Clinical Insights® in
PEDIATRIC RESPIRATORY CARE
VOLUME 4, NUMBER 7, 2008

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Lack of Protection With N95 Respirators Against Particles of Bacterial and Viral Sizes

Interest in respiratory protection against a number of infectious disease agents, such as those that cause severe acute respiratory syndrome (coronavirus), avian influenza (H5N1 influenza A virus), and anthrax (*Bacillus anthracis*), has increased in recent years. Current guidelines issued by the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) recommend the use of National Institute of Occupational Safety and Health (NIOSH)-approved N95 or higher level protection respirators against airborne transmission of bacteria and viruses. When N95 respirators are not available, surgical masks are considered alternatives.

Lee and colleagues recently studied the filtration efficiency, measured as protection factors (PFs), of N95 respirator filters and surgical masks against inert, aerosol NaCl particles within the bacterial and viral size ranges (aerodynamic size, 0.04–1.3 µm). The PF was calculated by dividing the particle concentrations outside the respirator by those inside the respirator. As designated by the US Occupational Safety and Health Administration (OSHA), a PF of 10 for N95 filtering facepiece respirators represents the level of protection provided by a properly functioning respirator in the workplace. The protection levels of N95 filtering facepiece respirators (4 models) and surgical masks (3 models) were assessed while worn by 12 subjects performing the OSHA fit-testing exercises in a test chamber.

Results indicated that N95 filtering facepiece respirators may not attain the expected level of protection against bacteria and viruses.

PFs of <10 were demonstrated in approximately 29% of N95 respirators and approximately 100% of surgical masks. Among the 36 tested N95 respirators of types A, B, and C, and among 9 tested N95 respirators of type D, PFs <10 were found for 13.9%, 63.9%, 11.1%, and 22.2% of the respirators, respectively. The respective percentages for PF <5 were 0%, 16.7%, 0%, and 0%. Overall, the PFs of N95 respirators were 8 to 12 times greater than those of surgical masks. The minimum PFs were noted in the particle size range of 0.04 to 0.2 µm. There were no significant differences in PFs between N95 respirators with or without an exhalation valve, which is designed to ease the wearer's breathing in the presence of filter resistance.

This study was the first to use human subjects to investigate the protection level provided by N95 filtering facepiece respirators and

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Release Date: Aug 28, 2008
CME Credit Valid Through: Oct 28, 2008

This educational activity is conducted as a part of the *Pediatric Respiratory Care Initiative*™ (PRCI™), sponsored by Professional Postgraduate Services® (PPS).

Participants who wish to receive CME credit for this educational activity should do the following: (1) read the current issue; and (2) complete the post-test and evaluation form included to conclude this CME activity. You may also complete the post-test and evaluation form on our website, www.PediatricRespiratory.org and select "Clinical Insights." You may also return the completed post-test and evaluation via fax to 1 (201) 430-1441 or mail to: **Professional Postgraduate Services®, CME Dept. T328, 200 Meadowlands Parkway, Secaucus, NJ 07094-2302.** If you have any questions, please call 1 (800) 606-6106 Ext. 6015. Applicants will receive a certificate of participation from PPS by return mail within 6 to 8 weeks of the date of receipt of the completed evaluation form and post-test. Online applicants will automatically receive their CME credit certificate upon completion of the post-test and evaluation form.

LEARNING OBJECTIVES After studying the literature presented in this issue, participants will be able to:

- Describe the ability of N95 respirators and surgical masks to protect against particles of bacterial and viral sizes.
- Discuss the effects of a multifactorial infection-control intervention consisting of hand-sanitizer use and surface disinfection in reducing elementary school absenteeism.

TARGET AUDIENCE This educational activity is designed for pediatricians, primary care physicians, pediatric and family nurse practitioners, neonatologists, infectious disease specialists, allergists, pulmonologists, immunologists, and other healthcare professionals involved in the care and management of pediatric respiratory patients.

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This CME activity is supported by an educational grant from MedImmune, Inc.

OFF-LABEL DISCLOSURE Some of the drug treatments discussed in this issue may note uses not approved by the Food and Drug Administration. Articles containing such uses will be noted at the end of the article.

Disclosures:

Dr Piedra is professor of pediatrics and molecular virology and microbiology at Baylor College of Medicine, Houston, Texas. He has indicated that he receives grant/research support from Juvaris BioTherapeutics, Inc., MedImmune, Inc., Sanofi Pasteur and Novartis Pharmaceuticals; is a speaker for MedImmune, Inc.; and is an ad hoc consultant for MedImmune, Inc., Sanofi Pasteur, Novartis Pharmaceuticals, Hoffman-La Roche, Inc., and Merck.

Dr Hall is professor of pediatrics and medicine at the University of Medicine and Dentistry, Rochester. She has indicated that she is an ad hoc consultant for MedImmune, Inc.; she also receives grant/research support from MedImmune, Inc.

Barbara Guidos is a senior managing editor for Professional Postgraduate Services®. She has indicated no relevant financial relationships.

Mr Palangio is a medical writer for Professional Postgraduate Services®. He has indicated no relevant financial relationships.

Terri Setteducato is a senior program director; Wadee'ah Terry is a CME program manager for Professional Postgraduate Services®. They have indicated no relevant financial relationships.

Lack of Protection With N95 Respirators Against Particles of Bacterial and Viral Sizes *(Continued)*

surgical masks against particles of bacterial and viral sizes. These results indicated that N95 filtering facepiece respirators may not attain the expected level of protection against bacteria and viruses. Most of the tested N95 respirators and surgical masks in this study performed at their worst against particles of similar size to coronavirus and influenza virus (0.04-0.2 µm). Although the tested N95 respirators provided about 8 to12 times better protection than the surgical masks, about 29% of the tested N95 respirators had PFs <10. This finding indicates that the newly assigned OSHA PF of 10 may overestimate the actual protection offered by N95 respirators against bacteria and viruses.

Lee SA, Grinshpun SA, Reponen T. Respiratory performance offered by N95 respirators and surgical masks: human subject evaluation with NaCl aerosol representing bacterial and viral particle size range. *Ann Occup Hyg*. 2008;52(3):177-185.

COMMENTARY

CAROLINE B. HALL, MD, Professor of Pediatrics and Medicine, Pediatric Infectious Diseases, University of Rochester School of Medicine and Dentistry, Rochester, New York.

Transmission of infectious organisms is complex, variable, and unpredictable. Viruses may be spread by small-particle aerosols (10 µm mass median diameter) of secretions, which may traverse long distances, or by large-particle droplet aerosols (10-100 µm), which usually travel no more than 3 feet. Touching contaminated objects, such as countertops, toys, or tissues, and then one's face commonly results in self-inoculation of respiratory viruses. Respirators (N95 or higher) are primarily reserved for protection against small-particle aerosols of highly pathogenic agents. However, most viruses may be transmitted by more than one route and even simultaneously. Which routes occur and whether infection results depend on multiple and changing circumstances. The temperature and humidity in the environment and respiratory tract will change the particle size, as noted in this article. However, many other interacting factors will also determine whether a sufficient viral inoculation will reach a susceptible host to result in infection. The propulsion and trajectory of viral particles will be affected by ventilation and pressure changes, such as from opening doors. The viability of viruses within aerosols is similarly affected by environmental conditions, such as light and the surfaces they reach. Most common respiratory viruses survive longer on hard surfaces, including those on parts of respirators, than on skin or porous materials such as cloth and tissues. Effective routes of inoculation vary among viruses, but for many respiratory viruses, this includes the eyes, which are not covered by masks.

Two conclusions may therefore be drawn. First, the interplay of all these factors cannot be predicted. Thus, no single method or device may be relied on for protection against viruses, especially those capable of resulting in serious morbidity. Second, consistent, well-maintained infection control programs, as outlined in Sandora et al below, are generally the most effective means of protection for healthcare workers, patients, and families; and of the recommended procedures, hand cleansing remains most effective and feasible.

Hand Sanitizer and Surface Wipes Reduce Elementary School Absenteeism

Elementary school children are at risk for developing respiratory and gastrointestinal infections, which commonly cause school absenteeism. Such infections result from exchange of secretions. Hand washing is widely accepted as the best method to avoid transmission of infections.

Sandora and associates performed a school-based, cluster-randomized, controlled trial at a single elementary school to assess the effectiveness of a multifactorial intervention in reducing absenteeism caused by gastrointestinal and respiratory illnesses. Students were in the third, fourth, and fifth grades. Intervention classrooms received an alcohol-based hand sanitizer and quaternary ammonium wipes to disinfect classroom surfaces daily for 8 weeks, whereas control classrooms followed usual hand-washing and cleaning practices.

During the study, absences were recorded along with the reason for absence. The primary

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Hand Sanitizer and Surface Wipes Reduce Elementary School Absenteeism *(Continued)*

outcomes were rates of absenteeism caused by respiratory or gastrointestinal illness. The absenteeism rate was adjusted for race, health status, family size, and current hand-sanitizer use in the home. Additionally, swabs of environmental surfaces were evaluated by bacterial culture and polymerase chain reaction for norovirus, respiratory syncytial virus, influenza, and parainfluenza 3.

A total of 285 students were randomly assigned to the intervention and control groups, which had similar baseline demographic characteristics. All of the students completed the study. The adjusted absenteeism rate for respiratory illness was not significantly different between the intervention and control groups (rate ratio, 1.10; 95% confidence interval [CI], 0.97–1.24; *P*=0.12). However, the adjusted absenteeism rate for gastrointestinal illness was significantly lower in the intervention group than in the control group (rate ratio, 0.91; 95% CI, 0.87–0.94; *P*<0.01). Over the course of 8 weeks, 25% and 27% of students in the control and intervention groups, respectively, missed ≥1 day because of a respiratory illness. In contrast, 24% and 16% of the students in the control and intervention groups, respectively, missed ≥1 day because of a gastrointestinal illness.

Norovirus was the only virus detected and was found significantly less frequently on surfaces in intervention classrooms than in control classrooms (9% vs 29%; *P*<0.01). The median total heterophilic bacterial colony count on classroom surfaces was 60 colony-forming units (CFU)/mL in the control group and 50 CFU/mL in the intervention group (*P*=0.11).

This study showed that a multifactorial infection-control intervention consisting of hand sanitizer and surface disinfection reduced absenteeism caused by gastrointestinal illness in elementary school students. Norovirus was detected less often on classroom surfaces in the intervention group than in the control group. Norovirus is transmitted by hands through the fecal-oral route, from person to person, or via contaminated food and water. The authors recommended that schools should consider adopting these infection-control practices to reduce absenteeism due to common illnesses.

Sandora TJ, Shih M-C, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: a randomized, controlled trial of an infection-control intervention. *Pediatrics*. 2008;121(6):e1555-e1562.

Clinical Insights ® in Pediatric Respiratory Care Post-Test

1. The study conducted by Lee et al showed which of the following?
   a. Most of the tested N95 respirators performed at their worst against particles of similar size to coronavirus and influenza virus.
   b. Most of the tested N95 respirators performed at their best against particles of similar size to coronavirus and influenza virus.
   c. Surgical masks performed better than N95 respirators at particles of similar size to coronavirus and influenza virus.
   d. Performance was worse with N95 respirators with an exhalation valve than with those without such a valve.

2. In the study by Sandora et al, a multifactorial infection-control intervention consisting of hand sanitizer and surface disinfection reduced absenteeism caused by which of the following?
   a. Respiratory illness
   b. Gastrointestinal illness
   c. Both respiratory and gastrointestinal illness
   d. Neither respiratory nor gastrointestinal illness

ANSWERS

Question 1 answer: a. Most of the tested N95 respirators and surgical masks in this study performed at their worst against particles of similar size to coronavirus and influenza virus. The minimum PFs for N95 respirators were noted in the particle size range of 0.04 to 0.2 μm.

Question 2 answer: b. The adjusted absenteeism rate for gastrointestinal illness was significantly lower in the intervention group than in the control group, but the adjusted absenteeism rate for respiratory illness was not significantly different between the groups.

PRCI MISSION STATEMENT

The PRCI is a multicomponent educational program on pediatric respiratory disorders designed for pediatricians, primary care physicians, pediatric and family nurse practitioners, neonatologists, infectious disease specialists, allergists, pulmonologists, immunologists, and other healthcare professionals involved in the care and management of pediatric respiratory patients. PRCI programs address issues concerning asthma, respiratory syncytial virus, and other respiratory tract infections and disorders. Methods to prevent, control, and treat respiratory illnesses in children are also evaluated.

In addition to regular issues of *Clinical Insights ® in Pediatric Respiratory Care*, visit **www.PediatricRespiratory.org** for information about upcoming CME activities.

Activity Code: T328-7 **Issue Date:** August 28, 2008 **Valid Through:** October 28, 2008

CME Activity Evaluation/Registration Form

Participants who wish to obtain CME credit, please complete the contact information below, sign this form, and fax it with the completed post-test to 1 (201) 430-1441 or mail to PPS, CME Dept. T328, 200 Meadowlands Parkway, Secaucus, NJ 07094-2302. You may download previous issues of *Clinical Insights® in Pediatric Respiratory Care* e-newsletters by visiting us online at www.PediatricRespiratory.org.

I have participated in this activity as designed and am claiming _____ *AMA PRA Category 1 Credit*™ (maximum 0.50)

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Overall Program

	Strongly Disagree		Disagree	Agree		Strongly Agree
1. This activity met the stated objectives in such a way that I am better able to:						
a. Describe the ability of N95 respirators and surgical masks to protect against particles of bacterial and viral sizes.	1	2	3	4	5	6
b. Discuss the effects of multifactorial infection-control intervention consisting of hand-sanitizer use and surface disinfection in reducing elementary school absenteeism.	1	2	3	4	5	6
2. Please rate the following statements:						
a. Activity provided clear evidence to support the content	1	2	3	4	5	6
b. Activity was presented in a way that facilitated learning	1	2	3	4	5	6

3. Did the activity present a balanced view of therapeutic options available for the disease state(s)? ☐ Yes ☐ No*
***** If you checked "No," please explain. _____

4. Did the activity present content that fairly represented and was based on a reasonable and valid interpretation of the information available on the subject? ☐ Yes ☐ No*
***** If you checked "No," please explain. _____

5. Did the activity appear to place an unreasonable emphasis on one particular product/service? ☐ Yes* ☐ No
***** If you checked "Yes," please explain. _____

6. In reflecting on your practice, what type of impact will this educational activity have? *(Select all that apply.)* I will:
☐ Be cognizant of the limitations of N95 respirators in protecting against bacteria and viruses and that not all N95 respirators provide comparable levels of protection against bacteria and viruses.
☐ Recommend the use of hand sanitizer and surface disinfection in the elementary school setting.
☐ Other *(please specify)* _____

7. What topics should be dealt with in more detail? *(List topics.)* _____

8. What is the most important thing you learned from this activity? _____

Thank you for your participation.