Effect of Infection Control Measures on the Frequency of Diarrheal Episodes in Child Care: A Randomized, Controlled Trial

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ABSTRACT. ***Background.*** **Diarrheal infections are common in children who attend child care, and preventing transmission of disease in this setting depends on actions by child care staff. We set out to discover whether transmission of gastrointestinal infections in child care could be reduced by improved infection control procedures.**

Methods. **We performed a cluster randomized, controlled trial of an infection control intervention conducted in child care centers for 1 city in Australia. The intervention was training of child care staff about transmission of infection and handwashing and focused on both staff and child behavior. Implementation of the intervention was recorded by an observer. Illness was measured by parent report in telephone interviews every 2 weeks.**

Results. **There were 311 child-years of surveillance for diarrheal episodes. The rate of episodes of diarrhea was 1.9 per child-year in intervention centers and 2.7 per child-year in control centers. Multivariable analysis showed that diarrheal episodes were significantly reduced in intervention center children by 50%. However, the impact of the intervention was confined to children over 24 months of age. For those centers in which children's compliance with handwashing was high, diarrheal episodes were reduced by 66%.**

Conclusions. **This trial supports education about infection control, for staff and children in child care, as a means of reducing transmission of diarrhea. Reduction in episodes of diarrhea in children in child care was limited to children over 24 months of age.** ***Pediatrics*** **2000;105:743–746;** ***diarrhea, infection, child care, child daycare centers.***

ABBREVIATIONS. CI, confidence interval; RR, relative risk.

Infectious diarrhea is the second most common type of infection acquired by children in child care.[1] Numerous pathogens cause infection in children in child care centers.[2–6] These infections may result in serious illness, have high secondary attack rates in families, and carry economic costs from parent loss of work time.[2–11]

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Child care is a unique environment for transmission of diarrhea and preventing transmission of disease in this setting depends on actions by child care staff. Four studies have assessed the impact of infection control training of staff on the occurrence of diarrhea in children. In the hallmark study by Black et al[12] in 1979, diarrhea in child care centers was reduced by 50% when handwashing was improved. This and 2 subsequent studies were limited by an important potential bias, the caregivers who received training were also the source of information about child illness.[12–14] Furthermore, these trials did not control for potential confounders, such as breastfeeding or having a sibling in child care. The only trial to address these issues reported only episodes of severe diarrhea, in young children under 24 months of age were reduced by training.[15] They concluded that although the intervention improved the behavior of caregivers, it may have had a lesser impact on child-to-child transmission. We set out to establish whether infection control training could reduce episodes of diarrhea in children of all ages.

METHODS

We performed a cluster randomized, controlled trial of an infection control intervention in child care centers in the Australian Capital Territory between March and November 1996. The trial was approved by the Ethics Committee of the Australian National University. Centers eligible to participate in the trial were those licensed in the Australian Capital Territory at February 1, 1996 to care for 50 or more children for >9 hours a day, 5 days a week. We invited directors of all eligible daycare centers to participate. One center was a pilot site to develop and test methods for the trial and did not participate in the trial. We delivered information booklets about the trial for staff and parents at each center and recruited parents of children by letter delivered through the centers. Centers were randomized to the intervention group after the center directors agreed to participate in the trial, using a random number table generated using EpiInfo.[16]

Children were eligible to participate if they were 3 years of age or younger at January 1, 1996, attended the child care center for at least 3 days per week, and had no underlying chronic illness that predisposed to infection. A target sample size of 314 child-years of observation was determined based on requiring 80% power to detect a 25% reduction in diarrhea from a background rate of 1.4 infections per child-year, using a test of 5% significance level.[17] We adjusted the sample size by a factor of 1.3 for clustering, this being appropriate for an intracluster correlation coefficient of .01 with 20 clusters and 28 children in each cluster.[18–19] The required clustered sample was, therefore, 408 child-years of observation or 544 children observed for 9 months.

Training for the intervention centers was performed by L.R. in March 1996. The training incorporated elements of good health training developed by Kendrick[20] and a exercise of handwashing using GloGerm (Moab, UT).[21] The lessons were of 3 hours' duration and were held in the evening in the centers. Staff members who were unable to attend training in their own center were invited to attend sessions in other centers or lessons during lunch periods. Those staff members who joined the center after the onset of the trial were trained in a 1-hour lesson during lunch periods. We reinforced training and communicated techniques and routine practices in fortnightly visits and newsletters for intervention centers. We delivered 9 newsletters that highlighted how staff had incorporated the hygiene methods into their daily routines. Staff in control centers undertook training and received newsletters at the end of the trial in November 1996.

The recommended handwashing technique is outlined in the Australian National Health and Medical Research Council Guidelines for preventing infectious diseases in child care.[22] Only soap was recommended as a washing agent. The duration of a handwash of an approximate "count to 10" to wash and "count to 10" to rinse was emphasised. Child care staff members were asked to teach the handwashing method they had learned to the children in their care and to perform handwashes for infants. We developed techniques to encourage children to wash their hands well, such as the use of songs about handwashing in melodies of nursery rhymes. The recommended circumstances for handwashing for staff and children were on arrival at the center, after toileting, before eating, and after changing a diaper (staff and child). We recommended that toys were washed daily using dishwashers where possible. Staff members who changed diapers were discouraged from preparing food for children on the same day.

The primary outcome measures were parent reports of symptoms of illness in telephone interviews every 2 weeks. To improve the parents' recall of illness, we issued calendars at the beginning and middle of the trial. The calendars included definitions of illness. The interviewers asked a standard set of questions about respiratory and diarrheal illness, doctor diagnosis of otitis media, medication given, health service use, and parent and child absenteeism from work and child care. The definition of diarrhea was 2 or more watery or unusually loose bowel motions in 24 hours. We defined a new episode of diarrhea as the occurrence of diarrhea after a period of 3 symptom-free days. Analysis of diarrheal episodes was also performed with a new episode of diarrhea defined as occurrence after a symptom-free period of 7 days. Parents also completed a questionnaire about risk factors that may modify infections as described in Table 1.

The secondary outcome measure was implementation of the intervention. One observer recorded compliance with recommended practices for a period of 3 hours in the morning in each center every 6 weeks. The observer was not informed of the content of the training sessions or the intervention status of the centers. The staff members in the centers were aware the observer was watching hygiene practices but not which specific practices were being recorded. We graded compliance for each child care center, by 3 groups of children's performance of recommended handwashing.

We analyzed the data using Stata Statistical Software, Release 5.0.[23] We calculated incidence of diarrheal episodes per child-year for all children and then for children in 2 age groups: over 24 months of age and 24 months of age or under. We chose this age grouping for 2 reasons: transfer from diapers to use of a toilet occurs around 24 months of age and the intervention trial by Kotch et al[15] identified a reduction in illness only in children under 24 months of age. We constructed Poisson regression models with robust confidence interval (CI) estimates adjusting standard errors for the impact of clustering by center.[24–26] Our modeling strategy followed recommendations by Kleinbaum.[27] The goal of our model was to obtain a valid estimate of the exposure–disease relationship. We performed backwards stepwise analysis for significant interaction terms. We applied the multivariable model for all children and children in the 2 age groups. Further, we analyzed the results by grading compliance in intervention centers, maintaining analysis by intent-to-treat by comparing intervention grades with control centers.

TABLE 1. Risk Factors for Diarrheal Illness Included in Multivariable Model

Child factors
Age in the middle of the trial
Sex
Weight at birth
Breastfed categorical variable of
Referent predominantly breastfed for at least 6 mo
Ever breastfed
Never breastfed
Child care history
Attendance at child care before 6 mo of age
First started in child care in the previous 6 mo
Attends another child care center in addition to the enrolled center
Home factors
A sibling who attends child care
A sibling who attends school
More than 1 child in a bedroom

RESULTS

The recruitment rate for centers was 88% (23/26). After randomization, there were 11 intervention and 12 control centers. Sixteen of the centers were commercially operated (8 intervention and 8 control centers). There was no difference between the proportion of staff members with child care qualifications in intervention and control centers (59/125 and 58/110, respectively; χ^2 test, P value = .4). In all centers, children were separated by age into differing care rooms with a range of between 3 and 5 rooms per center. Staff to child ratios, regulated by the government, were 1 to 5 for care of infants and 1 to 12 for care of preschool children.

Children were enrolled in the trial for 113 677 days, representing 311 child-years (see Fig 1 in the companion to this article, page 000). One third of the children were 1, 2, or 3 years old, respectively (see Fig 2 in the companion to this article, page 000). The attrition rate during the trial was 22% (51/299 and 17% intervention; 72/259 and 28% control). This coincided with offers of young retirement from the principal employer in the city, the Commonwealth Government of Australia.

The incidence of episodes of diarrhea per child-year was lower in intervention centers than in control centers. However, this was attributable to a decrease in infections in older children over 24 months, not in children 24 months of age or younger (Table 2). There was no difference in incidence by intervention status in males compared with females, the stratified incidence rate ratio for males being .77 and for females .70.

The final multivariable model adjusted for clustering by center, confounding by 11 variables and 2 significant interaction terms (being in the young age group and intervention status and having a sibling who attends child care and intervention status). The confounding variables in the final model are listed in Table 1.

Using the fully adjusted model, there was a significant reduction in diarrheal episodes of 50% in intervention center children across the full age range. However, when the 2 groups were examined separately, the significant reduction in illness was present only in children over 24 months of age (Table 3). The reduction in children over 24 months of age was seen in every month of the trial except July. The intracluster correlation coefficient for diarrhea in intervention centers was .003 and in control centers .022. When the definition of an episode of diarrhea was altered

TABLE 2. Incidence of Diarrheal Episodes by Intervention Status and Age Group

Age Group	Intervention Status	Number of Episodes	Number of Child Days	Episodes per Child-Year	Incidence Rate Ratio	95% CI
≤24 mo	Intervention	208	22 620	3.4		
	Control	208	21 312	3.6	.94	.77,1.15
>24 mo	Intervention	127	39 539	1.2		
	Control	172	30 206	2.1	.56	.44,.71
All	Intervention	335	62 159	1.9		
	Control	380	51 518	2.7	.73	.63,.85

TABLE 3. RR of Diarrheal Episodes in Intervention Group After Adjusting for Interaction, Confounding Variables, and Clustering by Center

Age Group	RR*	95% CI	*P* Value
≤24 mo	.90	.67,1.19	.44
>24 mo	.48	.29,.78	.003
All	.50	.36,.68	<.0001

* Multivariable model by age group includes 1 interaction term sibling in child care and intervention status. The model across the full age range includes a second interaction term age group and intervention status.

to allow for a 7-day symptom-free period between episodes, the results were similar (24 months of age or under: relative risk [RR]: .96, 95% CI: .75,1.23, P = .8; over 24 months of age: RR: .51, 95% CI: .37- .69, $P < .001$). Adjusted absence from child care with diarrhea was lower in the intervention group but was not a statistically significant reduction (RR: .54; 95% CI: .28,1.05; $P = .07$).

We graded compliance for children washing their hands, corresponding to intervention centers with a score of low, moderate, and high compliance. Improved compliance with infection control procedures was associated with lower illness incidence but the effect was still confined to older children. With high compliance of child handwashing, diarrheal episodes were reduced by two thirds (RR: .34; Table 4).

TABLE 4. RR of Diarrheal Episodes (Relative to Control Centers) After Adjusting for Confounding Variables and Clustering by Center for Three Groups of Children's Handwashing Compliance Among Intervention Centers

Age Group	Handwash Group*	RR†	95% CI	*P* Value
≤24 mo	Control	1		
	1	.98	.63,1.54	.94
	2	.85	.58,1.24	.39
	3	.87	.57,1.33	.53
>24 mo	Control	1		
	1	.43	.29,.63	<.0001
	2	.62	.36,1.09	.10
	3	.34	.17,.65	.001
All	Control	1		
	1	.52	.37,.75	<.0001
	2	.53	.37,.76	<.0001
	3	.43	.27,.70	<.0001

* Handwash group 1 = lowest compliance rate (53%–69%) for 4 centers; handwash group 2 = moderate compliance rate (70%–79%) for 4 centers; handwash group 3 = high compliance rate (over 80%) for 3 centers.

† Multivariable model by age group includes 1 interaction term, sibling in child care and intervention status. The model across the full age range includes a second interaction term age group and intervention status.

DISCUSSION

This trial supports the importance of training staff about infection control techniques to reduce episodes of infectious diarrhea in children in child care. The impact for children over 24 months of age was substantial with a 66% reduction in episodes of diarrhea when children's compliance with handwashing was high. Children's handwashing may not be responsible alone for reducing illness; it may be a marker of general good performance of infection control techniques.

Our work initially seems contradictory to that by Kotch et al[15] where severe diarrhea episodes were reduced only in younger children under 24 months of age. They did not find a change in all episodes of diarrhea. Although we found no reduction in diarrhea in the younger age group, we did not separately identify severe from all episodes of diarrhea. We, therefore, could not identify if there was a reduction in severe episodes.

In older children in control centers, our rate of 2.1 episodes per child-year were similar to those reported by Kotch et al[15] of 2.8 per child year. Although they found no reduction in children over 24 months of age, we found significant and substantial reduction. Unlike their work, our intervention did impact on children's behavior, and presumably, child-to-child transmission as shown by observations of children's handwashing. From ~24 months of age, children become independent with toileting and handwashing. It is not surprising that if the intervention impacted on child-to-child transmission, reductions in illness would occur in this older age group. Another explanation for reduction of diarrhea in only children over 24 months of age may be interruption of transmission of pathogen(s) that caused diarrhea in older, but not in younger, children. We were not able to collect fecal specimens for microbiologic tests and cannot comment on which pathogens were reduced.

Our work has some limitations but these do not invalidate our conclusions. We did not directly inform parents of their center's intervention status, but they may have recognized this from other sources and parent reporting of illness may have been biased by this knowledge. The recording of compliance with infection control practices could have been prone to bias from the observer or children may have changed their behavior when she was present. We argue that children were not likely to change their behavior to impress the observer and that their handwashing followed a routine that was not readily alterable. The dropout rate in the control group was higher than in the intervention group and this may have introduced a selection bias if related to occurrence of infection. This is unlikely as the out-migration occurred from children reducing their care attendance at a time of downturn in employment in the city. The families in this trial were predominantly affluent, Caucasian, with 2 parents in the home, and our findings may not be generalizable to all circumstances. Children from these affluent homes may be at lower risk of acquiring diarrhea than others.

This study supports the need for training of child care staff about infection control methods. Our new evidence is the substantial reduction of episodes of diarrhea in children over 24 months of age, an effect we consider resulted from interruption of child-to-child transmission.

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