ANTIBIOTIC USE IN CHILD CARE CENTERS: THE IMPACT OF AN ENHANCED ENVIRONMENTAL HYGIENE INTERVENTION

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ABSTRACT

Pathogens on child care center (CCC) fomites can contribute to illness among attendees and may thereby influence use of antibiotics. This intervention study was conducted to assess, in part, the effect of using specific disinfecting products and cleaning protocols in child care centers on the incidence of antibiotic use among children attending those centers. During the 10-week study period, children from twelve centers were observed. Six of the centers (206 children in the analysis) were randomly assigned to the intervention. The other six (196 children in the analysis) were controls. Intervention centers were given cleaning protocols and disinfecting products. Control centers were asked to retain their original procedures and products. Antibiotic use was determined by telephone calls made to parents of ill children. A call was also made to one randomly selected healthy child's parents for every two ill children recorded. Parents were given a questionnaire requesting information including bedroom sharing status, environmental tobacco smoke exposure, and chronic illnesses. Multivariable Poisson regression revealed that the number of weeks intervention center children were using antibiotics was 32% lower compared to children in control centers. This was a statistically significant reduction (95% CI = 0.54-0.86; p = 0.001), suggesting that disinfection interventions appear to be useful for reducing antibiotic use among children in child care centers.

Key words: antibiotics, child care, child day care centers, hygiene

INTRODUCTION

In the United States, twenty to thirty percent of children under five years of age attend organized care facilities (1). Unfortunately, these children have significantly more infections than those cared for at home (2-11). Enrollment in a child care setting also increases the risk that the child will receive prescription medication (9, 12), and antibiotics in particular (13). Though the long-term effects of antibiotic use by children are unknown, extended use will likely contribute to the growing problem of antibiotic resistant microorganisms. Attending child care has already been seen as a significant risk factor for colonization by antibiotic-resistant *Streptococcus pneumoniae* (13).

Education of clinicians, parents, child care center personnel, and community organizations does not appear to reduce antibiotic use in child care center attendees (14), but another potential method of doing so would be to interrupt the transmission of microorganisms to the children. Previous interruption interventions have often focused on hands, as they are important vehicles for transmission (15-17). Some programs addressing hand washing and hygienic practices among child care center staff have been effective in reducing respiratory and diarrheal illness (17-19), but other trials evaluating the effectiveness of hygiene and surveillance programs have provided varied results (16, 20).

An alternative focus for intervention is the environment, which also has a role in the transmission of microorganisms (21-27). Although microorganisms are largely unable to multiply on surfaces in the environment, many can survive there for long periods of time (15, 23, 25). Studies have shown that the presence of microorganisms on environmental surfaces can be reduced (23, 26, 28, 29), which could in turn reduce the risk of infection among individuals in contact with those surfaces. Such an intervention may decrease respiratory and diarrheal illness, possibly leading to a decrease in the need and use of antibiotics(17, 30).

One of the primary objectives of this study, therefore, was to assess the effect of using a variety of disinfecting products and cleaning protocols in child care centers on the incidence of antibiotic use among children attending those centers.

METHODS

Design and Participants

Twelve child care centers of 30 to 100 children each were studied beginning the week of February 4, 2002. All of the centers were located in the Tucson, AZ metropolitan area. Selected child care facilities were matched based on the total number of children in each center and on percentages of children whose families were eligible for financial assistance from Arizona's Department of Economic Security. Centers were also matched on the presence of infant rooms. Centers were then randomly assigned into either the intervention group or the control group, with six being assigned into each. The study period lasted 10 weeks and the centers were recompensed $100 a week for their participation.

Children under six years of age who had been attending the child care facility more than three days a week were eligible for inclusion. Parents of eligible children were asked to read and sign a consent form. This informed them that the purpose of the project was to measure the possible exposure to infectious agents, the effects of disinfection of toys and surfaces on such agents, and whether this disinfection process had beneficial effects on health. They also learned that the center their child attended might be chosen as an intervention center in which the cleaning practices would include the use of disinfectant products on surfaces. Parents were required to speak English or to have an interpreter in the household so that the telephone interviews were possible. Parents were recompensed $50 per child for their participation.

Intervention centers were given five different commercially available cleaning products: bleach, a cleaner with bleach, disinfecting wipes, disinfecting spray, and a toilet bowl cleaner (Table 1).   Centers were also provided a detailed protocol to follow that included which products to use, where and how exactly to use the products, and how many times per week or day each product should be used (Table 2). Centers were given as much product as they deemed necessary to follow the protocol. Study personnel delivered the product to each center once per week unless a special request for additional product was made. The amount of product each intervention center used was documented, and twice per week study personnel verbally verified that the cleaning procedures were being followed. Control centers continued with their regular cleaning routine, which primarily involved the use of soapy water and bleach products in the manner required by state health department guidelines (31).

Data Collection

All facility directors were asked to use a daily log to record each child's attendance, absence due to illness, and absence due to other reasons for each day. The director was asked to record any signs or symptoms of illness, any use of medication (antibiotics, asthma medication, and allergy medication), and any medical visits for illness, if known. Information was not collected regarding the illnesses for which the antibiotics were prescribed. The daily logs were collected weekly.

Follow-up calls to the parents of all acute cases were attempted. Acute cases were defined as those children who were absent due to illness; those with a sign or symptom of illness; those who used prescription or over the counter allergy, asthma, or antibiotic medications; and those who had a medical visit. The specific symptoms - allergy symptoms, runny nose, sinus congestion, cough, sore throat, ear pain, fever, diarrhea, and vomiting - were identified by the parents rather than being precisely defined by the interviewer.

Follow-up calls were also attempted to parents of children randomly selected from those not considered to be acute cases. The number of these children that were selected was equal to 50% of the number of acute cases in that week. The same interviewer conducted all of the interviews. Although the interviewer was aware of the intervention status of the child care centers each child attended, she did not know which children being called had been listed as acute cases and which were the randomly selected healthy children.

To assess the history of chronic conditions and prior acute illnesses, a simplified standardized parental self-administered questionnaire was distributed during the tenth week of the study. The parents of children who were no longer present at the child care center were mailed the questionnaire. Parents were asked to fill out and return a questionnaire for each child enrolled in the study. Parents who did not return the questionnaire were sent a reminder letter until over 400 questionnaires were obtained. Information collected by the questionnaire included: age, gender, ethnicity, environmental tobacco smoke (ETS) exposure, bedroom sharing, presence of chronic disease, past acute respiratory problems, history of diarrhea, and head of household's highest level of education.

Additional data were not collected after the study period ended because of changes in season, because of related changes in the child care center populations, and because the intervention child care centers were no longer receiving the study products.

Statistical Methods

Data were entered using an Epi Info 2000 questionnaire for both the telephone interviews and the self-administered questionnaire. Stata Statistical Software Release 7.0 (Stata Corporation, College Station, TX) was used to merge the telephone interview data with the questionnaire data. Each questionnaire was considered to be an observation, with data from all affiliated telephone calls attached to each questionnaire record.

Chi-square analysis was performed on most of the demographic characteristics as well as on acute and chronic illnesses by intervention status. Zero-inflated Poisson regression models were used with weeks of prescribed antibiotic use as the dependent variable. Versions of the models that examined the impact of clustering by center were tested. All differences between intervention and control groups were controlled for in these analyses. Statistical significance was defined as $p<0.05$.

RESULTS

Participation

Across all 12 participating CCCs, 483 consent forms were returned with 241 for children attending control centers and 242 for children attending intervention centers. This is an estimated 52% of all consent forms distributed, based on reported maximum capacities for the centers. Those capacities included 6-year-olds and may not have been met at the time of the study, so the actual percent of returned consent forms is likely higher.

Thirty-four children (10 intervention, 24 control) did not take part in all 10 weeks of the study. One child was removed from the study by the parents after consent was signed and another was dropped because the parents were unable to speak English or provide an interpreter for the telephone interview. The other 32 children left the CCCs during the study.

There were 1449 follow-up calls attempted over the ten weeks, with 703 calls concerning the 241 children in the intervention group and 746 calls concerning the 242 children in the control group. Of these, 1289 calls (89%) were completed: 628 (89%) of those for the intervention group and 661 (89%) of those for the control group. Of the telephone interviews conducted, 87% were within 14 days after the week discussed in the interview, with a median length of time between the week of study and the interview of six days.

Two of the 483 children were removed from the study and were not provided questionnaires. Of the 481 questionnaires distributed, 440 (91%) were returned. Children for whom a questionnaire was not returned were not included in the analysis. Six more children were removed because they were six years of age or older. An additional 32 children (17 control, 15 intervention) were not included in the final regression model because of missing risk factor data. Of the remaining 402 children, 196 (49%) were in control centers and 206 (51%) were in intervention centers. These participants were enrolled for a total of 3903 child-weeks (Figure 1).

The children for whom questionnaires were not returned did not statistically differ from the children with questionnaires with respect to the numbers of weeks of prescribed antibiotic use.

Demographics

Intervention and control groups were not significantly different with regard to age, gender, race / ethnicity, shared bedroom, ETS exposure, or head of household's highest level of education (Table 3).

Medical History

Although children in the intervention centers were statistically less likely to have a history of hay fever and allergies, the intervention and control groups were not significantly different with regard to asthma, chronic bronchitis, other respiratory illnesses (including bronchiolitis and otitis media), or diarrhea (Table 4). The statistically significant difference was controlled for in the analysis.

Poisson Regression

The final hypothesis-testing model for weeks of prescribed antibiotic use adjusted for confounding by five variables: age (<3 vs. 3-5 years of age), ethnicity (Hispanic vs. non-Hispanic), history of otitis media, and head of household's education level (high school or less vs. more than high school). No significant interaction terms were identified.

Children in the intervention centers were using prescribed antibiotics significantly fewer weeks than the children in the control centers (RR = 0.68, $p = 0.001$). Those who were three through five years of age (RR = 0.27, $p < 0.001$) used antibiotics significantly fewer weeks than children less than three years of age. Children identified as Hispanic (RR = 0.69, $p = < 0.001$) used antibiotics significantly fewer weeks than non-Hispanics. Conversely, history of otitis media (RR = 2.56, $p < 0.001$) and the head of the household having greater than a high school education (RR = 1.37, $p = 0.001$) were significant risk factors for an increased number of weeks with prescribed antibiotics (Table 5).

No differences in significance were observed, compared to the results presented above, when this model was adjusted to account for clustering within the child care centers (data not shown).

DISCUSSION

A statistically significant reduction in weeks of prescribed antibiotic use was observed among the children in the intervention centers, compared to those in the control centers and adjusting for the other factors in the analysis. This suggests that the intervention was effective.

Children three through five years of age experienced fewer weeks of antibiotic use compared to children less than three years of age. This agrees with recorded differences in antibiotic treatment rates for US children (32) and makes sense when examined in conjunction with additional analyses from this study and with other literature. Specifically, children three through five years of age in this study had statistically fewer weeks with diarrheal illness and LRIs, and fewer medical visits, than their younger counterparts, and other researchers have reported higher rates of illness in younger children (4, 6, 33).

Children identified as Hispanic had fewer weeks of antibiotic use than non-Hispanic children. While this appears contrary to reports that Hispanic parents were more likely to believe antibiotics were necessary for their children when compared to non-Hispanic whites (34), it seems to be in agreement with the reasoning that some Hispanic parents will be more likely to use home remedies and over-the-counter antibiotics rather than take their child to a health care provider to get medication (35).

Finkelstein et al. (36) state that diagnosis of otitis media accounts for 56% of antimicrobial drugs prescribed to children less than three years of age and 40% of those prescribed to children between three and six years of age. It is not surprising, then, that having a history of otitis media was associated in our study with higher weeks of antibiotics use.

The head of the household having greater than high school education was a risk factor for increased weeks of antibiotic use by the child. This may be a reflection of the family's socioeconomic status (SES) and health care access, with higher education being linked with higher SES and easier – or even any – health care access.

Although analyses were run that took into account a possible clustering effect based on child care center, the results were effectively the same as those seen without the adjustment. This seems logical given that, while children in the same child care center are likely to share communicable diseases, being in the same child care center will not necessarily affect whether or not a child receives prescribed antibiotics.

The Centers for Disease Control and Prevention recommend that frequently touched surfaces, toys, and commonly shared items be cleaned at least daily, as well as when visibly soiled, using an "Environmental Protection Agency (EPA)-registered household disinfectant labeled for activity against bacteria and viruses, an EPA-registered hospital disinfectant, or EPA-registered chlorine bleach/hypochlorite solution"(37). State health department guidelines for cleaning and sanitation also recommend that bleach solutions be used in child care centers (31).

Because of these state guidelines most of the control centers were already using bleach prior to the study. It is therefore possible that the difference seen in antibiotic use was due to the products not in use prior to the intervention, such as the disinfecting wipes and disinfecting spray, rather than the bleach.

One limitation of the study design was that the parental self-administered questionnaire was not distributed until the end of the study period. This may have potentially biased some of our analyses because some questions on the questionnaire asked about past illnesses. The telephone interviews asked about similar illnesses and symptoms so it is possible that the parents responded about acute infections within the 10 weeks of the study rather then true past illness from before the study began. Thus, the significant difference between the control and intervention that exists for hay-fever / allergies (Table 4) may be the result of the intervention over that previous 10 weeks and not a true difference in the historical illness of the underlying population.

Another concern is that the analyses looked specifically at the use of prescribed antibiotics. No data were collected with regard to over-the-counter medications. The relatively easy access to such antibiotics provided by the nearness of the U.S.-Mexico border may have resulted in some children receiving them, but there is no reason to suspect this would have differed between control and intervention centers. However, if the parents of Hispanic children were more likely to obtain non-prescribed antibiotics from Mexico than this may be partly why Hispanic children were seen as less likely to use prescribed antibiotics.

There was also no direct witnessing of whether or not the child care centers' staffs followed the protocol or used the products given. Other studies have used outside cleaning companies to make sure that protocols were followed (19), but this option was not available in this study. However, indirect measures taken included keeping track of the amount of product consumed, swabbing and culturing indicator bacteria, and personally asking the child care directors about protocol adherence. Intervention centers used reasonable amounts of product and the directors always answered that the protocols were being followed. Thus, they appear to have followed the protocols.

CONCLUSION

The children in the child care centers where enhanced disinfection practices were employed used prescribed antibiotics statistically less often than their counterparts in the control centers. In addition to potentially decreasing the chances of antibiotic-resistance evolution, this reduction may reflect considerable financial savings on the behalf of the families and insurance companies that would have had to pay for those antibiotics. It may also be that this reduction is an indicator of fewer illness-related medical visits.   If so, then this intervention could have even greater economic impact with respect to health care costs.

It is not known what combination of cleaning products and cleaning procedures may have been responsible for this difference, but the combination used by the intervention centers did differ from common practice.

Figure 1: Children and centers in the study: recruitment, observation, and analysis

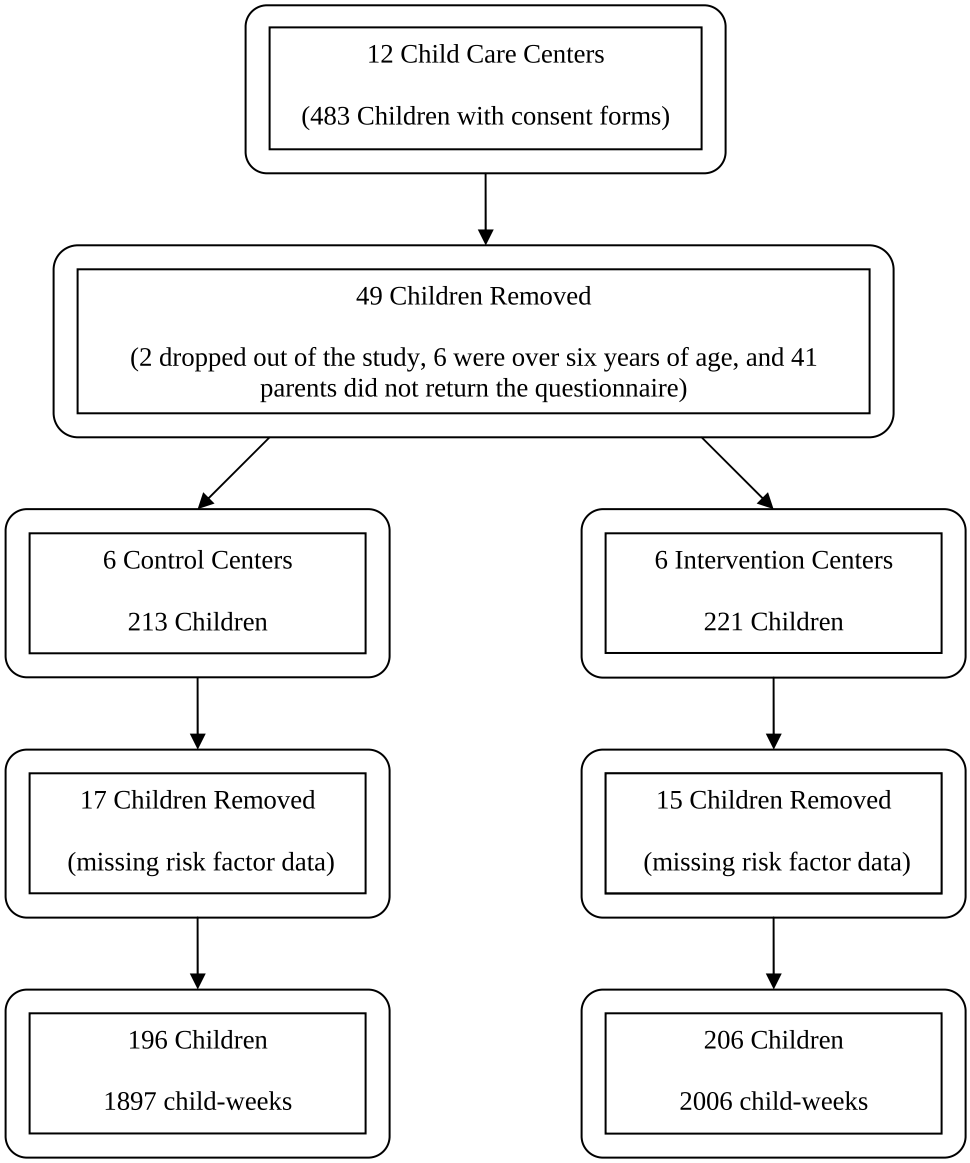

Table 1: Active ingredients of products used by intervention child care centers

Product	Active ingredients*
Bleach	Sodium hypochlorite (6.0%)
Cleaner with bleach	Sodium hypochlorite (1.9%)
Disinfecting wipes	Alkyl dimethyl benzyl ammonium chloride (0.1%)
	Dimethyl benzyl ammonium chloride (0.1%)
Disinfecting spray	Octyl decyl dimethyl ammonium chloride (0.2%)
	Dioctyl dimethyl ammonium chloride (0.1%)
	Didecyl dimethyl ammonium chloride (0.1%)
	Alkyl dimethyl benzyl ammonium chloride (0.2%)
	Ethanol (65.0%)
Toilet bowl cleaner	Sodium hypochlorite (2.0%)

* Percent active ingredient in product

Table 2: Cleaning protocols provided to intervention centers

Surface	Cleaning & Disinfecting Method	Frequency
Kitchen Surfaces:		
Sink	Wash with cleaner with bleach, leave wet 30 seconds.	Daily
Sponge / dish cloth	Soak in bleach* for 5 minutes.	3 times per week
Cutting board	Spray with cleaner with bleach, wipe clean after 30 seconds, rinse.	Daily
Counter / table top	Spray with cleaner with bleach, wipe clean after 30 seconds, rinse. Spot clean with disinfecting wipes. Leave wet for 4 minutes.	Daily
Refrigerator handle	Wipe with disinfecting wipes. Leave wet for 4 minutes.	Daily
High chair	Spray with cleaner with bleach and wipe. Leave wet for 30 seconds.	After each use
Floor	Mop with bleach*. Let stand 5 minutes and rinse.	3 times per week
Bathroom Surfaces:		
Sink / faucets	Spray with cleaner with bleach, leave for 30 seconds, wipe clean. Spot clean with disinfecting wipes. Leave wet for 4 minutes.	Daily
Counter tops	Spray with cleaner with bleach, leave for 30 seconds, and rinse. Spot clean with disinfecting wipes. Leave wet for 4 minutes.	Daily

Toilet seat / flush handle	Spray with cleaner with bleach, leave for 30 seconds, and rinse. Spot clean with disinfecting wipes. Leave wet for 4 minutes.	Daily
Toilet bowl	Apply toilet bowl cleaner, brush entire bowl; flush after 10 minutes.	Weekly
	Spray top rim with cleaner with bleach. Wipe clean after 30 seconds.	3 times per week
Toilet training equipment	Spray with cleaner with bleach, wipe after 30 seconds. Spot clean with disinfecting wipes, leave wet for 4 minutes.	After each use
Bathroom floor	Mop with bleach*, let stand 5 min and rinse.	3 times per week
Bath/shower drain	Spray entire surface area, including drain, with cleaner with bleach, rinse after 30 seconds.	Weekly
All door handles & light switches	Spray with disinfecting spray.	Daily
Other Surfaces:		
Diaper changing area	Spray with cleaner with bleach, wipe clean after 30 seconds and rinse.	After each use
Waste and diaper storage / disposal	Wash with bleach*. Leave for 5 minutes, rinse. When dry, cleaner with bleach.	Daily

Playpens	Spray with cleaner with bleach, wipe clean after 30 seconds and rinse. Spot clean with disinfecting wipes. Leave wet for 4 minutes.	Daily
Toys for infants	Clean with bleach*. Leave for 5 minutes, rinse, and air dry.	Daily
Toys for older children	Clean with bleach*. Leave for 5 minutes, rinse, and air dry.	Weekly or when soiled

* (3/4 cup to 1 gallon water)

Table 3: Demographics by intervention status

	Control	Intervention	
	N (%)	N (%)	p-value*
3-5 years old	97 (46.2)	116 (53.0)	0.160
Male	114 (53.5)	111 (50.2)	0.492
Hispanic	86 (41.8)	96 (44.0)	0.634
Shared bedroom	118 (59.6)	137 (65.2)	0.239
ETS exposure	29 (13.6)	23 (10.5)	0.312
Highest education†			0.124
High school or less	69 (32.7)	88 (39.8)	
More than high school	142 (67.3)	133 (60.2)	

* P-value calculated by chi-squared tests

†Head of household's highest level of education

Table 4: Medical history by intervention status

	Control	Intervention	
	N (%)	N (%)	p-value*
Asthma	46 (21.6)	41 (18.6)	0.428
Chronic bronchitis	103 (48.4)	105 (47.5)	0.860
Other respiratory illnesses†	141 (66.2)	131 (59.3)	0.136
Bronchiolitis	31 (15.0)	30 (13.8)	0.736
Otitis media	118 (56.2)	104 (47.5)	0.071
Hay fever / allergies	116 (55.0)	99 (44.8)	0.034
Diarrhea	30 (14.5)	29 (13.4)	0.752

*P-value calculated by chi-squared tests

†Acute bronchitis, pneumonia, bronchiolitis, croup, whooping cough, and otitis media

Table 5: RR of Risk Factors for Prescribed Antibiotic Use and Effect on the Number of Weeks of Antibiotic Use

Antibiotic use	RR	95% CI	p-value	Effect on Weeks
Intervention	0.68	0.54, 0.86	0.001	- 0.4
3-5 years old	0.27	0.17, 0.42	< 0.001	- 1.3
Hispanic	0.69	0.58, 0.82	< 0.001	- 0.4
History of Otitis Media	2.56	1.66, 3.95	< 0.001	+ 0.9
>HS education*	1.37	1.15, 1.62	< 0.001	+ 0.3

* Head of household

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