square meter	Students per desk
		Diarrhea			*Colds*	
Statistical significance	$p = .0001$	NS†	$p = .01$	NS	NS	$p = .0001$
Sum of squares for regression divided by total sum of squares	.47		.08			.19
Improvement to be expected* from altering the factor	44%		1%			7%
		Vomiting			*Head lice*	
Statistical significance	$p = .001$	NS	$p = .0001$	$p = 0.1$‡	$p = .05$	$p = .001$
Sum of squares for regression divided by total sum of squares	.12		.20		.02	.07
Improvement to be expected* from altering the factor	34%		14%		0%	6%

* Assuming a level of hygiene scale = 3.5, students per area = .8/m^2 and students per desk = 1.8.
† NS = not significant.
‡ Positive relation.

lation between the socioeconomic factors and the conditions of the toilets, water flow, provision of toilet paper, etc. All the schools except the one outside Cali are under the same system, and our impression is that the variation in hygienic conditions between schools results from historical accident or from the interest of the directors in hygiene rather than from socioeconomic factors in the school populations.

The specificity of the relationship found also reinforces the judgment as to causal relationship. If socioeconomic or other factors related to transmission outside the school were responsible for this relationship they should have caused a similar correlation with head lice and colds, both of which we have found to be related to socioeconomic conditions in Cali. If there is any relationship between our hygienic scale and head lice or colds it is in the opposite direction from that of diarrhea and vomiting. This minimizes the probability of a confounding factor that could explain the relationship between diarrhea and toilet hygiene.

That 44 per cent or more of the cases of diarrhea in school children can be attributed to school transmissions rather than to transmissions in homes where most food preparation and consumption and most defecation occurs might at first seem surprising. However, consider the nature of infectious diarrhea. There are many different bacterial agents causing diarrhea and the number of known viral agents is increasing. The number, in fact, might well be as great as the number of agents causing colds (3). The vast majority of these agents are transmitted through feces. Despite more chances of contact with feces in the home than in most schools, the range of agents to which one is exposed in the

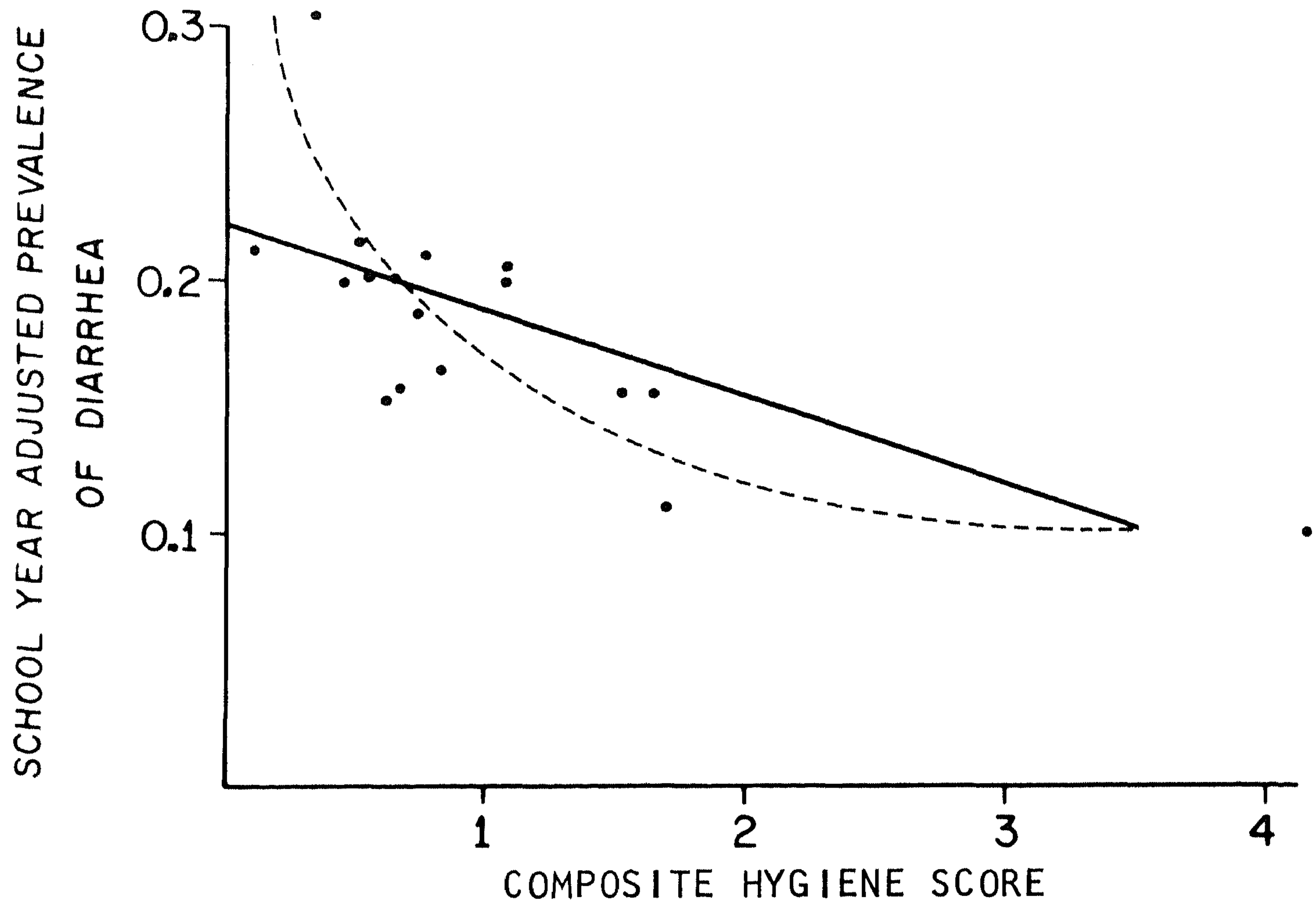

FIGURE 5. Relationship between school diarrhea prevalence adjusted for grade composition and the composite hygiene score for toilet facilities in schools studied in Cali, Colombia.

TABLE 3

Linear regression between hygienic factors and diarrhea in schools studied in Cali, Colombia, in February-March, 1976

Factor	Statistical significance	Sum of squares for regression divided by total sum of squares	Improvement to be expected from altering the factor
No. of toilets	$p = .001$	.13	5%
No. of malfunctioning toilets	NS*		
No. of toilets with water on the floor	NS		
No. of toilets with used paper on the floor	NS		
No. of toilets with feces in the bowl	$p = .0001$	.27	13%
No. of toilets with feces outside the bowl	$p = .001$	.06	4%
Water flow	$p = .025$	.06	1%
Sum of toilet paper, towel and soap	$p = .001$	.13	8.5%
Water faucets for hand washing	$p = .001$	.13	7%

* NS = not significant.

school toilet is going to be greater because of the greater number of children using them. Because of the variety of contaminating agents, the probability that toilets will transmit an agent to which the child is susceptible is likely to be greater in the school, even when total fecal contamination is greater in the home.

The Cleveland Study of *Illness in the Home* (4) presents some data on the rela-