Vaccine Storage in Remote Areas

Lu Aye
International Technologies Centre (IDTC)
Department of Civil & Environmental Engineering
The University of Melbourne
lua@unimelb.edu.au

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Outline

• Background
• Vaccine potency and the cold chain
• Temperature requirement
• Remote areas of Developing countries
• Two options widely available
• Photovoltaic refrigeration
Background

- A quarter of all children born every year - 34 million infants - are not protected against diseases for which there are inexpensive vaccines (Practical Action Consulting 2006).

- An estimated 2.1 million people around the world died in 2002 of diseases preventable by widely used vaccines (WHO 2005).

- 27 million children worldwide were not reached by DTP3 in 2003, including 9.9 million in South Asia and 9.6 million sub-Saharan Africa (WHO 2005).

- 50% of transported vaccines are wasted through spoilage, lack of electricity is the reason for spoilage (Woodyard et al. 1995).

Loss in potency of pertussis component of DTP vaccine
(Source: Galazka et al. 1998)
Viability of four BCG vaccines
(Source: Galazka et al. 1998)

Vaccine potency

- All vaccines are thermo-sensitive and need to be properly stored and distributed within an efficient cold chain system.
- The stability of vaccines varies considerably (Galazka et al. 1998):
  - Diphtheria and tetanus toxoids and hepatitis B vaccine showing the highest thermostability,
  - Freeze-dried measles, yellow fever and BCG vaccines occupying the middle position and
  - Oral poliomyelitis vaccine being the most fragile.
Heat sensitivity
(Source: WHO 1998)

- Live oral polio vaccine (OPV)
- Measles (Lyophilized) *
- Pertussis and Mumps (Lyophilized)
- Hepatitis B
- Adsorbed Diphtheria-Pertussis-Tetanus vaccine (DPT)
- Adsorbed Diphtheria-Tetanus vaccine (DT, Td)
- BCG (Lyophilized) *
- Tetanus Toxoid (TT)

* Note: These vaccines become much more heat sensitive after they have been reconstituted with diluent.

The cold chain system

- The cold chain refers to the system (personnel, equipment & procedure) used for keeping and distributing vaccines in good condition.
- The cold chain system, when implemented properly, can help overcome the challenge of the delivery of quality vaccines.
- The cold chain system can enhance the on-going quality, safety and efficacy of an immunization programme.
A typical cold chain
(Source: WHO 2002)

Vaccine manufacturer

Transportation with refrigerated trucks and/or cold boxes (vaccine carriers for outreach)

International transport

National airport

Vaccines

Primary vaccine store

Intermediate vaccine store

Intermediate vaccine store

Health centre

Health post

Child and mother

Bolivia cold chain monitoring study; March–May 2005
(Source: Nelson et al. 2006)

(A) Central stores, (B) transport 1, (C) Santa Cruz (province), (D) transport 2, (E) Cordillera Camiri (district), (F) transport 3, (G) Charagua (health center)
Remote areas in Developing countries

- ~2.5 billion people live in rural areas of developing countries.
- Adequate electrical power and refrigeration are often lacking in developing countries.
- Storage, handling and the heat stability of vaccines are consequently matters of great concern in these areas.
- Most of these rural areas lie in hot and humid climate and have abundant sunshine.

Fundamental of refrigeration

To transfer heat from low temperature region to high temperature region requires work input to the device (refrigerator or reverse engine).
Vapour compression system
(Source: www.polarpowerinc.com)

Absorption system
(Source: www.polarpowerinc.com)
## Comparative data

(Source: Derrick & Durand 1986)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>PV Refrigerator</th>
<th>Typical Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net vaccine capacity (Litres)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Initial capital cost ($)</td>
<td>4500</td>
<td>500</td>
</tr>
<tr>
<td>CIF and installation ($)</td>
<td>1500</td>
<td>800</td>
</tr>
<tr>
<td>Fuel costs ($/day)</td>
<td>-</td>
<td>0.70</td>
</tr>
<tr>
<td>Maintenance costs ($/year)</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>Life time (Years)</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Availability (% time in service)</td>
<td>95</td>
<td>50</td>
</tr>
</tbody>
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![Refrigerator compartment](http://www.lasersunenergy.com/products/refrigerator.jpg)

![Vaccine Refrigerator Powered by a Photovoltaic System](http://www.polarpowerinc.com)

(Source: www.polarpowerinc.com)
Performance specification
(Source: WHO 1998)

- The design of the system shall permit a minimum of five days continuous operation when the battery set is fully charged and the photovoltaic array is disconnected.
- In continuous ambient temperatures of +32°C and +43°C the internal temperature of the refrigerator, when stabilized and fully loaded with the standard vaccine load, shall not exceed the range of 0°C to +8°C.

Typical Medical-use PV Refrigerators

- Storage volume: 27 to 100 L
- Freezing volume: 5 to 60 L
- Energy consumption: 300 to 500 Wh/day
- With freezing of ice pack: 700 to 1200 Wh/day
- System cost: US$ 3000 to 5000 (ITDG 2000)
  - PV arrays 28%
  - Refrigerator 37%
  - Batteries 24%
  - Accessories 11%
PV Vaccine storage

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elimination of fuel problems</td>
<td>Possible component failure</td>
</tr>
<tr>
<td>(Electric vapour compression systems – Diesel generator; Absorption systems – Kerosene fridges)</td>
<td>System sizing and performance are site specific</td>
</tr>
<tr>
<td></td>
<td>Better user training required</td>
</tr>
</tbody>
</table>

IDTC has developed a performance prediction and system components sizing software tool for small-scale photovoltaic refrigeration system (SSPQRS).

References


Nelson, C; Froes, P; Dyck, AMV; Chavarria, J; Boda, E; Coca, A; Crespo, G & Lima, H 2006 ‘Monitoring temperatures in the vaccine cold chain in Bolivia’, Vaccine, vol. in press, corrected proof.


WHO (see - World Health Organization) 1998 Equipment performance specifications and test procedures, E3: Refrigerators and freezers. WHO/EPI/LHIS/97.06.


WHO 2005 Immunization Against Diseases of Public Health Importance, Fact Sheet No.288.

For more information contact:

Lu Aye
International Technologies Centre (IDTC)
Department of Civil & Environmental Engineering
The University of Melbourne
lua@unimelb.edu.au