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Home Hygiene Practices and Infectious Disease Symptoms Among Household Members

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Abstract Public health programs are generally targeted to communitywide, population-based prevention strategies, with little attention focused on the home environment as one potential source of transmission of infectious diseases. The purpose of this correlational prevalence survey was to describe the relationship between home hygiene practices and prevalence of infectious disease symptoms among household members. Three hundred and ninety-eight households with 1,662 members in an inner-city population (96.4% Hispanic) were surveyed to examine hygiene practices and determine the presence of transmission of infection, defined as the presence of the same symptom(s) in two or more household members for which at least one individual sought medical attention and received treatment. At least one individual in 78.6% of households reported symptoms of infection in the previous 30 days, and 37.9% of households met the definition of disease transmission. In univariate analyses, five factors were significantly associated with risk of household transmission, but in the logistic regression model, only use of communal laundry ($p = 0.009$) and lack of bleach use ($p = 0.04$) were significantly predictive of increased risk of transmission. This is the first comprehensive survey of home hygiene practices and the first study to identify a potential link between laundry and risk of disease transmission in homes. This potential link warrants further study in clinical trials.

Key words: hygiene, environment, infections.

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For decades, formalized infection prevention and control programs have been required for accreditation in U.S. hospitals, and the epidemiology of nosocomial transmission of infections is generally well-characterized in acute care settings. The traditional public health structure has focused on population-based programs such as immunizations, outbreak investigations, and health education campaigns that benefit the larger community. The role of the home environment in the transmission of infectious diseases, however, has received little attention in the developed world during the past few decades.

One advantage of community-based studies is the opportunity to track transmission patterns, but little work has been done to quantify the prevalence of disease transmission at the level of the individual household or to correlate transmission with hygienic practices in the home. The major emphasis on controlling emerging and reemerging infections is currently on secondary prevention by early recognition (Louris, 1998), but home-based interventions could allow for primary prevention strategies to modify or eliminate risk factors. The purpose of this study was to examine the relationship between hygienic practices in the home and the prevalence of infectious disease symptoms among household members.

BACKGROUND

Despite major medical advances, the economic and social consequences of infectious diseases in the United States continue to be serious. Approximately one-fourth of visits to primary care providers are associated with infections, with an estimated cost of >$120 billion per year (Larson, 1997; Satcher, 1995). The majority of such infections are not "serious" in that they do not result in increased mortal-

ity rates, but even minor infections create a large burden of illness. Rhinoviruses, for example, cause more illness of any severity than any other virus in all age groups (Monto, 1994). Further, infections acquired in the community are important causes of hospital admissions, particularly for children. For example, respiratory infections (32%) and gastroenteritis (38%) were the principal causes for admission of 1,599 children in one British hospital (Shears & Wright, 1995).

Microbial Contamination in the Home Environment

In one field study of 70 sites tested 200 times each in 200 homes in the United Kingdom, bacterial counts of up to 10^6 colony-forming units (CFUs) per sample were found, primarily at wet sites such as sinks, mops, showers, and tubs (Bloomfield & Scott, 1997a). Others have reported similar counts on wet surfaces and surfaces which are frequently handled such as faucet handles and sink drains (Bloomfield & Scott, 1997b; Rusin, Orosz-Coughlin, & Gerba, 1998; Speirs, Anderton, & Anderson, 1995). Sponges and dishcloths are particularly prone to support high microbial populations. In an evaluation of 325 sponges and 75 dishcloths from households in four U.S. cities, Enriquez, Enriquez-Gordillo, Kennedy, and Gerba (1997) identified 23 different bacterial species with geometric mean counts of $>10^5$ CFU. Studies over the past 4 decades have demonstrated that cloth and fabric can become contaminated with high levels of microorganisms and that these organisms survive for long periods of time in fabric (Boyce, Bynoe-Potter, Chenevert, & King, 1997; Ridenour, 1952; Sanderson & Rawal, 1987; Sidwell, Dixon, & McNeil, 1967; Wetzler, Quan, & Schatzle, 1971). Thus, high levels of microbial contamination are present in the ambient home environment. This does not mean, however, that there is an associated risk of clinical infection.

Evidence of a Link Between Home Contamination and Infections

The role of the inanimate environment and fomites in the transmission of endemic infections in hospitals was shown during the 1980s to be minimal (Maki, Alvarado, Hassemer, & Zilz, 1982), but the emergence of organisms such as vancomycin-resistant enterococci has resulted in a resurgence in interest and concern about the importance of the environment in potential spread (Boyce, 1995). Experimental evidence linking microbial contamination in the home with disease transmission is lacking, although some descriptive studies are relevant. Denton and colleagues (Denton, Todd, Kerr, Hawkey, & Littlewood, 1998) examined the homes of children with cystic fibrosis who were colonized or not colonized with Stenotrophomonas maltophilia, an organism commonly associated with infections in such children. They reported widespread contamination with this organism in 36% of the homes of colonized children and 42% of homes of noncolonized, and concluded that the home environment was the likely source of infection for these children.

In a study of 50 homes of children younger than 4 years of age who were infected with Salmonella spp., isolates of the identical serotype were identified at multiple locations in 32% of the homes, including dirt on the floor, household members, a refrigerator shelf, vacuum cleaner, and pet. The investigators concluded that contaminated foods played a less important role in disease transmission than did the child's environment (Schutze, Sikes, Stefanova, & Cave, 1999). Several outbreaks of salmonellosis in health care facilities have also implicated transmission by items such as laundry (Standaert, Hutcheson, & Schaffner, 1994; Datta & Pridie, 1960). The secondary household transmission rate during an outbreak of Escherichia coli in Wales was estimated to be 4 to 15% (Parry & Salmon, 1998).

When artificially contaminated fabrics or utensils are handled, organisms are transferred in sufficient numbers to potentially result in infection (Scott & Bloomfield, 1990b). Indeed, evidence from several community-based studies has demonstrated that staphylococcal disease may be spread by fomites such as contaminated clothing or bedding (Kundsin, Walter, Ipsen, & Brubaker, 1963; McNeil, 1964). More recently, Wilcox and Jones (1995) have raised the possibility that hospital laundry may be a source of cross-infection with enterococci. Based on evidence to date, however, the risk of transmission of infection by contaminated linen or clothing appears to be extremely small, since there are only a few documented reports of cross-infection by this route (Standaert et al., 1994; Datta & Pridie, 1960; Oliphant, Gordon, & Parker, 1949).

Relationship Between Hygienic Practices and Disease Transmission

There is a large body of evidence for a causal link between handwashing and risk of infection, but most of the evidence is either from developing countries where levels of hygiene are low or from hospitals where patients are at increased risk of infection (Larson, 1988; Bryan, Cohran, & Larson, 1995). Several studies in child care centers have shown a reduced risk of infectious disease transmission when handwashing interventions were implemented (Black et al., 1981; Butz, Larson, Fosarelli, & Yolken, 1990). But data on the relationship between personal hygiene practices such as bathing and handwashing in the home and the transmission of disease are lacking.

METHODS

This was a correlational prevalence community survey of 398 households to examine the relationship between hygienic practices in the home and the transmission of infectious disease symptoms among household members.

Setting and Sample

The study was conducted in the Washington Heights neighborhood of upper Manhattan. A large proportion of the approximately 250,000 population is Hispanic, primarily from the Dominican Republic. This area was selected because it is representative of inner-city neighborhoods, with a predominantly immigrant population of working poor and middle class groups. It is densely populated with many households including several generations, often with young children. This factor facilitated the study of transmission of infections within household units. Almost 30% of local residents speak little or no English, but about 90% of the households have telephones. To qualify for the study, a household unit had to include two or more individuals, with at least one preschool child.

To determine the sample size required for a two-sample comparison of proportions with unequal group sizes (those households with evidence of transmission of infection and those without), with an alpha of 0.05 and beta 0.80, approximately 320 households were needed to detect a difference in proportions of 20% versus 40% and 385 households would be needed to detect a difference in proportions 0.10 (Brent, Mirelli, & Thompson, 1993). Hence, our sample of 398 households had sufficient power to identify clinically meaningful differences.

Subject Recruitment

Participating households were identified by convenience sampling. Four sources were used to identify and recruit potential subjects: the waiting room of a pediatric urgent care clinic located in the study neighborhood, local churches and elementary schools, and word-of-mouth by neighborhood referrals ("snowball sampling"). A pamphlet describing the study in Spanish and in English was distributed at local clinics and posted in several sites throughout the neighborhood. Subjects were recruited by one of four trained interviewers (see a description of their training below).

Instruments

Description of the Instrument

A 31-page interview booklet with five sections was developed and tested in both English and Spanish. In Section I interviewers recorded demographic and recruitment information about each household at the time of initial recruitment. Section II included 45 questions about home hygiene practices: food preparation and handling, laundry, general cleaning, and personal hygiene (handwashing and bathing). Section III had 16 questions for every individual living in the household that solicited demographic and illness information, including age and sex, ethnicity, amount of time spent outside the home, state of health, presence of chronic illness, and whether or not the following symptoms had been present within the previous 30 days: vomiting, diarrhea, fever, runny nose, cough, sore throat, skin infection, any other infections. For each symptom, the duration was recorded and whether or not the household member sought medical attention for the symptom(s), received any treatment, and/or received antibiotics. Section IV was an observation in the home by the interviewer, which included recording the brands of all cleaning and personal hygiene products present in the home and visual examination of the kitchen, laundry, or storage areas, and the bathroom. In Section V interviewers asked participants three questions to solicit their attitudes and beliefs: (1) where they thought their family picked up the most germs (at home or outside the home), (2) what were the three most important things they did to prevent infection in the home (open-ended question), and (3) to rank order the likelihood of spreading germs from five items: kitchen sink and counter, bathroom, floor, soiled laundry, and toys.

Reliability and Validity

The components of the instrument were developed based on a literature search to identify those elements of hygienic practices demonstrated to be of potential importance in disease transmission (for example, food preparation areas, general cleaning, personal hygiene). Content and face validity of the instrument were assessed by having the instrument reviewed at several points in its development and in its final form by experts in the fields of food and environmental microbiology, home hygiene, and infectious diseases. The instrument, first developed in English, was translated by a native Spanish-speaking physician and then reviewed and back translated by a second individual fluent in Spanish to assess comparability of the instrument in English and Spanish. Then a focus group of five neighborhood residents, native Spanish speakers from the Dominican Republic and El Salvador, was convened and conducted by a researcher fluent in Spanish to review the questions for clarity, ease of use, and appropriateness of language level. Several changes in the wording of questions were made as a result of this focus group, as members pointed out variations in meaning of certain words within various Hispanic ethnic groups. The instrument was reviewed by a statistician who made several design suggestions to facilitate data analysis.

The instrument included the initial interview followed by the interviewer observations in order to examine the reliability of subject reporting (that is, for several items, the observers recorded the same information that had been previously asked of the informant). There were significant correlations between products that were reported by the informant to be used and their observed presence in the house for general cleaning, laundry, and dishwashing (all $p < 0.000$). On the contrary, 56.9% of informants reported using an antibacterial product for handwashing, but such a product was present in only 27.4% of households. Based on discussions with subjects and interviewers, this discrepancy seemed to be due to subjects' confusion about what an "antibacterial" handwashing product was rather than an intentional misreporting.

Finally, a phone follow-up was attempted 7 to 14 days after the home interviews during which the same 16 illness questions were asked about each household member as well as five of the same questions regarding home hygiene asked during the initial interview. The purpose of this follow-up was to reduce the potential for recall bias by soliciting more recent illness information (the illness questions) and to get a measure of test-retest reliability (the practice questions). The follow-up calls were made by a trained interviewer different than the one who made the initial home visit and blinded to the subject's initial responses. Three telephone attempts were made to contact each household, 221 (55.5%) were contacted, and there were significant correlations between the initial response and the follow-up response in all five questions that were asked again (all $p < 0.002$). In these follow-up calls, 10.7% of households reported someone ill during the follow-up interval, a percentage consistent with what was reported for the 30 days prior to interview. Thus, there was confirmation of minimal recall bias and high levels of test-retest reliability.

Procedures

The study was reviewed and approved by the Institutional Review Board of Columbia University Medical Center.

Interviewer Training and Supervision

Four bilingual, but native Spanish-speaking persons who had experience in previous community-based projects at Columbia University Medical Center conducted all of the interviews. The project director who trained and supervised the four interviewers was a native Spanish-speaking physician. Prior to beginning the project, a pilot study that included five households was conducted in order to allow each interviewer to practice in the presence of the project director and each other. Problems were addressed in debriefing sessions. During the pilot study, interviewers suggested ways to further improve the questionnaire and to facilitate the data collection, and these were incorporated. Throughout the study, meetings with the interviewers were held at least weekly to review concerns or problems and to role-play difficult situations, and the project director made occasional unscheduled visits with the interviewers for quality control. Interviewers were particularly trained to deviate as little as possible from the wording of the questions and not to provide "leading" information or give advice.

Conducting the Interview

At the time of recruitment or soon thereafter, an appointment with the informant was made for a home visit by the interviewer. All but seven of the informants (391 of 398, 98.2%) were the female heads of the households, the others were the male head of household. After obtaining written consent from the informant, all interviews were conducted in the home and all questions were read to the participant and recorded by the interviewer in the language of their choice (English or Spanish). Interviewers recorded data directly onto a coded form. Specific products, however, were recorded by brand name and written down by the interviewer from the product label. An average interview, including the observation session, took about 1 hour. At the conclusion of the interview, participants were given a small box of hygiene products such as soap as a token of appreciation, but they were not told prior to the interview that this was going to occur. Interviews were conducted between January and July 1999.

Operational Definition of Transmission

The dependent (outcome) variable, infectious disease transmission in the household, was operationally defined in two ways. First, the presence in two or more individuals within the same household of one or more of the same symptom(s) (vomiting, diarrhea, fever, cough, sore throat, skin infection, or other infection). Second, a more rigorous definition was used: if there were two or more individuals with the same symptom(s) and at least one of them sought medical attention for the symptom and received specific treatment or antibiotics for their symptom(s).

Data Coding and Analysis

Within a few days of each interview, data were reviewed by the project director. If there were discrepancies, inconsistencies, or incomplete entries, the project director reviewed these with the interviewer and attempted to correct them if possible. The project director coded product brands into one of four categories: liquid antimicrobial, liquid nonantimicrobial, powder or bar antimicrobial, and powder or bar nonantimicrobial. A product was coded as "antimicrobial" if it contained hypochlorite or oxygen bleach,

ammonia, triclosan, alcohol (in concentrations >50%), or other recognized antimicrobial agent above preservative levels, or if it was labeled "antibacterial" or "kills germs." Products without these ingredients or language listed on the label were coded as "nonantimicrobial." A list of brand names of 72 of the most commonly used products and their categories was provided by several of the local stores and supermarkets for the purposes of this coding.

Data were entered into an Access database and downloaded into SPSS software for analysis. The chi square statistic and Student's t-test were used to compare rates of illness among individual household members by demographic variables: age, sex, ethnicity, time spent outside the home, presence of chronic disease, and reported state of health. Bivariate analyses using the chi square statistic were conducted, using the first definition of transmission (two or more persons in the same household with the same symptoms), to examine the relationship between illness and each hygiene variable. Odds ratios and 95% confidence intervals were calculated for each statistically significant variable. Next, variables significant in the bivariate analysis were entered into a logistic regression model using the more rigorous definition of transmission (two or more persons with same symptom and at least one person sought medical attention and received specific treatment or antibiotics for their symptoms) to control for interaction and confounding.

RESULTS

A total of 430 households were initially recruited, but 32 (7.4%) were not interviewed: four refused, four were out of the country for a prolonged period of time, and 24 were not reached by phone after three attempts. Hence, the final sample consisted of 398 households including 1,662 individual members.

Description of the Population

Household members were female (57.7%), mean age of 20.4 years, 96.4% Hispanic, and 56.8% foreign-born. Most (79.8%) were rated by the informant as being in good or excellent health, 15.6% had a chronic illness such as asthma, cancer, or diabetes, and 39.0% of household members were reported to spend less than 20 hours per week outside the home (Table 1).

TABLE 1. Characteristics of Household Members

Characteristic	Number	Percent
Sex (n = 1,649)		
Male	695	42.1
Female	954	57.8
Age (n = 1,650)		
Up to 5 years	423	25.5
5–12 years	284	17.1
13–20 years	199	12.0
21–50 years	660	39.9
> 50 years	90	5.4
Ethnicity (n = 1,644)		
Hispanic/Latino	1,585	96.4
African American	44	2.7
White, non-Hispanic	11	0.7
Other	4	0.2
Country of Birth (n = 1,644)		
Dominican Republic	791	48.1
United States	710	43.2
Other Central/South America	93	5.7
Europe/other	50	3.0
Health Status (n = 1,639)		
Excellent/good	1,307	79.7
Fair/poor	331	20.2
Chronic Illness (n = 1,637)		
Yes	255	15.6
No	1,382	84.4
Time Spent Outside Home (n = 1,641)		
40+ hr/week	485	29.6
20–39 hr/week	516	31.4
< 20 hr/week	640	39.0

Home Hygiene Practices

Food preparation and cleaning were primarily done by a single person, and more than two-thirds of household members (76.3%) were reported to eat more than 10 meals per week at home. Very few homes had automatic dishwashers (5.0%) or clothes dryers (5.8%), and 32.1% used communal laundries for washing clothes. Most households used sponges for dishwashing, and these were changed an average of every 19.5 days. Most subjects (88.1%) reported bathing daily and changing bath towels an average of every 4.6 days (Table 2). From 33.6% to 58.0% reported using at least one antimicrobial-containing product for washing dishes or laundry or for general cleaning (Table 3). In over 85% of all households, the food preparation area, mop, sinks, and tubs were noted by the interviewers to be visibly clean (Table 4).

Prevalence of Symptoms of Infections

A high prevalence of infections was present in this study, with evidence that infectious disease symptoms occurred in more than three-fourths of households over 1 month, and resources expended for medical attention and specific treatment in more than one-third. In 78.5% (306 of 390) of households, at least one individual was reported to have at least one symptom of infection during the previous 30 days: 28.5% (111 of 390) reported only one symptomatic person and 50.0% (195 of 390) reported two or more symptomatic individuals. The most prevalent symptoms,

TABLE 2. Home Hygiene: Reported Practices and Their Relationship to Prevalence of Infection

Practice	No. of Households	Percent	p Value*
Kitchen (n = 397)			
Food prepared by single person	314	79.1	0.83
> 10 meals/week at home	303	76.3	0.53
Automatic dishwasher at home	20	5.0	0.64
Use sponge to wash dishes	334	84.1	
Duration of sponge use (n = 386 sponges; mean = 19.5 days):			
1–14 days	188	48.7	
15–30 days	156	40.4	0.80
> 30 days	42	10.9	
Air dry dishes (n = 395)	257	65.1	0.06
Wear gloves for dishwashing (n = 395)	104	26.3	0.35
Laundry (n = 396)			
Washing machine			
At home	269	67.9	0.003
Communal	127	32.1	
Dryer			0.02
At home	23	5.8	
Communal	129	32.6	
Clothesline	208	52.5	
Several of above	36	9.1	
4 or more loads of washing/week (n = 391)	272	69.6	0.75
Use bleach (n = 396)	359	90.7	0.02
Diapers in household (n = 396)	163	41.2	0.55
Disposable	153	93.9	
General cleaning			
Done by one person	265/396	66.9	0.37
Daily cleaning			
Bathroom	354/395	89.6	0.67
Kitchen	369/395	68.1	0.15
Sinks	255/389	65.6	0.46
Bathtub	148/389	38.0	0.56
Shower	62/282	22.0	0.40
Toilet	188/395	47.6	0.75
Wear gloves when cleaning toilet	290/394	73.6	0.52
Use cloth or sponge to clean bathtub/shower	118/174	67.8	0.003
Personal hygiene			
Daily bathing	348/395	88.1	0.44
Bath only	76/394	19.3	
Shower only	134/394	34.0	
Both	184/394	46.7	
Duration of bathroom towel use (mean = 4.6 days):			
2 days or fewer	82/382	21.4	
3–7 days	243/382	63.6	0.43
> 7 days	57/382	14.9	

*Chi square comparing households with and without evidence of transmission of symptoms of infection.

in rank order, were runny nose, cough, sore throat, fever, vomiting, diarrhea, and skin infections (Table 5). In more than one-third of households (148 of 390, 37.9%), the operational definition of transmission of infection was met: that is, two or more individuals with one or more of the same symptoms, with at least one individual seeking medical attention and receiving specific treatment or antibiotics for those symptom(s).

Beliefs and Attitudes About Disease Transmission

The majority of respondents (259 of 338, 76.6%) reported that household members were more likely to pick up germs

TABLE 3. Home Hygiene: Products Used and Their Relationship to Prevalence of Infection

Product Types	No. of Households	Percent	p Value*
Dishwashing			
Antimicrobial liquid or powder	134/397	33.6	
Nonantimicrobial liquid or powder	200/397	50.4	0.53
Both	63/397	15.9	
Laundry			
Antimicrobial liquid or powder	186/395	47.1	
Nonantimicrobial liquid or powder	88/395	22.3	0.22
Both	121/395	30.6	
General cleaning			
Kitchen floors			
Antimicrobial liquid or powder	168/393	42.7	
Nonantimicrobial liquid or powder	109/393	27.7	0.15
Both	116/393	29.5	
Bathroom floors			
Antimicrobial liquid or powder	149/393	37.9	
Nonantimicrobial liquid or powder	86/393	21.9	0.22
Both	158/393	40.2	
Sinks			
Antimicrobial liquid or powder	219/390	56.2	
Nonantimicrobial liquid or powder	85/390	21.8	0.73
Both	86/390	22.0	
Bathtub			
Antimicrobial liquid or powder	222/388	57.2	
Nonantimicrobial liquid or powder	52/388	13.4	0.60
Both	114/388	29.4	
Shower (if separate from bathtub)			
Antimicrobial liquid or powder	167/288	58.0	
Nonantimicrobial liquid or powder	56/288	19.4	0.02
Both	65/288	22.6	
Toilet			
Antimicrobial liquid or powder	217/384	56.5	
Nonantimicrobial liquid or powder	47/384	12.2	0.51
Both	120/384	31.3	
Personal hygiene			
Handwashing			
Antimicrobial product used	223/392	56.9†	0.61
Bathing			
Antimicrobial product used	189/395	47.8†	0.54

*Chi square comparing households with and without evidence of transmission of symptoms of infection.
†Reported frequency of using antimicrobial products exceeded presence of such products in homes (27.4% of homes actually had an antimicrobial product available). The correlation between reported product use and the presence of these products in the home was significant ($p < 0.000$) for all products except those used for handwashing and bathing ($p > 0.55$).

outside the household, 20.1% felt that members were equally likely to acquire germs from inside or outside the house, and 3.3% felt that members were more likely to acquire germs inside the home. Risk areas for disease transmission were rank ordered as (1) toys (39.0%), (2) floor and laundry (tied at 17.6% each), (3) bathroom (14.3%), and (4) kitchen (11.6%). When respondents were asked in an open-ended fashion to name the three most important things they did to prevent the spread of germs in the home, responses were in seven major categories: general cleaning (57.9%), cleaning the bathroom (10.0%), food preparation and storage (7.2%), laundry (6.9%), handwashing and cleaning the floor (tied at 6.6% each), and other, which included cleaning the kitchen, bathing, filtering water, avoiding cockroaches, and garbage handling (4.8%).

TABLE 4. Observations of Home Hygiene

Observation	No. in Household	Percent	Correlation with Symptom Transmission: p Value*
Food preparation area			
Visibly clean	328/385	85.2	
Visible food remnants or dirty dishes	50/385	13.0	0.94
Visible dirt or mold	7/385	1.8	
Storage of soiled laundry			
In container	349/387	90.2	
Scattered throughout house	26/387	6.7	0.45
In container and scattered	12/387	3.1	
Mop			
New	51/380	13.4	
Used, but visibly clean	368/380	70.5	0.56
Used, and visibly soiled	61/380	16.1	
Bathroom sink			
Visibly clean	354/384	92.2	
Visible dirt or soil	24/384	6.2	0.054
Visible mold or scum	6/384	1.6	
Kitchen sink			
Visibly clean	343/373	91.9	
Visible dirt or soil	26/373	7.0	0.25
Visible mold or scum	4/373	1.1	
Shower and tub			
Visibly clean	349/371	94.1	
Visible dirt or soil	14/371	3.8	0.12
Visible mold or scum	8/371	2.2	

*Chi square comparing households with and without two or more individuals with symptoms of infection.

TABLE 5. Reported Symptoms of Infection in Previous 30 Days Among 1,662 Household Members

Overall Prevalence (n = 390)		Number	(Percent)
Nobody ill;		84	(21.5)
One person ill;		111	(28.5)
Two or more persons ill, but no medical attention or treatment;		39	(10.0)
Two or more persons ill and at least one sought medical attention but did not receive specific treatment or antibiotics for symptoms;		8	(2.1)
Two or more persons ill and at least one sought medical attention and received specific treatment or antibiotics for the symptoms.		148	(37.9)
Prevalence of Specific Symptoms in Individuals	**Mean Duration (min/max, ± stand deviation)**	**Number**	**(Percent)**
Vomiting (n = 1,625)	2.68 days (1–30, ± 3.40)	142	(8.7)
Diarrhea (n = 1,620)	4.64 days (1–180, ± 16.27)	106	(6.5)
Fever (n = 1,621)	2.48 days (1–13, ± 1.81)	209	(12.9)
Runny nose (n = 1,622)	8.81 days (1–160, ± 15.44)	383	(23.6)
Cough (n = 1,622)	7.63 days (1–240, ± 14.37)	378	(23.3)
Sore throat (n = 1,621)	5.29 days (1–240, ± 14.11)	312	(19.2)
Skin infection (n = 1,620)	18.8 days (1–180, ± 38.16)	56	(3.5)

Home Hygiene Practices and Transmission

For individual members of the households, there was no significant association between having symptoms of infections that required medical attention and gender (women, 51.3% and men, 53.9%, p = 0.55) or ethnicity (Hispanic, 52.7% and other, 35.0%, p = 0.18). Ill individuals were, however, significantly younger (mean ages of those receiving and not receiving medical attention were 16.7 and 22.4 years, respectively, t-test, p < 0.000), more likely to spend more time in the home (57.1% of ill vs. 38.2% of well spent <40 hours outside the home, p = 0.00002), more often judged to be in fair to poor health as compared with excellent to good (63.0% and 46.4%, respectively, p = 0.00004), and more likely to have at least one chronic disease (65.9% vs. 47.1%, p = 0.00002). There was no significant relationship between households in which there was disease transmission and whether respondents thought household members picked up more germs inside or outside of the home (p = 0.63), how they ranked the importance of various fomites (p = 0.08), or what they ranked as the most important thing they did in the home to prevent the spread of infections (p = 0.31).

In the bivariate analyses, five variables were significantly correlated with household transmission: location of washing machine (home or communal, defined as any shared laundry facility outside the home), location of clothes dryer (home or communal dryer), use of bleach in laundry, equipment used to clean bathtubs (cloth, sponge, brush, or several), and type of product used to clean the shower (antimicrobial or nonantimicrobial). None of the food preparation or personal hygiene practices were associated with transmission in these data. In the logistic regression model, only two variables were independently predictive of increased risk of transmission among household members—use of a communal washing machine and lack of bleach use in the laundry (Table 6).

DISCUSSION

It would be logical to assume that the effectiveness of hand hygiene shown in other settings might be applicable to the home environment as well. It is therefore surprising that the two significant predictors of transmission in this study related to laundry (use of communal laundries and lack of bleach use), whereas the personal hygiene variables were not significant. Participants in this study rated handwashing relatively low when asked about the most important things they did to prevent the spread of germs in their homes (ranked fifth, tied with cleaning the floors). Additionally, they often reported using an antibacterial soap when none was present in the home. Finally, we did not solicit information on specific handwashing behavior such as frequency and duration, so the measure of handwashing practices used in this study was quite crude. Hence, the practice of handwashing in these homes may have been inadequately measured in this study. Recently, investigators have shown that generic hand dishwashing detergents are 100-fold more effective than proprietary antibacterial soaps in inactivating respiratory syncytial virus (Contreras, Sami, Darnell, Ottolini, & Prince, 1999). In our study, subjects often reported using the dishwashing detergent for handwashing in the kitchen, so this practice may have had a positive impact on reducing microbial contamination of the hands.

Similarly, one might expect to find that food handling and preparation practices would be identified as contributors to disease prevalence since microbial contamination is high in the kitchen and dish cloths and sponges are so readily and persistently colonized, but none of these variables were significantly predictive. This may suggest that in the absence of specific pathogens such as Salmonella, the presence of areas likely to have high bacterial counts is not necessarily causally linked with an increased risk of infection.

While the role of environmental sanitation in specific situations of high risk such as crowded child care centers, residential facilities, or clinics is generally accepted, the corresponding benefits in the home are less completely understood. Clearly there has been less effort invested in understanding the home environment, but the on-demand usage pattern of antimicrobial products in the home (vs. within health care institutions) may also contribute to the current lack of clearly defined benefits. That is, antimicrobial products are widely available for public use and have been widely adopted without any systematic evaluation of their benefit.

Although antimicrobials such as phenolics or oxidizers are highly effective (Rutala, Barbee, Sobsey, & Weber, 1998; Sattar, Jacobsen, Springthorpe, Cusack, & Rubino, 1993), their protection usually lasts only 3 to 6 hours (Scott, Bloomfield, & Barlow, 1984). Further, some investigators have found that routine practices such as use of nonantimicrobial detergents alone may actually be associated with increased bacterial counts, seeding the environment with more microorganisms (Dharan et al., 1999; Josephson, Rubino, & Pepper, 1997). In one recent in-vitro study testing

TABLE 6. Significant Predictors of Prevalence of Infectious Disease Symptoms Among Household Members*

Variable	Odds Ratio, p Value
Using communal laundry	4.02 p = 0.009
Using bleach in laundry	0.17 p = 0.04

*Logistic regression.

ammonia, baking soda, borax, vinegar, a liquid dishwashing detergent, and bleach, only bleach was effective against S. aureus, Salmonella typhi, and E. coli (Parnes, 1997). Nevertheless, a reduction in absenteeism, respiratory infections, and other indicators of infection has been demonstrated with a comprehensive infection control program that included environmental antimicrobial cleaning in a specialized preschool (Krilov et al., 1996). Given the mixed evidence, more controlled evaluations of home environmental antimicrobial cleaning are indicated.

The finding in this study that laundry variables were associated with disease transmission was unexpected, but consistent with other research. A number of investigators have reported that bacteria, including coliforms, are frequently recovered from washed clothing, particularly when low water temperatures are used (Christian, Manchester, & Mellor, 1983; Davis & Ainsworth, 1989; Smith, Neil, Davidson, & Davidson, 1987). Studies of communal laundries demonstrate that the washing machines are contaminated after use and can colonize laundry between loads (Buford, Pickett, & Hartman, 1977; Legnani & Leoni, 1997). Hot water temperature (80 to 90°C) is more microbicidal, but machines are often used at temperatures of 25 to 60°C. In these circumstances, the addition of an effective antimicrobial additive is necessary to effect a significant reduction in microbial contamination of the laundry and machine (Scott & Bloomfield, 1990a). Belkin, in a thorough review of the research regarding institutional laundry practices, concluded that ". . . chlorine bleach should continue to be an integral part of the laundering formulations for all textiles used in health care facilities" (1998, p. 151). Thus, while the results from this present study are consistent with previous reports, this is the first study in a home setting to demonstrate a potential link between laundry practices and disease transmission in the household.

This study had the usual limitations of a self-report design, although confirmation of subject reporting with direct observations in the home and follow-up calls to examine test-retest reliability and recall bias indicated that the reliability of the self-reports was generally high. The population studied was representative only of an immigrant urban poor to middle class group and results cannot be generalized to a more affluent suburban setting. Further, the presence of infections was not confirmed by physical examination or laboratory diagnosis. For that reason, a rigorous definition of infection transmission was used: two or more members in the household ill with the same symptom(s), at least one of whom sought medical attention and received specific treatment or antibiotics for the symptoms. Finally, measurement of personal hygiene practices was limited to self-report of type of soap used and frequency of bathing. Other important aspects of personal hygiene such as handwashing practices were not measured. Despite these limitations, new data on the potential role of the home environment in infectious disease transmission were generated.

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this large community survey was to identify hygienic practices in the home that were associated with transmission of infectious disease symptoms among household members. This was the first comprehensive survey of home hygiene practices and the first study to identify a potential link between laundry and risk of disease transmission in homes. These findings are intriguing and suggest that the potential role of laundry in the transmission of infections within households warrants further study, ideally in prospective, randomized clinical trials.

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