

Vaccines and hurricanes don't mix

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At 12:10 am Atlantic daylight time, Monday, September 29, 2003, hurricane Juan made landfall in Nova Scotia as one of the most powerful and damaging hurricanes to affect Canada.

The eye of the hurricane measured 35 km to 40 km in diameter. The winds raged at 158 km/h. A category 2 hurricane, Juan proved to be more devastating than anyone expected (1).

It took 3 h for hurricane Juan to tear north through the middle of mainland Nova Scotia. It lost speed along the way, but maintained hurricane-force winds (1).

Two people were killed when trees fell on their vehicles. Two fishermen died, three others died in a house fire speculated to have started by candles used during the power outage, and one person involved in relief work died after the storm.

Hurricane Juan will be recorded as the most damaging storm in modern history for Halifax, as measured by the widespread tree blow-downs, power outages and damaged homes (1). Hundreds of thousands of Maritimers in Nova Scotia and Prince Edward Island, and many physicians' offices lost power with the last of the affected customers having power restored almost two weeks later (Figure 1).

The power outages had an impact on the storage of vaccines throughout the affected areas of Nova Scotia.

BACKGROUND:

VACCINE DISTRIBUTION IN NOVA SCOTIA

The main supply of vaccines for the province is stored in a large refrigerator at the Nova Scotia Department of Health. This refrigerator maintains the vaccine at a temperature between 2°C and 8°C. This is achieved through an alarm system and a backup generator. When there is a refrigerator failure or power outage, the alarm alerts a designated individual and the generator takes over.

The districts receive vaccine from the main Department of Health supply. In the districts, the vaccines are stored in the Public Health Services offices. These offices have either generator backup or an alarmed refrigerator system. If there is only an alarmed system, but no generator backup, the vaccines are moved to a hospital refrigerator before the event, based on the strong likelihood that there will be a significant power outage. Otherwise, if there is an outage or refrigerator failure, the refrigerator will sound the alarm when the temperature goes out of the recommended range and a designated person on call responds.

Physicians provide approximately 80% of publicly funded preschool and adult immunizations, and receive their vaccine from the district Public Health Services offices. Their supply of vaccines is stored in refrigerators in their offices.

The other 20% of immunizations are provided through public health clinics or school-based clinics provided by public health nurses. A few travel clinics also provide vaccine, but there are very few publicly funded vaccines provided by these clinics. Also, the majority of the travel clinics are Public Health Services administered clinics and their vaccines come from the supply stored at Public Health Services offices.

PUBLIC HEALTH SERVICES VACCINE MANAGEMENT ACTIONS

Immediately following hurricane Juan, Nova Scotia's response in terms of vaccine program management consisted of:

- communication with physicians and Public Health Services staff;
- assessment of vaccines and storage;
- advice to physicians and clinics;
- replacement of vaccines;
- education of physicians; and
- feedback to physicians.

Following hurricane Juan, the district Public Health Services offices corresponded with physicians' offices to have them send their vaccines to the nearest office to have them



Figure 1) Uprooted tree takes down power lines in central Halifax

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replaced. However, it was a challenge to communicate this information because many phones were not working and fax machines only worked in the areas that had power restored.

An assessment of all vaccines exposed to temperatures outside the recommended ranges was made by public health staff. The vaccine providers were asked to provide a list of all vaccines in their refrigerator, the time of their power outage and the time the power was restored. They also supplied the maximum temperature reached, if they had a thermometer in the refrigerator. The public health staff then assessed what vaccines could be placed back into circulation, with information on how to monitor that particular stock and how to return those vaccines that required replacement.

Each contact with a physician's office was used as an opportunity to provide advice on the storage of vaccine and cold chain issues.

When the assessment was complete, the vaccines were replaced.

A follow-up letter was sent to each physician detailing the lessons learned with suggestions for improving future storage and monitoring (J MacPhee, D Vaughan, M Pickles, K McGill, Public Health Services staff, personal communications).

The spoiled vaccines returned to Public Health Services from the physicians' offices in the affected areas following hurricane Juan amounted to approximately \$220,500 worth of vaccines, which was 7% of the provincial yearly vaccine budget. There were anecdotal reports of vaccines that were discarded and not returned (J MacPhee, D Vaughan, M Pickles, K McGill, Public Health Services staff, personal communications).

The vaccines stored by the Public Health Services offices was maintained at acceptable temperatures either because they had a generator or they were moved to a hospital refrigerator that had a generator (J MacPhee, D Vaughan, M Pickles, K McGill, Public Health Services staff, personal communications). However, it was determined that the varicella vaccines would not be used and they were returned to the manufacturer. This determination was made based on the fact that it is a relatively new vaccine and there is not enough known about the amount of time that it could be above 8°C. As a precaution, it was not used because it was above 8°C for a short period of time. This occurred because of the time interval from the refrigerator alarming to the response by the individual on call, and the time taken to pack and transport the vaccine to a hospital refrigerator contributed to the change in temperature as well.

OBSERVATIONS

There were considerable cold chain and other vaccine issues identified in regard to the storage and handling of vaccines

On the positive side of vaccine cold chain maintenance, some physicians' offices had minimum-maximum thermometers and were able to provide the maximum temperature reached in the refrigerator. With this information, Public Health Services was able to consult with manufacturers and other provinces on whether these vaccines were still potent.

Some physicians' offices were able to move their vaccines to a refrigerator in the area that had power and had no loss of their stock (J MacPhee, D Vaughan, M Pickles, K McGill, Public Health Services staff, personal communications).

There were outdated vaccines in the refrigerators of physicians

- The longest was five years out of date.
- There were vials of influenza vaccine from the 2001/2002 season. These vaccines were outdated because they were made for the the flu composition from two years ago.
- Some offices had vaccines that had not been supplied to physicians for approximately six years or more.

Thermometers

- Very few offices had minimum-maximum thermometers in their refrigerators. Without a minimum-maximum thermometer, it is not possible to determine the maximum temperature reached in the refrigerator.
- Some offices put the vaccines in the freezer section of the refrigerator, which means they could not be used because they were frozen.

Storage

- Vaccines in some offices were found days later buried under food and drinks.

Stockpiling

- One of the main issues that came to light was the stockpiling of large amounts of vaccines by some offices.

Diluent

- Many offices did not have diluent in equal amounts to the measles, mumps and rubella (MMR) and varicella vaccine. In most cases, there was far more diluent than vaccines. This raises concerns about how the MMR and varicella vaccines are being reconstituted. The MMR and varicella vaccines must be reconstituted by mixing with the diluent provided for that particular product.

Assessment

- Some vaccines were promptly returned to Public Health Services but were not assessed by anyone from Public Health Services before their return. They were not returned in coolers so it was impossible to determine what may have been still potent (J MacPhee, D Vaughan, M Pickles, K McGill, Public Health Services staff, personal communications).
- There were offices that removed the vaccine during the power outage and did not place them in another refrigerator, but put them back into circulation without an assessment when the power was restored (J MacPhee, D Vaughan, M Pickles, K McGill, Public Health Services staff, personal communications).

RECOMMENDATIONS FOR VACCINE MANAGEMENT

While physicians involved in vaccine administration should follow the guidelines provided by their local public health agency, the following are the type of practices that will ensure appropriate cold storage of vaccine.

Management in physicians' offices

- Designate and train a specific staff person to be responsible for managing vaccines, including the recording of refrigerator temperatures (2).
- Post storage and handling guidelines on the refrigerator.

Transportation

- Use insulated storage containers (coolers) with ice packs for transport of vaccines. To avoid freezing, do not place vaccine packages in direct contact with the ice packs.

Refrigerators

- Household or industrial refrigerators are much more reliable and efficient than bar refrigerators; and
- Place newly delivered vaccines into the refrigerator immediately upon delivery to the office.

Storage

- Store vaccines in the middle of the refrigerator to avoid the coldest and warmest parts of the refrigerator; do not store vaccines on the door shelves.

Thermometers

- Place a minimum-maximum thermometer on the middle shelf of the refrigerator. A minimum-maximum thermometer ensures that the highest and lowest temperature is known if there is a power outage or a refrigerator failure. It is very difficult, and sometimes impossible, to determine if a vaccine is still potent if this information is not available. These thermometers are commercially available for purchase and are useful for most office storage.
- Read, record and reset the thermometer at least once daily.

Storage

- Do not store food or biological specimens in the same refrigerator (2).
- Secure the electrical cord from the refrigerator to the wall outlet to prevent accidental power interruptions (2).
- Ensure that the refrigerator door does not swing open by installing a fail-safe (eg, Velcro) closing mechanism (2).
- Rotate the stock so that vaccines with the earliest expiry date are at the front of the shelf.
- Only remove vaccine from the refrigerator immediately before administration.

Vaccines exposed to temperatures lower than those recommended by the manufacturer present a serious problem.

Most vaccines cannot be used if they freeze. The exceptions are unreconstituted live virus vaccines such as yellow fever and MMR vaccines (3).

RECOMMENDATIONS FOR VACCINE SECURITY IN A POWER FAILURE

To ensure an efficient response to a potential or actual power failure:

- If a power outage or refrigerator failure occurs, place the vaccines in a refrigerator that is working and consult your Public Health Services office. Do not remove the vaccines and leave them on the counter;
- During a power failure, open the door of the refrigerator only when necessary, as this will help to maintain the temperature for a longer period of time (3);
- During a power failure, try to keep the ambient temperature in the office low. For example, close the window blinds (3); and
- Consult with your local Public Health Services office before administering any vaccines that have had an interruption in the cold chain.

Some vaccines are more stable outside the recommended 2°C to 8°C range than others. Public Health Services consults with experts to assess whether these vaccines are still potent and can be considered for use.

Do not discard vaccines before consulting with your local public health agency

If a physician's office experiences a power outage or a refrigerator failure, the following will assist the public health staff to make a proper assessment of the vaccines.

- Is there any ice left in the freezer?
- Are the ice packs in the freezer still frozen or partially frozen?
- Is the vaccine cold to the touch?
- Does the refrigerator feel cold?
- Is there condensation in the refrigerator?
- What is the temperature?
- Try to calculate the time of the outage – are there electric clocks in the office to indicate what time the power outage occurred? The local power company may be able to estimate the time of the outage if given the address of the office.
- Ensure that everyone is aware of what vaccines had a break in the cold chain (and are determined to be salvageable) by labeling them. These vaccines should be used first and if they sustain another cold chain interruption they should be discarded (4).

DISCUSSION

The Public Health Services response aimed at ensuring that only potent vaccines that had been maintained properly were used after the hurricane. This issue was of particular concern for children who, because of either the short time period between the primary pentavalent vaccine series or the use of vaccines

Lessons Learned

that are more vulnerable to cold chain failures such as MMR or varicella, might end up being inadequately protected despite a record of immunization. The observations made during the recall process showed not only that there was a short term issue but that several underlying problems with vaccine storage existed. In addition, refrigeration of vaccines had been identified as one of the most common deficiencies by the Atlantic Provinces Medical Peer Review Program (Sue Lordon, Atlantic Provinces Medical Peer Review, personal communication), an educational process sponsored cooperatively by the medical societies and licensing authorities of the four atlantic provinces. In their list of the most common deficiencies it is noted that "some drugs need to be refrigerated, and all vaccines should be kept at a temperature between 2°C and 8°C. These materials should be stored in the central location of a refrigerator, preferably in an insulated container. A record should be kept of refrigerator temperatures weekly" (Sue Lordon, Atlantic Provinces Medical Peer Review, personal communication).

The initial feedback to physicians on lessons learned needs to be followed up with an ongoing program of education and monitoring of vaccine storage.

LESSONS LEARNED

- Public health agencies must have a contingency plan to deal with severe weather and other events.

- A process for the evaluation of vaccine handling practices by physicians and other providers should be developed in all jurisdictions. This process should be a collaboration between public health agencies and the respective health professional licensing organization.
- Education and feedback on vaccine practices should be provided to physicians and other providers on a regular basis.
- Guidelines for evaluating vaccines exposed to temperatures outside the recommended temperature ranges should be developed for public health agencies to use as a guide.

REFERENCES

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