The prevalence of latex allergies in healthcare workers has significantly increased over the past 2 decades. Increases in exposure to latex products in healthcare environments are related primarily to the use of gloves for barrier protection. In the early 1980s, with the implementation of universal precautions and appropriate healthcare worker protection, latex glove use dramatically rose in many countries. Manufacturing techniques and additional factories for latex gloves were developed to meet the tremendous demand. As a result of new “fast-track” production processes, some of the latex gloves had variant amounts of powder and allergen content.

Synthetic materials, such as polyvinyl, polyurethanes, nitrile, and neoprene, are being used to manufacture medical gloves. Some hospitals and clinics have adopted the use of these alternatives to provide a “latex-free” healthcare environment. Risk reduction and prevention strategies are being implemented in many countries. Latex sensitivity and allergy can present as variable clinical reactions including contact dermatitis, rhinoconjunctivitis, asthma, and anaphylaxis.

Some healthcare providers who have coexisting risk factors, such as atopy and food allergies (chestnuts, bananas, avocados, passion fruit, celery, potatoes, and peaches), are at an even greater risk for severe allergic reactions following repeated latex exposure. This Journal course will provide an overview of the information available related to latex allergy in healthcare workers.

Key words: Healthcare worker exposure, latex allergy, latex-reduced environments, latex sensitivity.

OBJECTIVES
At the completion of this course, the reader should be able to:

1. Discuss the epidemiology and development of latex allergy in healthcare workers.
2. Identify the clinical reactions, diagnosis, and treatment for latex allergy in healthcare workers.
3. Discuss the effectiveness of glove materials and requirements for their use.
4. List strategies to use in preventing sensitization and reactions.
5. Describe clinical advances in latex allergy research.

Introduction and overview
Latex allergy and sensitivity have emerged as significant healthcare and occupational hazards over the past several decades. As anesthesia providers, we are at high risk for latex exposure and development of subsequent sensitivity reactions. Sensitization of healthcare workers (HCWs) may involve high costs in terms of day-to-day risks at work, disability, and loss of employment, as well as development of life-threatening health problems. Awareness and education about this occupational health problem will facilitate adoption of risk-reduction strategies.

This Journal course provides an overview of the historical perspectives and manufacturing of rubber latex products. The epidemiology, stages of allergy develop-
ment, diagnostic tests, and treatment modalities for latex-related reactions are described. Information related to medical glove production and effectiveness is detailed. Strategies for hospital departments and healthcare providers are addressed to decrease latex sensitization and reactions. Recent advances in latex allergy research, such as immunotherapy, are reviewed. Employment concerns related to liability and disability will be presented for latex-sensitive and latex-allergic HCWs.

**Historical perspectives**
Natural rubber has been used for more than 500 years in the manufacturing and production of healthcare, industrial, and household products. It is estimated that there are more than 40,000 products that contain latex, 20,000 of which are used in healthcare. The predominant source of occupational-related latex allergy is through the use of latex gloves. Rubber gloves for medical and surgical procedures were introduced in the late 1800s. Nurses began wearing gloves in 1890 to protect their hands from chemicals and disinfectants used during surgery. The first report of irritant dermatitis and rubber allergy related to occupational use of gloves was in 1933. Subsequent reports have documented a series of reactions to latex products ranging from contact dermatitis to death. Exposure to latex and patterns of usage may be different not only among different countries but also from hospital to hospital.

Despite the extensive number of products made with natural rubber latex, only the materials that aerosolize or contact the skin, mucosa, respiratory system, and vascular system are likely to cause reactions. The most commonly used latex products causing reactions are balloons, condoms, and gloves.

**Latex sources and manufacturing processes**
Latex products are derived from the latex sap of commercially grown rubber trees, Hevea brasiliensis. Natural rubber latex is harvested principally in Malaysia, Thailand, and Indonesia. The sap is extracted and heated while chemical preservatives, primarily ammonium and sulfite, are added. Compounding agents are added to enhance the processing and the rubber's structural qualities. Other materials that may be added include emulsifiers, colorants, stiffeners, biocides, ultraviolet light absorbers, and fragrances. The antioxidants, accelerators, and other chemical additives form synthetic rubber that has increased durability and strength.

Latex products are made by pouring the rubber into molds or by forming a coating in a dipped process as is done with gloves, balloons, and condoms. The figure shows a pictorial overview of the processes involved in glove production. Dipped or very soft rubber products appear to have the highest content of latex proteins and therefore have the greatest allergenic potential. Corn starch powder is applied to latex gloves during the manufacturing process to prevent stickiness and give the gloves a smooth feel. Latex particles have been shown to adhere to the surface of these cornstarch particles and to aerosolize on removal of the gloves. In an operating room, the aerosolization of latex particles has been identified as the primary source of allergens.

Latex contains low molecular weight soluble proteins, which are the cause of IgE-mediated reactions. Of the 240 latex proteins that have been identified, at least 60 are associated with an allergic response. Many of the allergens are defense proteins that the plant uses to respond to pathogens. Rubber elongation factor (Hev b 1), hevein protein, hevamine, phenyltransferase, glucanase, and Hev b 2-10 have been identified as the key allergenic proteins. Once the amino acid sequence of the protein is identified, the location of the antibody binding sites (epitopes) can be determined. The antigenic and allergenic determinants of rubber elongation factor have been analyzed and 2 regions were identified as both IgE and IgG binding epitopes. Mapping of hevein preprotein found 6 IgE binding epitopes within the molecule. Four of the 6 regions have similar compositions to the proteins found in potato, tobacco, soybean, and many other plants. These similarities help to explain the high incidence of food cross-reactivity in latex allergic patients. Because many of the latex allergens are not known, molecular-biology techniques will be required to identify and characterize the molecules.

**Epidemiology considerations**
Why the increase? Explanations for the increase in latex sensitivity and allergy in HCWs are related to a combination of factors. These include an increase in the number of gloves used, revisions in the glove manufacturing techniques, alterations in latex agriculture, increased healthcare worker awareness, and prompt diagnosis, treatment, and reporting. The number of medical and surgical gloves used by HCWs has increased exponentially over the past 2 decades. It is estimated that in the United States, more than 30 billion pairs of medical and surgical gloves are used each year. The increase in glove use is related to the introduction of universal precautions as protection against blood borne pathogens (autoimmune deficiency syndrome [AIDS] and hepatitis). The routine use of gloves for barrier protection has occurred at different rates throughout the world. For example, in the United States, Canada, and European countries, disposable glove supplies were readily purchased and included in direct patient care protocols. In third world countries,
1. Natural latex containing protein is harvested from Hevea brasiliensis rubber tree.

2. Autoagglutination of natural latex is prevented by the addition of ammonia.

3. Natural latex is centrifuged and concentrated from 30% to 60% solids. Removal of serum phase reduces the concentration of water-soluble proteins.

4. Processing and attributes of the finished device depend on the addition of many chemicals to the natural latex (compounding). Significant Type IV allergens include the accelerators and antioxidants.

5. Porcelain formers attached to a continuous chain are cleaned to remove debris to a previous cycle.

6. Formers are dipped in an emulsion to apply cornstarch as a releasing agent and a compound that coagulates liquid natural latex on contact.

7. Releasing agent and coagulant are oven-dried.

8. Formers dip into natural latex and a uniform film is deposited.

9. The coagulant and heat convert the natural latex from liquid to solid.

10. Rotating brushes contact the rotating formers and a cuff is rolled onto the glove.

11. Formers pass through warm water baths to remove water-soluble protein and excess additives.

12. Cross-linking of the polyisoprene polymers is catalyzed by heat and requires an accelerator.

13. Cornstarch is applied as a slurry to the outer surface of the natural rubber latex as a detaching agent. Residual rubber proteins may elute from the gloves at this point and bind to the cornstarch particles.

14. The gloves are stripped from the porcelain formers.

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since disposable gloves were not readily available and reusable, resterilized rubber gloves were used when needed. The prevalence of latex sensitivity and allergy is reported to be lower in certain areas of the world as a result of limited access to latex products. There are some HCWs who wear gloves for any type of patient contact or job task to “protect” themselves from all types of exposure. These workers are actually increasing their risk of allergic or chemical dermatitis and possible development of latex allergy. Variations in the manufacturing of latex occurred in the early 1980s in response to the dramatic demand for disposable gloves. Many new plants were quickly established to meet the demand, and manufacturing techniques were “fast-tracked.” As a result, some of the gloves produced had high allergen content, were of poor quality, and had high powder concentrations.

Alterations in latex agriculture to facilitate adequate supply of product included cloning of rubber plants that produce maximum yield, are drought-tolerant, disease resistant, and can tolerate different soil and climate conditions. These changes may have altered the protein distribution in raw latex. There are more than 200 plant species capable of producing natural rubber latex.

### Epidemiological considerations: Prevalence rates

There have been multiple reports regarding the prevalence rates of latex allergy for the general population and high-risk groups. High-risk populations include individuals with occupational exposure (HCWs, rubber industry workers, hair stylists), atopy (rhinitis, eczema, asthma), spina bifida and congenital genitourinary abnormalities, and other conditions that require multiple surgeries. In addition to these risk groups, individuals who have certain food allergies may have a coexisting latex allergy. Table 1 lists the foods and food products that may be associated with latex allergy. The use of fruit enzymes (papain, bromelain, ficin) as extracts in food and drugs may be a source of cross-sensitivity. Individuals who have allergies to these foods are at an increased risk for latex allergy because of a cross-reactivity with the latex protein. The latex sensitivity may appear before, at the same time, or after the development of the food sensitivity. Not all patients with these food allergies will require latex avoidance, and similarly not all patients with latex allergies will have problems with these foods. Mugwort, ragweed, and grass pollen share IgE epitopes with latex allergens.

In the general population, the prevalence rate is reported as 1% to 7.6%. Recently, Saxon and associates reported a prevalence rate range from 5.4% to 7.6% in 1,997 unselected blood donors at 3 different institutions. The anti-latex serum (AlaSTAT) test was used to determine the prevalence rate. Investigations based on skin testing provide evidence that the prevalence in the general population is less than 1%. The marked difference in the findings is based on the nonspecificity of serological assays. Previous studies on the adult and pediatric surgical populations have reported an incidence of 6.8% and 8.6% respectively.

Prevalence rate for HCWs has been reported in a range from 0.9 to 30%. Table 2 lists the international distribution of latex sensitivity in HCWs based on recent literature. Prevalence rates for occupational categories vary greatly due to different levels of exposure and the methods used to estimate latex sensitization. The difference is not surprising because repeat exposure to latex is essential for the development of latex allergy, and glove-wearing time varies in different tasks. It is likely that the most significant factors that contribute to latex sensitivity include the frequency and duration of exposure as well as the specific amount of available protein content of the product. The incidence of latex sensitivity and the degree of clinical manifestations of allergy can be greatly influenced by the latex protein source. Assays of natural rubber latex gloves have demonstrated great ranges of relative concentrations of total proteins ranging from 1 to 2,960 latex allergy U/mL.

Inconsistency in prevalence findings across studies include methodological problems, (self-reporting, survey serological vs skin tests), different outcomes studied, lack of standardized skin tests, and the possibility of work exposure. There is difficulty in interpreting epidemiological studies, as most reported prevalence rates are percentages based on those who volunteered for testing rather than on the overall population.

### Table 1. Foods with possible cross-sensitivity with latex allergy

<table>
<thead>
<tr>
<th>Foods</th>
<th>High</th>
<th>Moderate</th>
<th>Low or undetermined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apricot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avocado</td>
<td>Banana</td>
<td>Carrot</td>
<td>Pear</td>
</tr>
<tr>
<td>Celery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chestnut</td>
<td>Tomato</td>
<td>Nectarine</td>
<td>Mango</td>
</tr>
<tr>
<td>Cheese</td>
<td>Apple</td>
<td>Plum</td>
<td>Cherry</td>
</tr>
<tr>
<td>Kiwi</td>
<td>Potato</td>
<td>Strawberry</td>
<td>Grape</td>
</tr>
<tr>
<td>Papaya</td>
<td>Melon</td>
<td>Ragweed</td>
<td>Mugwort</td>
</tr>
<tr>
<td>Passion fruit</td>
<td>Fig</td>
<td>HazelNut</td>
<td>Walnut</td>
</tr>
<tr>
<td>Pineapple</td>
<td></td>
<td>Peanut</td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td></td>
<td>Profilin</td>
<td>Potatin</td>
</tr>
<tr>
<td>Tomato</td>
<td></td>
<td>Ficus</td>
<td>Wheat</td>
</tr>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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also are a variety of diagnostic tests with variable specificity that are used to make the diagnosis of latex allergy. Longitudinal studies are needed to better define risk factors, the progression and/or regression of symptoms with various levels of exposure, and the true prevalence of latex hypersensitivity in the population. 7

### Description of clinical reactions

The routes of exposure to latex allergens are cutaneous, percutaneous, mucosal, inhalational, and parenteral. 46-51 In HCWs, most clinical reactions are caused by skin contact, mucosal exposure, or inhalation of latex allergens. Repeated exposures to latex can precipitate escalating severity in symptomatic reactions. 46-51 Confusion exists when the terms “latex sensitivity” and “latex allergy” are interchanged. Latex sensitivity means testing positive for specific immunological changes related to exposure to latex. 9 Having a sensitivity does not necessarily mean that the individual will experience any clinical symptoms when exposed to the allergen. The presence of specific latex IgE antibodies only demonstrates that sensitization has occurred and does not indicate when an individual will have a reaction or the severity of a potential reaction. 45 Latex allergy means having an allergic reaction when exposed to a latex protein allergen. The diagnosis of latex allergy is based on the identification of individuals with latex-specific IgE and symptoms consistent with IgE-mediated reactions to latex-containing devices. 46-51

Clinical manifestations associated with latex allergy include contact dermatitis (irritant and allergic), conjunctivitis, rhinitis and asthma, and anaphylaxis. Accurate diagnosis of latex allergy is based on a thorough medical history, physical examination, skin or serum testing, and possibly provocation challenges. 28 In hospital workers, the majority (77%) report contact dermatitis from gloves and more than 50% also experienced allergic rhinitis, conjunctivitis, or asthma while working in areas of high glove use. 8-10

Contact dermatitis includes both irritant and allergic (Type IV delayed hypersensitivity) reactions. Irritant contact dermatitis is a nonallergic skin reaction that occurs within minutes to hours following exposure. It is the most common health problem associated with natural rubber or synthetic rubber products. 55-51 Factors that may lead to this type of dermatitis include irritants from soaps, disinfectants, or other chemicals; prolonged dampness from sweating in gloves; and powders that may cause drying of the skin and subsequent irritation. 55-51 Acute symptoms include redness, swelling, burning, and itching of the skin. The intensity of the reaction depends on the dose, duration of exposure, and the skin condition at the time of the exposure. 55-51

### Table 2. International distribution of prevalence rates for latex sensitivity in healthcare workers 8

<table>
<thead>
<tr>
<th>Country</th>
<th>Author</th>
<th>Method*</th>
<th>Number</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>Vandenplas</td>
<td>SPT</td>
<td>237</td>
<td>4.7%</td>
</tr>
<tr>
<td>Brazil</td>
<td>Graunendz</td>
<td>Q/SPT/CAP*</td>
<td>183</td>
<td>1.6%</td>
</tr>
<tr>
<td>Canada</td>
<td>Liss</td>
<td>SPT</td>
<td>1,451</td>
<td>12.2%</td>
</tr>
<tr>
<td>Canada</td>
<td>Sussman</td>
<td>Q/SPT</td>
<td>947</td>
<td>1%</td>
</tr>
<tr>
<td>Denmark</td>
<td>DuBuske</td>
<td>Q/CAP</td>
<td>196</td>
<td>7.2%</td>
</tr>
<tr>
<td>Eastern Europe and Russia</td>
<td>DuBuske</td>
<td>Case history/SPT*</td>
<td>738</td>
<td>5% LS*/2.5% LA*</td>
</tr>
<tr>
<td>England</td>
<td>Sinha</td>
<td>Q/RAST*</td>
<td>1,827</td>
<td>Q: 7% RAST: 12.5%</td>
</tr>
<tr>
<td>England</td>
<td>Handfield-Jones</td>
<td>SPT</td>
<td>867</td>
<td>0.9%</td>
</tr>
<tr>
<td>Israel</td>
<td>Shalit</td>
<td>SPT/AlaSTAT*</td>
<td>1,529</td>
<td>4.8%</td>
</tr>
<tr>
<td>Israel</td>
<td>Levy</td>
<td>AlaSTAT</td>
<td>300</td>
<td>1.66%</td>
</tr>
<tr>
<td>Poland</td>
<td>Palczynski</td>
<td>Q/SPT/PFT/PT</td>
<td>2,867</td>
<td>18.6%</td>
</tr>
<tr>
<td>Spain</td>
<td>Vila</td>
<td>Q/SPT/CAP</td>
<td>1,150</td>
<td>5%</td>
</tr>
<tr>
<td>Turkey</td>
<td>Sener</td>
<td>Q/SPT</td>
<td>200</td>
<td>9.2%</td>
</tr>
<tr>
<td>United States</td>
<td>Kim</td>
<td>Q/SPT/AlaSTAT</td>
<td>1,967</td>
<td>1.5%</td>
</tr>
<tr>
<td>United States</td>
<td>Watts</td>
<td>Q/SPT</td>
<td>122</td>
<td>14%</td>
</tr>
</tbody>
</table>

* Q indicates questionnaire; SPT indicates skin prick test; PFT indicates pulmonary function tests; PT indicates provocation test; AlaSTAT indicates anti-latex serum test; CAP indicates coated allergen particle test; LA indicates latex allergy; LS indicates latex sensitivity; RAST indicates radioallergosorbent test.
Allergic contact dermatitis is a cell-mediated delayed hypersensitivity reaction. Delayed hypersensitivity (6-48 hours) results from the interactions between specific antigens and sensitized lymphocytes. It is caused by soaps, disinfectants, and glove chemicals used as accelerators, antioxidants, and preservatives. Symptoms include the appearance of a rash with clustered bumps, redness, itching, and pain. The symptoms may be localized or systemic. The dose of chemicals, frequency of exposure, and preexisting skin condition are the most important factors causing the reaction. With each exposure, the individual becomes more sensitized, and the reaction is more intense. Treatment includes avoidance of exposure to gloves with high levels of chemicals, consultation with a dermatologist, and allergy testing.

Contact dermatitis (irritant or allergic) can reduce the barrier properties of the skin and allow absorption of larger amounts of chemicals or proteins. The loss of protection can increase the risk of latex sensitization. An increased frequency and progression through allergic contact dermatitis may precede the onset of latex allergy.

Rhinitis and asthma are symptoms that are increasing in frequency in workers with occupational exposure to latex. HCWs and rubber industry workers are risk populations due to the inhalation of latex allergen particles from gloves. Latex-induced occupational asthma may result in permanent disability and termination of employment. Treatment includes individualized care management by an allergist, chronic drug therapy with steroids, antihistamines, bronchodilators, and avoidance of latex aeroallergens.

Anaphylactic (Type I) are immediate hypersensitivity reactions caused by direct contact or inhalation of latex allergens. The latex proteins directly sensitize the individual and cause allergic symptoms. Symptoms include rhinitis, conjunctivitis, urticaria, angioedema, asthma, anaphylaxis, and death. A recent study identified latex allergen level at 0.6% ng/m3 as a critical threshold above which workers can develop Type I latex allergy symptoms. The type and severity of the reaction depend on the level of sensitivity, the amount of allergen, and site of exposure. Urticaria is characterized by pink hives and swelling, itching, and tingling. Individuals who initially have mild cutaneous or respiratory reactions can experience more severe reactions with mucosal or parenteral exposure. Progressive sensitization occurs with repeated exposure to latex, and even very low levels of latex allergen can precipitate anaphylactic shock. Treatment is focused on the symptoms and initiation of anaphylactic protocols. HCWs with a diagnosis of latex allergy should avoid contact with latex, carry an epinephrine autoinjection kit (epi-pen), and wear a medical alert bracelet.

Diagnostic tests for latex allergy
Diagnostic tests for latex allergy include skin testing, serum immunoassays, and challenge studies. Skin prick testing (SPT) has been the gold standard for diagnosis of latex allergy and is the most sensitive means of detecting IgE antibody. It involves pricking the skin with a latex solution (extract) and observing for a reaction. Commercially available extracts are not standardized, and some allergists concoct their own solutions resulting in variable allergenic protein levels. In the United States, there is no SPT reagent that has been licensed by the US Food and Drug Administration (FDA). A potential for life-threatening symptoms exists during SPT; therefore, testing must be done by qualified experts who have all resuscitation supplies and medications available. Skin patch tests are used to identify reactions to the chemicals found in latex products. A patch with the chemical substance is placed on the skin and observed for 24 to 72 hours for a localized reaction.

In vitro immunoassays are tests used to measure the IgE responses in the serum of latex-allergic individuals. Latex IgE binding proteins vary in size and appear different in various risk groups, which accounts for some of the variations in testing results. Three tests are currently FDA-approved for use, AlaSTAT (American Diagnostics Corporation, Los Angeles, Calif), CAPS (Upjohn, Kalamazoo, Mich), and Hytec (Hyco Biomedical, Irvine, Calif). Latex allergen-specific IgE antibody results from different assays should not directly compared because each assay may detect a different subset of antibodies presumably to different latex allergen epitopes on their respective allergen-containing reagents.

Considerable controversy exists as to the use of these serum tests in predicting prevalence and sensitivity rates due to the variations in specificity and sensitivity. In one report, CAPS and AlaSTAT assays produced 24% and 27% of false negative (when the assay fails to diagnose an allergic test subject as such) results, whereas Hytec produced 27% false positive (when the assay misdiagnoses a nonallergic test subject as being allergic) results when compared to the SPT. Another comparison study evaluated results from CAPS and AlaSTAT serum testing. It reported sensitivities of 79.5% and 73.8%, and specificities of 90.2% and 91.7% for CAPS and AlaSTAT respectively. The overestimation of the prevalence of latex allergy when using in vitro assays has been recently described. In vitro latex diagnostic tests based on latex-specific IgE pose few hazards to the patient, and they do a good job
when used for the purpose for which they are designed (to confirm the diagnosis of latex allergy).61 Where latex allergy is rare (general population), latex IgE assays may vastly overestimate the true prevalence and its associated risks.61 The seroprevalence of latex-specific IgE in a population is directly proportional to the risk of latex allergy in that population.62

Challenge studies include glove, nasal, and bronchial inhalational tests. Glove challenge tests involve having the HCW put on either a finger cuff or whole latex powdered glove and observing for a reaction.1,7-11 Nasal and bronchial inhalation tests are used to further aid in diagnosing the presence and severity of respiratory-related symptoms.63

Gloves

Gloves can be made from a variety of materials, although natural rubber latex has been the gold standard. With the intensified concerns about latex sensitivity and allergic reactions, institutions, regulatory agencies, and HCWs have implemented the use of low allergen, powder-free latex examination gloves and alternative products.64 Gloves should be chosen for their suitability, in terms of dexterity, durability, and level of barrier protection for the task to be performed.45,48,49,65 HCWs need to consider carefully the degree of glove barrier effectiveness if there are risks for chemical, bio-hazard, or blood borne pathogen exposure.45,48,49,65 Alternative sources of materials for synthetic gloves include nitrile, neoprene, styrene, polyvinyl chloride, and tactylon. Table 3 lists brand gloves commonly used for alternatives to latex products.18,66,67

Reports on the effectiveness of glove alternatives have identified comparable safety and tactile sensitivity.65-71 One report indicates that the latex and nitrile gloves were comparable in terms of barrier protection.70 Vinyl gloves had a decreased durability and potentially compromised barrier protection when used.70 Concerns related to switching from latex gloves to one of the synthetic brands include costs, effectiveness of barrier protection, and tactile properties. Costs for the synthetic brands vary, and actual purchase prices are related to usage volumes and purchasing agreements.12,66-71 Glove prices for latex, vinyl, and nitrile gloves based on purchasing information from a 820-bed community hospital are listed in Table 4.

Regulatory agencies in the United States, Canada, Europe, and Finland have developed guidelines for the labeling, barrier effectiveness, powder levels, latex protein levels, and use for glove products.8,48,49 Labeling guidelines include a 1998 FDA labeling requirement: “This product contains natural rubber latex which may cause allergic reactions” on all medical devices containing natural rubber latex.35 Manufacturers have been advised to remove leachable proteins from latex products and consider alternative processes, such as chlorination of latex gloves, which eliminate the need for cornstarch powder.8 The American Society for Testing and Materials (ASTM) has developed standards for powder in latex gloves. The ASTM recommends a residual powder limit of 4 mg reduced by 1 mg per year until a final limit of 2 mg is reached for all rubber surgical and examination gloves.66,67 There have been major technologic advances in the design and manufacture of powder-free gloves including an improved tactile sensitivity and double glove puncture indication system.67

Significant differences exist between manufacturers and product lines in the amount of free latex protein that can be liberated from the glove and the number and types of chemicals used in glove production.18 Gloves can be soaked after production to try to leach out the protein and chemicals, washed, chlorinated, and undergo other treatments to reduce the levels of latex protein antigen.19 Protein residues can vary between different brands of latex gloves; the higher the extractable protein level is, the greater the risk is of sensitization and subsequent allergic reaction to latex.66 Many manufacturers print the extractable protein level on glove packaging or product literature. It is recommended that low allergen gloves (< 50 µg/g per glove) be used.66,72 A recent report identified that 58% of latex-allergic patients reacted at the 50 µg/g detection limit allowed by the FDA.45 This suggested that levels lower than the allowed 50 µg/g may have significant consequences in latex allergy.95 Substitution of low-allergen-containing latex gloves for high allergen-containing gloves can reduce levels of latex aeroallergen more than 10-fold in an operating room environment.73 Low protein, powder-free gloves have the minimal potential for sensitization in those who have not yet become sensitized to latex.35

Strategies to use in preventing sensitization and reactions

Many professional associations, agencies, and institutions — American Association of Nurse Anesthetists (AANA); American College of Allergy, Asthma & Immunology (ACAAI); Occupational Safety & Health Association (OSHA); National Agency for Medicines (NAM); Health Canada; and Medical Devices Agency (MDA) — have developed recommendations to prevent sensitization and latex allergy reactions.68,49,64,74 These include guidelines for minimizing latex-related health problems, reducing exposures using appropriate work practices, training and educating workers, monitoring symptoms, treatment protocols, and substituting nonlatex products when appropriate. Most of these recommendations focus on strategies HCWs and healthcare institutions can use to minimize or eliminate exposure to latex.
The most ideal strategy is to eliminate latex gloves from the workplace.\footnote{62} Several healthcare institutions have reported a complete transition to a latex-free environment.\footnote{75-79} These institutions have identified worker and patient safety as a priority by prohibiting all latex products. Advantages of this strategy include preventing any source of latex exposure that could lead to latex sensitivity and development of latex allergy. This primary prevention strategy can prove to be a cost saving in terms of payments for disability and workers compensation.

The most realistic strategy is to use synthetic alternative gloves or powder-free, low-protein latex gloves.\footnote{18,10-14,80} This strategy significantly lowers measurable airborne latex and risk of allergic reactions. Using powder-free gloves limits the amount of inhalation and contact with latex allergens, with a subsequent reduction in latex sensitization. A global Internet search has identified that 70 hospitals in the United States and 3 in Europe use only powder-free gloves.\footnote{81} Instituting a latex-safe environment allows allergic HCWs to continue in their career of choice.

Any substitution with nonlatex gloves or low-powder,
low-protein gloves must be made with gloves that have demonstrated the same barrier properties as the natural rubber latex gloves currently available.\textsuperscript{10,13} Although there are some up-front costs related to reducing latex in the work environment, many employers are finding out that the preventative costs are much less than that of one latex claim.\textsuperscript{77} The average cost difference between low-protein, powder-free examination gloves and powdered examination gloves is $2.50 per box. If the average claim was $30,315, one latex claim could purchase 12,086 boxes of powder-free examination gloves.\textsuperscript{77} In an analysis of 3 healthcare institutions (community-based hospital, tertiary-care hospital, and outpatient clinic), the level of worker disability required to make a latex-safe approach financially preferable was reported.\textsuperscript{82} Costs were examined for diagnoses, testing, partial and total disability, treatment, and synthetic alternative gloves. Results revealed that only 3% of those employees at risk would have to become disabled for the latex-safe option to remain preferable financially.\textsuperscript{82}

Most hospitals have developed extensive education materials and employee policies and procedures for glove use and latex allergy management. These guidelines provide employees with protocols regarding exposure to latex, glove choices, prompt diagnosis, and treatment options.

Clinical advances in latex allergy research

Advances in latex allergy research have focused on several areas. These include monitoring effects of latex reduced environments, worker awareness and education, standardized laboratory testing, improved diagnoses, alternative latex sources, and immunotherapy.\textsuperscript{11,13,14} Successes with latex-reduced and latex-free environments will continue to provide scientific rationale for the elimination of latex from our healthcare institutions. Heightened awareness and education of our hospital colleagues, policy makers, and public about latex allergy will generate support for regulations regarding exposure to latex, glove choices, prompt diagnosis, and treatment options.

Immunotherapy techniques are further refined, this treatment option may become available to more latex allergic HCWs. Alternative approaches to immunotherapy include allergen-specific immunotherapy, epitope-specific immunotherapy, and DNA (deoxyribonucleic acid) vaccine immunotherapy.\textsuperscript{62}

Liability and disability implications

The legal challenges resulting from latex allergy are primarily related to claims brought against glove manufacturers and hospitals for disability coverage. Individuals are filing product liability claims against the suppliers, manufacturers, and distributors of latex products.\textsuperscript{85-87} In the United States, about 250 cases against glove manufacturers have gone to federal court. Employers have been challenged for disability benefits related to occupational exposure. Disability from occupationally induced allergies can be compensated under workers’ compensation law.\textsuperscript{85,86}

In the United States, there are 2 sources of legal support for disability related to latex allergy, the Americans with Disabilities Act (ADA) and workers’ compensation.\textsuperscript{85} Employers are required to adhere to these in dealing with employees with latex allergy. In addition, institutions must adhere to national standards set forth by regulatory agencies including FDA, OSHA, and NIOSH. In a review of case law, it was disclosed that 13 states had reported latex allergy cases: Illinois, Mississippi, Minnesota, Montana, New York, Oregon, Pennsylvania, South Dakota, Texas, Vermont, Virginia, Washington, and Wisconsin. Of the 30 reported cases nationally, 21 were deemed to be eligible to receive compensation under the Workers’ Compensation Acts of the various jurisdictions.\textsuperscript{86} The projections demonstrate a consistently increasing number of claims for latex allergy sensitivity.

Reported workers’ compensation claims for latex are increasing throughout the United States at a rapid rate. Seventy percent of the reported decisions to date were held to be eligible for compensation by the courts. A significant percentage of the claims resulted in the awarding of total and permanent disability benefits to the claimant. Claimants are being awarded disability benefits that are substantial in nature due to the severity of the injury and the resulting inability to return to the labor market.\textsuperscript{86}

Legal implications outlined for HCWs include the following guidelines.\textsuperscript{87} Workers should adhere to institutional policies, avoid latex products and environments when possible, and seek prompt medical attention for latex-related symptoms. In filing for workers’ compensation, employees must keep complete records of symptoms, doctor’s visits, laboratory results, care, and treatment provided. Employees must notify their
employers in writing and receive notification of reasonable accommodations for continued employment. Most employers offer counseling and provide alternatives for gloves and reduced exposure.

**Summary**

Latex allergy is a significant occupational health problem for anesthesia providers. This discussion has provided a review of factors precipitating an increase in latex allergy, described how latex products are made, presented epidemiological trends, and provided a clinical presentation of latex sensitivity and allergy. Considerations for glove materials, strategies for risk reduction, clinical advances in latex allergy research, and the liability and disability implications have been discussed.

Each one of us can probably identify one of our anesthesia or nursing colleagues who has developed latex allergy. Preventing further exposure, using low-allergen, powder-free gloves, and eliminating latex glove use are strategies we can implement in our respective work settings. It is essential that we participate in continuing education, serve on latex-related hospital committees, and assist in developing appropriate protocols to help reduce the incidence of this health problem. We must raise ethical concerns regarding continued exposure to latex for employees and patients in our healthcare institutions. All of us are at risk for the development of latex allergy, and we must participate actively to minimize our exposure to the latex allergens.

Continued education through the review of current literature and Internet sources related to latex sensitivity and allergy as an occupational hazard are valuable resources. Recommended Internet sources include:

- NIOSH/CDC: http://www.cdc.gov/niosh/latexalt.html
- Health Canada: http://www.hc-sc.gc.ca/hpb/lcduc
- American Association of Nurse Anesthetists (AANA) Latex Allergy Protocol: www.aana.com

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