

Hygiene and health: An epidemiologic link?

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One of the great achievements of the public health enterprise in the 20th century has been the control of infection. In 1900, one third of all deaths were caused by 3 infectious diseases (pneumonia, tuberculosis, and diarrhea); 40% of these deaths occurred in children younger than 5 years. By 1997, more than half of all deaths were caused by 2 chronic diseases, heart disease and cancer.¹ This statistic indicates a profound improvement in infectious disease control that has been attributed to a variety of factors, including vaccination programs, improved public utilities (such as water chlorination and waste disposal), and general improvements in health related to nutrition and personal hygiene.

Despite these major health care advances, the economic and social consequences of infectious diseases continue to be serious, even in the "developed" world. For example, in the United States approximately one fourth of visits to primary care providers are associated with infections, and the economic burden has been estimated to be more than \$120 billion per year.^{2,3} Between 1980 and 1992 a 58% increase in death from infections occurred in the United States, only half of which was attributed to AIDS.⁴ Infections acquired in the community are important causes of hospital admissions, particu-

larly for children. Respiratory infections (32%) and gastroenteritis (38%) were the principal causes for admission of 1599 children in one British hospital.⁵ Each year, nearly 90,000 US children are hospitalized just for respiratory syncytial virus infections.⁶ Rotavirus causes more than 3 million cases of diarrhea, 50,000 hospitalizations, and up to 40 deaths each year in the United States.^{7,8} In addition, more than 80% of the world's population lives in tropical developing countries in Asia, Africa, and Latin America. In these areas, more than 35 new infectious diseases have been identified in the past 2 decades, and up to 1 out of 4 children still die of diarrhea and dehydration before the age of 5 years.⁴

Because many factors associated with the control of infections (eg, better nutrition, safe drinking water, vaccination, and improved personal hygiene) have been temporally related to each other, occurring simultaneously or very close in time, measuring the specific impact of any single intervention is difficult, particularly with regard to cleanliness and personal hygiene within the home and community. On one hand, a burgeoning of availability and use of a variety of antibacterial products in homes for bathing, washing clothes and dishes, and general cleaning has occurred. Although the public's renewed interest in issues of cleanliness is evidenced by the demand for such products, a paucity of evidence exists regarding the impact of such products on disease incidence or transmission. On the other hand, in recent years the programmatic emphasis within the formal public health structure has moved away from personal hygiene and the home environment, focusing more on secondary and tertiary prevention and community-wide interventions.³ Hence, the home environment has received little attention from public health professionals in the past few decades, and the question remains: What is the contribution of household hygiene and personal cleanliness practices to the risk of infectious disease transmission? The purpose of this article is to summarize the recent health care literature and to examine the epidemiologic link between personal and household hygiene and risk of infection.

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Table 1. Intervention studies assessing effects of hygiene on health outcomes, 1980-2000

Author, year	Location	Level of intervention	Intervention	Outcomes
Black, 1981 ¹¹	United States	Child care center	Handwashing program	Diarrhea incidence half of that of the control schools
Khan, 1982 ²¹	Bangladesh	Family	Soap and water pitchers provided for handwashing	Secondary infection rate 10.1% in study group, 32.4% in control group
Toron, 1982 ²²	Guatemala	Individual	Hygiene promotion program for mothers	14% reduction in diarrhea incidence; 32%-36% reduction during peak diarrhea season
Stanton, 1987 ²³	Bangladesh	51 communities	Intervention to improve handwashing, reduce open defecation, improve garbage and feces disposal	Diarrhea rate significantly lower in intervention communities
Hill, 1988 ²⁴	Philippines	Community (22 study groups)	Human development intervention including education with a curriculum based on Rogers' model of diffusion of innovation	Decrease of 70% in diarrhea and fever
Han, 1989 ²⁵	Rangoon	Community	Handwashing	Diarrhea rate significantly lower in intervention group
Alam, 1989 ²⁶	Bangladesh	Community	Water pumps and hygiene education	Use of handpump water, removal of feces from yard, maternal handwashing decreased yearly diarrhea incidence by >40%
Aziz, 1990 ²⁷	Bangladesh	Community	Water, sanitation, and hygiene education	25% fewer episodes of diarrhea when compared with controls
Wilson, 1991 ²⁸	Indonesia	Family	Soap and explanation of fecal-oral transmission	89% reduction in diarrhea episodes compared with control period before intervention
Monsma, 1992 ¹²	United States	School	Handwashing education program for children with disabilities	22% less absenteeism than in previous year
Ahmed, 1993 ²⁹	Bangladesh	Community	Hygiene practices intervention via village leaders	Lower diarrhea morbidity at intervention site
Araya, 1994 ³⁰	Chile	Family	Education for mothers about preventing diarrhea	Significantly fewer days of any illness, diarrhea, respiratory illness among intervention families
Haggerty, 1994 ³¹	Zaire	Community	Hygiene education program	11% reduction in diarrhea
West, 1995 ³²	Tanzania	Community	Face-washing program	Odds of having severe trachoma in intervention villages was 0.62 (statistically significant)
Mohle-Boetani, 1995 ³³	United States	Community	Promotion of handwashing	Control of shigellosis outbreak
Shahid, 1996 ³⁴	Bangladesh	Community	Handwashing in a periurban slum	2.6-fold reduction in diarrheal episodes in intervention area
Pinfold, 1996 ³⁵	Thailand	Community	Handwashing promotion	Significant reduction in diarrheal disease
Krilov, 1996 ¹³	United States	School	Comprehensive intervention including staff education, emphasis on environmental cleaning and disinfection, compliance monitoring	Significant decreases in illness, physician visits, courses of antibiotics, and school absenteeism
Kimel, 1996 ¹⁴	United States	School	Handwashing education for children	Significantly higher absenteeism, particularly for flu-like illnesses, among nonparticipants
Niffenegger, 1997 ¹⁵	United States	School	Handwashing education for children	Test group had significantly fewer colds than control group
Master, 1997 ¹⁶	United States	School	Scheduled handwashing	Nonsignificant reduction in absenteeism
Peterson, 1998 ³⁶	Malawi	Refugee camp	Soap distribution	27% fewer episodes of diarrhea when soap was present
Carabin, 1999 ¹⁷	Canada	52 child care centers	Hygiene program	Significant reduction in incidence of diarrhea and upper respiratory infections

Table 1. Continued

Falsey, 1999 ¹⁸	United States	Senior day care centers	Staff education about handwashing and alcohol foam	Rate of respiratory infections significantly lower than in previous 3 y
Roberts, 2000 ¹⁹	Australia	Child care centers	Staff training in handwashing and aseptic nosewiping	Significant reduction in respiratory illness in children 24 mo or younger, but not older
Roberts, 2000 ²⁰	Australia	Child care centers	Staff training in handwashing and aseptic nosewiping	Diarrhea rates decreased by 50% in children 24 mo or younger
Hammond, 2000 ⁵⁹	United States	16 public elementary schools	Provide alcohol handwipes to students	19.8% reduction in absenteeism resulting from infection compared with control schools ($P < .05$)

LITERATURE REVIEW

Method

The Medline database (<http://www.ncbi.nlm.nih.gov>) was searched for the years 1980 through June 2000, using certain parameters and limitations. Included in the search were English language articles published between January 1980 and June 2000 using either an interventional design (experimental or quasi-experimental) or correlational design (case-control or other descriptive design) at the community, school, or household level that examined the relationship between personal, environmental, or household hygiene and infectious disease transmission. Not included in the search were articles in languages other than English, studies in health care institutions (hospitals or long-term care facilities), and interventions that were primarily related to public health infrastructure and systems, such as municipal water supply and waste disposal.

Findings

We found 26 interventional and 24 correlational studies during the 20.5-year time frame (Tables 1 and 2). Most studies (38; 76%) were conducted in developing countries, and the remainder (12; 24%) were conducted in North America and Australia. Many of the interventions were described in very general terms, for example, "a hygiene education program" or "a handwashing campaign," but many were long-term, lasting months or years, and had large samples sizes. Interventions were targeted at various populations: 11 (42.3%) at the community level, 11 (42.3%) in schools, child care or senior centers, or a refugee camp, and 4 (15.4%) within families or individual households. Seven (29.2%) of the correlational studies were case-control studies; the others were a variety of prospective, retrospective, and cross-sectional surveys.

Thirty-eight of the studies (76%) used rates of diarrhea or intestinal infection as one of the primary outcomes; 9 (18%) examined rates of respiratory illness and/or school absenteeism, and 4 (8%) studied trachoma. All but 2

studies^{9,10} reported a significant correlation between specific hygiene practices and risk for infection; however, many of these studies used several interventions (eg, handwashing, waste disposal, water storage), making it impossible to identify which, if any, single intervention was the most effective. However, all 15 of the studies in which handwashing was the only intervention reported significant reductions in the incidence of diarrhea.

Discussion and conclusions

Even during the 1990s, studies from developing countries have demonstrated significant reductions in the incidence of diarrhea and related diseases when household and personal hygiene improves (Tables 1 and 2). However, such studies are difficult to conduct in many countries in North America and Europe for several reasons: (1) levels of hygiene in industrialized nations are generally high, (2) the public values personal choice and consumers are buying and using a variety of "germ-killing," antibacterial products even in the absence of evidence that they prevent infections and regardless of their health status, making it difficult to assess the effectiveness of new products and practices before they are widely used, and (3) few, if any, valid and reliable tools exist to measure hygiene and hygienic practices within households.

The home and school environments are of particular concern for the transmission of infections among young children or aged persons, who are at the greatest risk. Although there have been a number of reports of reduced absenteeism and infections in schools and day care sites associated with handwashing intervention programs,¹¹⁻²⁰ we found no reports of hygienic interventions in homes in developed countries. Although the household-based hygienic interventions within developing countries were successful at reducing rates of diarrhea,²¹⁻²³ the interventions took place under conditions of very poor hygiene, often with a lack of running or potable water and inadequate waste disposal. From these studies, it is impossible to determine the extent to which being "cleaner,"—that is, having hygienic standards above some undetermined minimal baseline—provides additional protective benefit.

Table 2. Correlational studies assessing effects of hygiene on health outcomes, 1980-2000

Author, year	Location	Study design	Variables studied	Correlations
Bertrand, 1983 ³⁷	Colombia	Descriptive survey	Diarrhea prevalence related to maternal knowledge and attitudes	Significant predictors of diarrhea: child malnutrition, age of mother, house appearance, maternal birthplace, mother's general knowledge of diarrhea
Stanton, 1985 ³⁸	Bangladesh	Case control	Handwashing, handling of excreta and garbage, food handling	Significantly more maternal handwashing and less disposal of excreta on floor in control subjects
Araya, 1985 ¹⁰	Chile	Descriptive correlational	Hygienic practices in family	Adequate hygienic habits not associated with decreased risk of diarrhea
Baltazar, 1989 ³⁹	Philippines	Case control	Disposal of feces	Unsanitary disposal significantly associated with increased diarrhea
Taylor, 1989 ⁴⁰	Tanzania	Descriptive correlational	Risk factors for trachoma	Significant risk factors: poor facial cleanliness, household fly density
Henry, 1990 ⁴¹	Bangladesh	Descriptive correlational	Contamination of children's hands and drinking water, diarrheal morbidity	Diarrhea rates significantly lower with more sanitation and water contamination among areas but not individuals and significantly correlated with degree of contamination of hands
Yeager, 1991 ⁴²	Peru	Descriptive correlational	Risk factors for diarrhea	Significant predictors of diarrhea: water storage, location of child defecation, child eating soil or feces, young age
West, 1991 ⁴³	Tanzania	Descriptive	Risk factors for trachoma	70% higher rate of trachoma in children with flies and nasal discharge on their faces
Ekanem, 1991 ⁴⁴	Nigeria	Case control	Risk factors for diarrhea	Significantly associated with diarrhea: feces around toilet area, use of chamber pots, indiscriminate waste disposal, source of domestic water
Moy, 1991 ⁹	Zimbabwe	Descriptive correlational	Risk factors for diarrhea	No association between diarrhea and feeding, environmental, educational, socioeconomic status
Wijewardene, 1992 ⁴⁵	Ceylon	Case control	Risk factor for diarrhea	Significant: lack of piped water and latrine, low level of maternal education and awareness of disease spread, no disposal of child feces in latrine, improper garbage disposal
Bartlett, 1992 ⁴⁶	Guatemala	Descriptive correlational	Risk factors for persistent diarrhea	Significant: presence of toy, fecally soiled diaper, or baby bottle on ground, dirty maternal hands, feces in yard, child wearing fecally soiled diaper
Baltazar, 1993 ⁴⁷	Philippines	Case control	Relation between personal and domestic hygiene and hospitalized childhood diarrhea	Significant association between diarrhea and indices for overall cleanliness and kitchen hygiene
Punyaratabandhu, 1993 ⁴⁸	Thailand	Descriptive correlational	Risk factors for diarrhea in government housing project	Risk factors for 1-2 y olds: nonworking mothers, unhygienic behavior of child caretaker such as no handwashing and method of cleaning milk bottles
Dikassa, 1993 ⁴⁹	Zaire	Case control	Risk factors for severe diarrhea	70% higher risk of severe childhood diarrhea if mothers scored poorly on disposal of child feces and household garbage and knowledge that poor caretaker cleanliness was a cause of diarrhea
Sempertegui, 1995 ⁵⁰	Ecuador	Descriptive correlational	Risk factors for diarrhea in child care centers and homes	Significantly associated with diarrhea: reuse of water for child handwashing and washing raw vegetables
Rudland, 1996 ⁵¹	Iraq	Descriptive correlational	Diarrhea in British and Australian troops	Those not taking doxycycline and no enforcement of a plate and handwashing regimen had significantly higher diarrhea rates

Table 2. Continued

Ghosh, 1997 ⁵²	India	Case control	Maternal behaviors and child diarrhea	Significant risk factors: bottle feeding, nonuse of soap to clean feeding container, open water storage, drinking pond water, indiscriminate disposal of child feces
Oyemade, 1998 ⁵³	Nigeria	Cross-sectional survey	Environmental and personal hygiene practices and diarrhea	Risk factors: water and food bought from vendors, child defecation practices, mothers' cleaning up after child defecation, refuse disposal
St Sauver, 1998 ⁵⁴	United States	Descriptive correlational	Hygienic practices and respiratory illness in family and group day care homes	Infrequent handwashing significantly associated with higher rate of respiratory illness
Gorter, 1998 ⁵⁵	Nicaragua	Prospective follow-up study	Effect of hygiene practices on diarrhea in children <2 y	Consistent relationship between almost all hygiene practices and diarrhea
Barros, 1999 ⁵⁶	Brazil	Prospective study	Child care practices in child care centers associated with respiratory infection and diarrhea	33% less diarrhea in classes where soap was frequently used during diapering; risk factors for diarrhea: presence of flies during meals, infrequent child handwashing before meals and after defecation; no modifiable characteristics identified for respiratory infection
Scolari, 2000 ⁵⁷	Brazil	Survey	Prevalence of helminth infections in urban and indigenous schoolchildren	Statistically significant correlation between helminth infections and most housing/hygienic variables
Pruss, 2000 ⁵⁸	39 parts of the world	Review of 19 studies	Methods to prevent trachoma	Clear evidence to support facial cleanliness and environmental improvements to prevent trachoma

Therefore, on the basis of the current database, the following conclusions can be made:

- The 3 primary measures associated with reduced incidence of infections include availability of a clean water supply, adequate disposal of waste (particularly for feces), and hand hygiene;
- such interventions are primarily useful for infections spread by the fecal-oral route (specifically, diarrheal and respiratory diseases);
- most of the research on an environmental link between hygiene and health has been conducted in developing countries;
- in developed countries, the effectiveness of measures such as hand and environmental hygiene have been demonstrated in settings such as schools and day care centers;
- in developed countries, the importance of cleanliness in the home environment has received little attention and the role of the home environment in the spread of infections is unknown; and
- the effectiveness of additional efforts to improve cleanliness (eg, use of antibacterial products and specific home cleaning regimens) beyond minimal standards has not been demonstrated.

Because of the paucity of data regarding “cleaner” home environments in developed countries, it is not possible to make recommendations regarding the advisability of using more or different types of soap and other cleaning products. Unfortunately, a multitude of such products are widely used, and significant resources are spent to clean household surfaces and items and for personal hygiene. On one hand, increasing concerns have been raised about the potential for the development of antiseptic resistance (and potential for cross-resistance with antibiotics) when antimicrobial products are used routinely. On the other hand, it may be that such regimens and products confer additional health benefits; however, the data necessary for a cost-benefit analysis are lacking. For that reason, we recommend that studies be conducted in developed countries to examine the epidemiologic link between home hygiene and health and also between routine use of antimicrobial products for cleaning and health.

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