The role of preschool children and day-care centers in the spread of shigellosis in urban communities

Shigellosis epidemics were investigated in two urban centers. In each city, preschool children played a major role in infecting their families and were most susceptible to secondary infection after illness had been introduced into the household. Children attending day-care centers were significantly more likely to be initial cases and to be the major cause of intrafamilial spread of disease than were their counterparts who did not leave the home for daytime care. This study suggests that day-care centers may play an important role in the transmission of shigellosis in urban communities.

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IN RECENT YEARS, the increasing occurrence of Shigella sonnei infections in urban centers has raised questions about how illness spreads within communities. Epidemiologic investigation of outbreaks in two urban areas, Lexington, Ky., and Cleveland, Ohio, was undertaken during the past year by Center for Disease Control (CDC) workers in association with local health officers in response to requests for epidemiologic assistance. These studies revealed that preschool children attending day-care facilities played a major role in the propagation of this disease. This report describes these investigations and their findings.

EPIDEMIOLOGIC INVESTIGATION IN LEXINGTON

Surveillance. A review of shigella isolates from Kentucky for the period 1969-1972 disclosed that an epidemic occurred in Kentucky in late 1972 (Fig. 1). There were 98 isolates from the four Lexington hospitals and 14 additional isolates from the state health department laboratory. Of these 112 isolates, 65 (58 per cent) had been or would eventually have been reported to the Lexington-Fayette County Health Department through case-reporting mechanisms in existence at the time.

Index cases and families. The 112 culture-proved cases of shigellosis in Lexington identified by review of laboratory records were considered "index cases" of the four-month epidemic. Each of these cases served as the focus of an investigation of a family for possible contacts or sources of common exposure. Other cases within families were defined as occurring in patients with febrile diarrhea in the "epidemic period" (September, 1972, to January, 1973). The "initial case" within the family was not always culture proved. Of the 112 index cases, 84 were located for epidemiologic investigation. There

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were 367 members in the 84 families investigated; of these, 169 (46.0 per cent) had been ill. The combined secondary attack rate for the 84 families was 29 per cent. Age- and sex-specific data are summarized in Table I. The initially affected members tended to be younger than those secondarily infected, and all those who were ill tended to be younger than the family members in general.

Secondary attack rates, also given in Table I, show that not only did the younger children introduce illness into their households more often, but they also were more susceptible to secondary infection. The secondary attack rate for those ≤ 10 years of age was 43 per cent, compared with 22 per cent for those > 10, a highly significant statistical difference (p < 0.001). There were no significant sex-specific characteristics of illness. Of the 87 children under 5 years old in the households investigated, 40 were initial cases. Twenty-two (55 per cent) attended day-care centers or a daytime nursery compared with 12 of 47 (26 per cent) who were not initial cases (p < 0.01).

Household and environmental factors. There were no significant correlations between rate of illness within a family and size of family, number of rooms or bedrooms in the dwelling, or number of household members per room or bedroom. There was no correlation between illness and sharing a bedroom with an ill person or sleeping in the same bed with an affected individual. Geographic distribution of cases showed that, although the over-all population of Lexington is 17 per cent black, census tracts in which cases occurred had a population which was 24.9 per cent black, compared with a 2.4 per cent black population in census tracts without illness (p < 0.001). The 17,685 households in census tracts with illness were compared with the 8,294 households in census tracts where illness was not reported; those with illness had a higher proportion of female heads of household (15.2 vs. 12.3 per cent), a lower median income ($8,266 vs. $9,842), a greater proportion of families below federal poverty level (14.5 vs. 4.6 per cent), and greater percentage of family members under 6 years old (9.6 vs 8.5 per cent, all p < 0.001).

Contacts and possible reservoirs of infection. An acceptable history of contact was one in which the name, place, approximate dates, and nature of contact could be elicited from the person interviewed. Several additional cases were also judged to have “acceptable” contact histories if they shared a classroom or attended the same nursery as a known case. Three children who were hospitalized with unrelated illnesses developed shigellosis in

![Graph showing Shigella isolates by quarter, Kentucky, 1969-1973.](image-url)
Table I. Age- and sex-specific illness in 367 family members, Lexington, Ky.

<table>
<thead>
<tr>
<th>Age (yr.)</th>
<th>No. in group</th>
<th>Per cent in group</th>
<th>No. ill</th>
<th>Per cent in group ill</th>
<th>Per cent of total ill</th>
<th>No. of initial cases</th>
<th>Per cent of initial cases</th>
<th>Secondary attack rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>5</td>
<td>1.3</td>
<td>3</td>
<td>60.0</td>
<td>1.8</td>
<td>3</td>
<td>3.3</td>
<td>0.0</td>
</tr>
<tr>
<td>1-5</td>
<td>82</td>
<td>22.3</td>
<td>58</td>
<td>70.7</td>
<td>34.3</td>
<td>37</td>
<td>41.1</td>
<td>46.6</td>
</tr>
<tr>
<td>6-10</td>
<td>75</td>
<td>20.4</td>
<td>50</td>
<td>66.7</td>
<td>29.6</td>
<td>33</td>
<td>36.7</td>
<td>40.5</td>
</tr>
<tr>
<td>11-15</td>
<td>35</td>
<td>9.5</td>
<td>14</td>
<td>40.0</td>
<td>8.3</td>
<td>3</td>
<td>3.3</td>
<td>34.4</td>
</tr>
<tr>
<td>16-20</td>
<td>31</td>
<td>8.4</td>
<td>6</td>
<td>19.4</td>
<td>3.6</td>
<td>3</td>
<td>3.3</td>
<td>10.7</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>139</td>
<td>37.9</td>
<td>38</td>
<td>27.3</td>
<td>22.5</td>
<td>11</td>
<td>12.2</td>
<td>21.1</td>
</tr>
<tr>
<td>M</td>
<td>175</td>
<td>47.7</td>
<td>84</td>
<td>48.0</td>
<td>50.0</td>
<td>43</td>
<td>47.8</td>
<td>31.1</td>
</tr>
<tr>
<td>F</td>
<td>192</td>
<td>52.3</td>
<td>85</td>
<td>44.2</td>
<td>50.0</td>
<td>47</td>
<td>52.2</td>
<td>26.2</td>
</tr>
<tr>
<td>Total</td>
<td>367</td>
<td>100.0</td>
<td>169</td>
<td>100.0</td>
<td>100.0</td>
<td>90</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

hospital. They shared wards with known cases, and their shigellosis was considered nosocomial. By these criteria, 67 per cent of cases were felt to have a traceable contact.

Many children with shigellosis attended the same schools or had siblings who attended classes with other known cases. When illness first began at one school, the local health department initiated a culture survey of the first three grades at the school. Of 350 children in grades 1 to 3, 273 were cultured, and six of these were positive. (These six children are not included among the original 84 patients.) An investigation of the 273 cultured children was undertaken; 207 were completed and disclosed that 46 of 207 (22 per cent) children in grades 1 to 3 were ill with diarrhea and fever at some time during the epidemic. There were no significant differences in attack rates by grade. Analysis of secondary attack rates in families of ill school children showed no significant differences between the 84 families studied initially and those surveyed at the school. Eleven of the cases at the school were coincidentally among the 84 index cases previously investigated.

Eight cases of S. sonnei infection were traced to children attending a private licensed day-care center with a capacity of 71 located in southwest Lexington. A questionnaire was distributed to all families with children at this nursery in an attempt to determine the extent of clinical illness and secondary spread. Permission for a culture survey was not obtained. Of 82 questionnaires returned, 34 families (42 per cent) reported diarrheal illness during the epidemic period. (The excess of families over capacity does not indicate overenrollment, but rather reflects "double enrollment" of children who did not stay the whole day.) In these 34 families, 69 of 112 family members were ill—a secondary attack rate of 44.9 per cent. This is significantly higher than secondary attack rates both in families of the index cases and in families surveyed at the school (p < 0.001).

**Hospitalized children.** Twenty-three patients were hospitalized during the course of the outbreak, and one person died. The one who died was an immunodeficient infant with multiple previous admissions for infectious illnesses; he died one month after admission, primarily as a result of other medical problems. The initial therapy with ampicillin, however, to which the shigella enteritis responded, may have contributed to subsequent infection with a multiple-resistant organism.

Two patients with shigellosis underwent laparotomy before cultures were reported as positive. One, a 15-year-old girl, was operated on in mid-November with a preoperative diagnosis of ovarian cyst; the second patient was an 8-year-old boy, also admitted in early November, who was thought to have acute appendicitis. Over half of the hospitalized infections occurred in or before the first week in November, two to three weeks before the peak of the outbreak. Several of these early patients were admitted not because of the severity of presenting symptoms but because they antedated recognition of the epidemic and consequently presented diagnostic enigmas. Ampicillin resistance developed during the progression of the epidemic, and many later hospitalizations occurred because the development of ampicillin resistance presented new therapeutic problems.

The median age of the hospitalized patients was 4.7 years, compared with 6.1 years for the total group who were ill. Eighty-seven per cent of hospitalized patients
were less than 10 years old, a significantly greater percentage than the 65 per cent for the total patients group (p < 0.05).

EPIDEMIOLOGIC INVESTIGATION IN CLEVELAND

Surveillance. A survey, similar to that undertaken in Lexington, showed that an outbreak occurred in Cleveland in the fourth quarter of 1972 (Fig. 2). Of the cases uncovered by active surveillance, 117 of 223 cases in 1971 and 219 of 528 cases in 1972 had been reported to the Cleveland Health Department, representing 55 and 41 per cent respectively, of the actual number of isolates for those years. Examination of health department data also disclosed that the increase in isolates was not secondary to a change in numbers of cultures submitted.

Index cases and families. The families of 25 recent patients, with onset reported in December, 1972, were interviewed and 25 consecutive patients with onset in January (beginning at the time of initiating epidemiologic investigation) were interviewed and visited at home. Rectal swabs were obtained from all available household members at the time of the home visit. Those with positive cultures were recultured at weekly intervals until two consecutive negative cultures were recorded. A questionnaire similar to the one used in Lexington was completed for each of the 50 children studied.

Table II shows the breakdown for age and sex of 251 household members who were ill in 50 households interviewed. Statistical analysis of these data shows no significant differences between numbers of male and female subjects who were ill. Illness was significantly more prevalent among those in the ≤ 10 year than in the > 10 year age groups (p < 0.001), as were secondary attack rates for these two groups (p < 0.01). A significantly higher proportion of those ≤10 years were initial cases (p < 0.001); 43 per cent of those ≤5 years were initial cases compared with 11 per cent of those over 5. In addition, a significantly higher proportion of males (32 of 57) than females (18 of 66) were initial cases (p < 0.01).

Household and environmental factors. No significant correlations were found between secondary attack rate and family size, number of rooms in home, population density of household (persons per room), number of adults in household, or proportion of adults in household. The number of people sharing a room did not correlate significantly with illness.

The cases occurred in some of the poorest areas of Cleveland. The population of the city is 38 per cent black, and there was highly statistically significant racial disparity between census tracts with illness (64 per cent black households) and those without illness (28 per cent black); similar disparity occurred in the few suburban communities with cases. As in Lexington, census tracts where illness occurred were of a statistically significant lower socioeconomic level than those without cases of shigellosis. The living conditions of families were significantly more crowded (5.0 vs. 3.2 people per household), had a higher proportion of children under 6 years old (25.9 vs. 9.9 per cent), and had a greater percentage of female heads-of-household (46.0 vs. 26.5 per cent) than did other families from the same census tracts. Families from affected census tracts differed, again significantly, in these same factors from families living in census tracts in which there was no illness.

Contacts and reservoirs of infection. Over 50 per cent of the initial cases occurred in preschool children,
Table II. Age- and sex-specific illness in 251 household members of 50 families, Cleveland, Ohio

<table>
<thead>
<tr>
<th>Age (yr.)</th>
<th>Household members: no. in group</th>
<th>Per cent of total in group</th>
<th>No. in group ill</th>
<th>Per cent of total ill</th>
<th>Per cent of initial cases</th>
<th>Per cent of initial cases</th>
<th>Secondary attack rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>10</td>
<td>4.0</td>
<td>8</td>
<td>80.0</td>
<td>6.5</td>
<td>4</td>
<td>8.0</td>
</tr>
<tr>
<td>1-5</td>
<td>62</td>
<td>24.7</td>
<td>45</td>
<td>72.6</td>
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<td>6-10</td>
<td>49</td>
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<td>29</td>
<td>59.2</td>
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<td>26.0</td>
</tr>
<tr>
<td>11-20</td>
<td>53</td>
<td>21.1</td>
<td>17</td>
<td>32.1</td>
<td>13.8</td>
<td>2</td>
<td>4.0</td>
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<td>&gt; 20</td>
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<td>30.7</td>
<td>24</td>
<td>31.2</td>
<td>19.5</td>
<td>4</td>
<td>8.0</td>
</tr>
</tbody>
</table>

M: 111 44.2 57 51.4 46.3 32 64.0 31.6
F: 140 55.8 66 47.1 53.7 18 36.0 39.3
Total 251 100.0 123 49.0 100.0 50 100.0 36.3

although they accounted for only 28.7 per cent of the total household members; conversely, over 40 per cent of preschoolers represented initial cases. The secondary attack rate for these children, moreover, was highest of any group (53.7 per cent).

Many of these youngsters were cared for outside the home during the day in day-care centers, nurseries, or other facilities in which they were exposed to other children of similar ages. Of 62 children 1 to 5 years old, 45 were ill, 27 of whom were initial cases (Table II). Fourteen of the 45 ill 1- to 5-year-olds received day care, 12 of whom were initial cases (85 per cent). Only 15 of 31 (48.4 per cent) of those who did not leave the home during the day were initial cases (p = 0.018). Thus, children aged 1 to 5 who left the home to mingle with other children in day-care settings were significantly more likely to introduce shigellosis into their households than were children who stayed at home.

In addition to acting as a source of infection, preschoolers (0 to 5 years old) served as the primary mode of secondary spread of illness in a household. Of the 50 families surveyed, in 31 the initial case was in a preschool child and 54 of 72 family members were ill, with a secondary attack rate of 56.1 per cent. In the remaining 19 families, in which the initial case was in a person over 5 years old, 69 of 179 family members were ill, with a secondary attack rate of 31.3 per cent. There was no significant difference in the age distributions of the two family groups. The secondary attack rate for families with an initial case in a preschool child was significantly higher, however, than in families with an initial case in an older person (p < 0.01). Analysis of the data showed that the presence of any ill preschool child in a family increased the risk of spread to older family members. Thirty-nine families had preschool children who were ill; their secondary attack rate among older household members was 36 per cent, significantly greater than the rate of 13 per cent in households without an ill child of preschool age (p = 0.01).

DISCUSSION

Shigellosis is principally a disease of the young, with significantly higher attack rates for children less than 10 years of age than for older age groups. The disease tends to spread by person-to-person transmission, accounting for high secondary attack rates within families. Common-source (food and water) outbreaks of shigellosis have been reported. An increasing proportion of S. sonnei infections over S. flexneri ones has been noted in recent years; since 1966 S. sonnei has accounted for the majority of shigella species isolated. Certain groups, notably persons residing on Indian reservations and in mental institutions, have been recognized as being at specially high risk. Boarding schools, summer camps, and other "closed communities" have also been the setting for large outbreaks of bacillary dysentery, in large part because intimate physical contact within the same group of people facilitates interpersonal spread.

Outbreaks of shigellosis have occurred in communities that do not fit the classic setting. A hospital outbreak in 1959 was traced to an epidemic in Buffalo, N. Y., but no epidemiologic information on the urban focus was obtained. In an outbreak of 87 cases in 41 households in Omaha, Neb., in 1961, cases occurred primarily in a poverty area of the city, in which crowding and poor sanitation correlated with high attack rates. A study of 50 households in Dallas, Texas, in 1966, also showed that endemic shigellosis was a disease of the "lowest
socioeconomic stratum," with intrahousehold spread related to poor hygienic practices.\textsuperscript{1}

The two outbreaks we report occurred in very different communities: Lexington's population was enjoying a high standard of living and was predominantly white; Cleveland's population had a large plurality of blacks and was in many respects a classic inner-city ghetto. Despite major sociologic differences, in neither city did illness correlate with family size or household crowding. In both cities the racial patterns were striking; the preponderance of blacks in census tracts with illness was the outstanding sociologic characteristic examined, and the data suggested that if adjustments were made to correct for income disparities there would still be a significantly higher proportion of blacks in affected census tracts than in nonaffected ones. There is no evidence to suggest that susceptibility to shigellosis is in any way racially determined. It is far more likely, assuming person-to-person transmission, that limited social contact among different racial and ethnic groups, even those living in proximity, accounts for the predominant spread of this illness among a single racial group. Although several schools were involved in the outbreaks, secondary spread within classrooms was uncommon, suggesting that the schools per se did not play a major role in disseminating the disease.

On the other hand, the first cases in families were in patients significantly younger than the rest of the family members, suggesting that these youngsters, particularly those of preschool age, played a major role in infecting their families. Also, the secondary attack rates for preschool children were significantly higher than rates for other family members, indicating that these children were more susceptible to secondary infection after illness had been introduced into the household.

Identification of the major importance of this age group in shigella transmission also enabled a directed search for possible sources of infection and transmission among preschool children. In this regard, it was found that children attending day-care centers or the equivalent were significantly more likely to be initial cases than were their counterparts who did not leave the home for daytime care. Most children were kept at home while they were ill. Our culture data suggest, however, that the period of clinical illness accounts for but a fraction of the total time that an infected individual excretes \textit{S. sonnei}. Over 10 per cent of family contacts who had no evidence of illness had positive cultures, indicating a significant amount of asymptomatic infection. Perhaps more important is the fact that in the clinical cases the patients continued to excrete shigellae for an average of 12.8 days after they had recovered—time when they presumably would have returned to school or to their usual daily activities. Thus the current practice of isolating only the sick will not insure the interruption of transmission of illness; infected persons may actually be most dangerous, from a public health standpoint, during their convalescence because of their greater mobility and increased contact with susceptible people.

The rapidly increasing number of day-care centers in the United States reflects an increasing demand for such services\textsuperscript{4,5}; in 1970 it was estimated that some 1.3 million children received full day-care in this country.\textsuperscript{5} It is doubtful, however, that the need has been fully met. For example, Fayette County, Ky., in 1970 had approximately eight per cent of the state's day-care facilities, or places for about 870 children, whereas that same year an estimated 6,950 children had mothers in the labor force.\textsuperscript{*}

Clearly, arrangements were made by these working mothers for their children's care other than day-care centers. As increasing numbers of women continue to join the labor force, which seems likely from current social trends, more and more preschool children will be brought into close contact with one another in day-care facilities. It is likely that at least one consequence of such contact will be to increase the potential for propagation and spread of shigellosis.

*Based on 1970 census data.

REFERENCES

4. Day care facilities in Kentucky, Published by Department of Child Welfare, Office of Special Services, Frankfort, Ky., 1972.