

# Temperature Recording System in National Vaccine Stores Khartoum, Sudan, and Tehran, Iran

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Both Iran and Sudan utilize alarm-based temperature recording system to monitor the performance of their national immunization cold stores. In order to better the utility and application of such systems in other countries, this report documents the benefits, challenges, and advantages of both Iran's and Sudan's systems.

## **Background: Sudan**

Sudan, with a population of 36 million including 1,086,000 surviving infants per annum,<sup>1</sup> has made significant progress in their vaccination program. Vaccination has increased dramatically in recent years across all antigens; the country has overcome most of the obstacles with which other African countries still struggle. The last endemic case of polio was detected in Sudan in 2001.

The Sudan National Vaccine Store in Sahafa, Khartoum, was certified to meet all minimum standards by a World Health Organization (WHO) and a United Nations Children's Fund (UNICEF) team in February 2008. The store has been using the Vaccination Supplies Stock Management (VSSM)<sup>2</sup> tool since late 2007 to track its inventory.

Over the years the number of doses handled by the central store has increased exponentially. In 2006 a total of 41.5 million doses of six traditional vaccines<sup>3</sup> arrived at the Sudanese National Vaccine Store in 38 different shipments.

In 2007 diphtheria-tetanus-pertussis (DTP) vaccine was gradually replaced by pentavalent vaccine, and a total of 58 million doses of vaccines (including pentavalent and DTP) in 37 shipments were handled by this store.

In 2008 and 2009 DTP was completely replaced by pentavalent vaccine and a total of 50.5 million doses of six different vaccines arrived at this store in a total of 73 shipments.<sup>4</sup> For details on the number of doses of vaccines and type of vaccines utilized in Sudan, see Annex 1.<sup>5</sup>

In 2007 the WHO Regional Office for the Eastern Mediterranean (EMRO) financially and technically supported the installation of a wireless temperature recording system in the Sudanese National Vaccine Store. A United Kingdom-based company—Wessex Power Technology Limited—was contracted to install the system. The company itself did not manufacture any of the parts required for this system but handled the procurement and assembly in order to construct the system. No detailed or technical terms of reference are available for this contract; the supplier was provided with the number of cold rooms and a schematic plan of the store. While there is no detailed record of the contract and

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<sup>1</sup> UNICEF, WHO. *Immunization Summary: The 2007 Edition*. Geneva: WHO; 2007.

<sup>2</sup> Vaccination Supplies Stock Management (VSSM) is a stock management computer tool designed by EMRO and recommended by WHO for vaccine stores.

<sup>3</sup> Bacilles Calmette-Guérin, diphtheria-tetanus-pertussis, oral polio vaccine, measles, hepatitis B, and tetanus toxoid.

<sup>4</sup> A total of 31 shipments in 2008, and 42 shipments in 2009 (as of 12 October 2009).

<sup>5</sup> Haghgou M. Vaccine Vial Monitor (VVM) Availability and Use in the Eastern Mediterranean Region, an In-Depth Review in Three Countries, (Sudan, Syria, and Oman). Geneva: WHO; 2009.

deliverables for the system implementation,<sup>6</sup> records show that the cost of the system was approximately £52,000.

## **Sudan's temperature recording system**

There are 10 small-sized cold rooms and 2 freezer rooms in the central store. The total net capacity of the cold rooms is approximately 25 m<sup>3</sup>, and the total capacity of two freezer rooms is 6 m<sup>3</sup>. There are also 13 chest freezers used mainly for oral polio vaccine (OPV), with a total net capacity of 4 m<sup>3</sup>.<sup>7</sup> For details of the cold storage equipment see Annex 1.

One temperature sensor (gas-type) is installed in each cold/freezer room for monitoring the internal temperature (see Figure 1). The sensor measures the internal temperatures of the cold/freezer rooms, and it is connected to a transmitter installed on the roof of each cold/freezer room (see Figure 2). The transmitter is manufactured by Elteck, and it functions with two normal and easily available AA batteries. Each transmitter sends wireless signals to a hub, and the hub (Wavecom Fastrack Squirrel 1000 Series) is connected to a computer for recording and saving the data (see Figure 3). There is an additional sensor outside the cold room which records the ambient temperature of the store.

At the time of the installation, the Sudan Ministry of Health decided to purchase a flat television monitor to display the recorded temperatures in the store manager's office (see Figure 4), which was not part of the original contract. The temperature sensors are calibrated annually.

The system also provides alarms for above 10°C and below 0°C. When the alarm is triggered, a siren sounds in the store. In addition, the alarm is connected to a telephone dialing system which rings the mobile phones of the store staff and the Expanded Programme on Immunization (EPI) manager. The alarm system also provides a short message service (SMS) text to the above-mentioned mobile phones and gives the details of the problem such as the identification of the cold/freezer room where the problem is located. It also specifies the internal temperature of the cold/freezer room in trouble through the SMS.

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<sup>6</sup> Optimize contacted both Supply Divisions in WHO EMRO and HQs.

<sup>7</sup> Information extracted from Sudan's VSSM updated data file.

**Figure 1.** Temperature sensor (gas type)



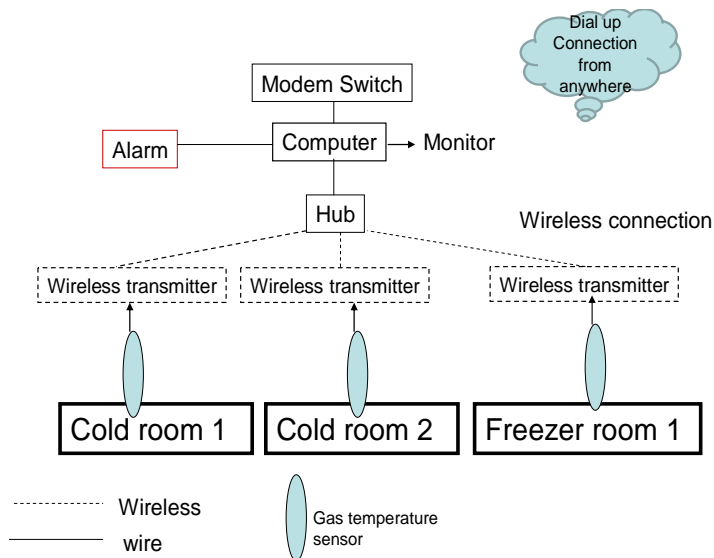
Photo: Mojtaba Haghighi

**Figure 2.** Wireless transmitter



Photo: Mojtaba Haghighi

**Figure 3.** Sudan temperature recording and alarm system



There have been no reports of any problems or faults related to this system so far in this store, and the system has functioned continuously since February 2007.

## Sudan: Installation

The installation of the system was part of the contract, and a technician from the United Kingdom spent four working days installing the system. The technician also trained the store staff on maintenance and troubleshooting for the system.

**Figure 4.** A flat-screen monitor displays readings from the system



Photo: Mojtaba Haghighi

## Sudan: Utility of the system

EPI Sudan is proud of their wireless temperature recording system, and it has become a show piece in the Eastern Mediterranean Region. Already EPI staff from Tunisia, Yemen, Libya, and Syria visited the store on study tours to observe the organization of the store and in particular to see the temperature recording system. There have been two regional vaccine management training courses organized in Khartoum, in 2008 and 2009, and the temperature recording system was highlighted and demonstrated to the participants from the other countries of the region.

The practice of manual temperature recording continues for each piece of equipment, and the results are compared with the wireless temperature recording system. The printout of the result (Figure 5) is sent to the EPI manager on a monthly basis for signature, and the records are kept on file.

The historical record of the temperatures inside the cool rooms and freezers has been particularly useful and became important during one incident in 2009 when vaccine vial monitors (VVMs) on 1,200 vials of pentavalent vaccines reached their endpoints much faster than was expected. As per WHO policy, the vials were immediately discarded. This was an unprecedented incident and, therefore, it was reported to UNICEF and WHO. Investigation took place immediately. The record of the temperatures of the cold room where the pentavalent vaccines in question were stored was reviewed together with manual recording and proved that the problem could not be attributed to irregularities in the central store cold room. The investigation resulted in reassigning the vaccine with a VVM that better reflected its true stability.



**Figure 5.** Sample printout of the results sent to the EPI manager monthly

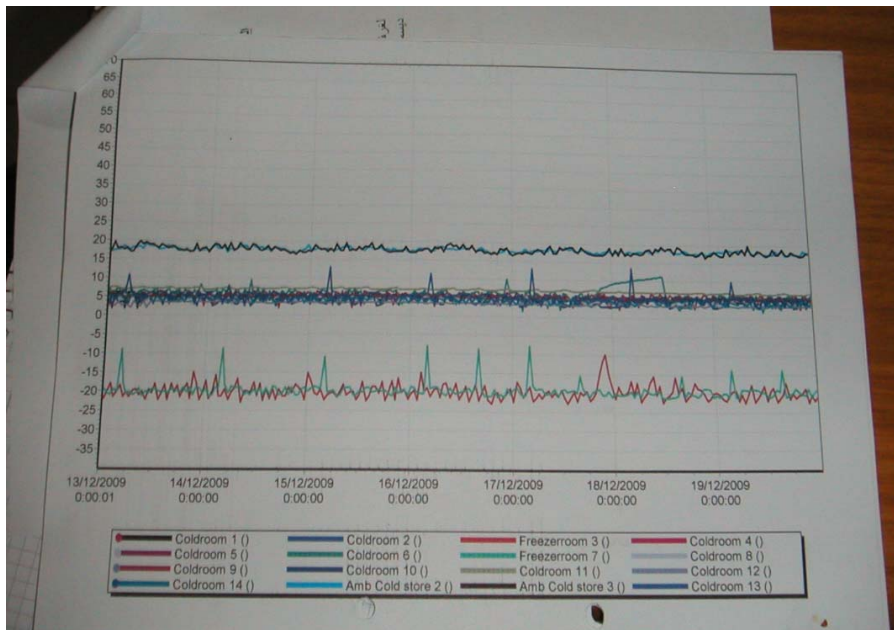


Photo: Mojtaba Haghighi

This incident highlights the value of having an accurate digital temperature monitoring system in place both for ensuring the integrity of the cold chain and most importantly the quality of the vaccines.

## **Sudan: Discussions and recommendations**

Sudan's National Vaccine Store is in a well-planned and a newly designed warehouse. The cold rooms and freezer rooms are small. The pieces of cold chain equipment, particularly in the cold and freezer rooms, are old but well maintained. They are all nicely installed in a completely covered warehouse close to each other. There was a need for an automatic temperature recording system but no particular reason for selecting a wireless temperature recording system. The temperature sensors could easily have been connected to the hub with a relatively short wiring network. However, there is no information as to whether the wireless system would have had a lower cost than the wired one.

A wireless system might be important in stores where cold/freezer rooms are scattered and wiring becomes either expensive or difficult to maintain. For instance, the wired temperature recording system failed in Pakistan since the distance between the cold rooms was long, and some wires were damaged during the repair of the roads and construction work in the store compound.

## Background: Iran

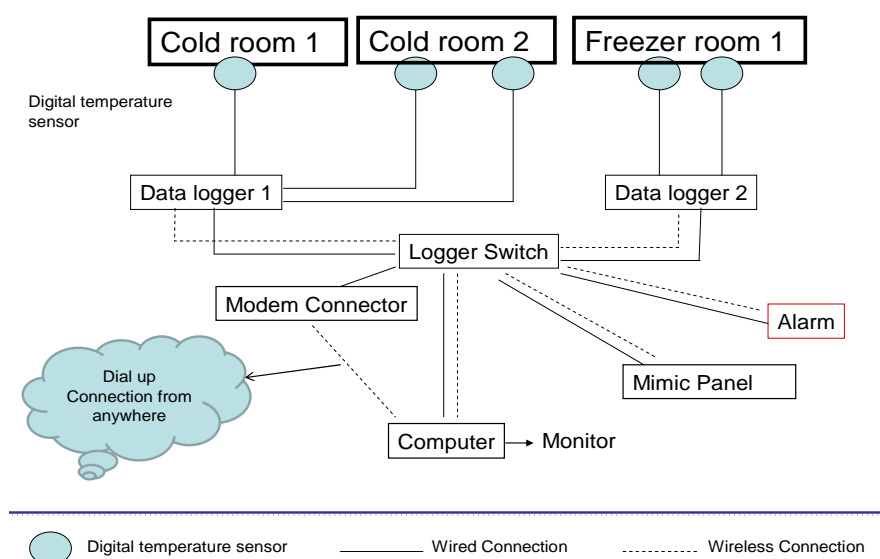
Iran, with a population of approximately 70 million including 1,300,000 surviving infants annually, has one of the best primary health care systems in the Eastern Mediterranean Region. The coverage of all antigens has been over 99% during the last two decades.<sup>8</sup> All vaccines, including measles and hepatitis B, are produced locally. A total of 109 million doses of seven different traditional vaccines<sup>9</sup> were handled in the Iranian National Vaccine Store in Tehran in 2007 and 2008. No new vaccines and no new presentation of vaccines have been introduced into the program yet. For details on the vaccine types, number of doses, and the types and the capacity of the cold storage equipment see Annex 2.

Iran receives almost no donations or external support for vaccines or equipment. The National Vaccine Store was assessed in 2005 but could not be certified due to the fact that the building is old and the store is not in a suitable location. The store has seven large cold rooms of different sizes with a total net capacity of 152 m<sup>3</sup> above 0°C and two freezer rooms with a total net capacity of 13 m<sup>3</sup> below 0°C. See Annex 2 for details.

## Iran: Temperature recording system

The automatic temperature recording system was designed, assembled, and installed by a local company—Sardzasaz—in 2005 (see Figure 6). The company is also responsible for the maintenance of the system and has had a contract for the last five years with the Ministry of Health and Medical Education. Similar systems were also installed in some other provincial vaccine stores by the same company.

**Figure 6.** Iran temperature recording and alarm system



<sup>8</sup> UNICEF, WHO Immunization Summary: The 2007 Edition.

<sup>9</sup> BCG, DTP, DT, Td, HepB, OPV, and MMR.

The Iranian system is similar to the Sudanese system with the following differences (see Table 1):

- It is totally designed, assembled, and installed locally (no foreign party was involved).
- All components were manufactured and/or assembled in Iran.
- The connection between the cold/freezer rooms to the modem is through a wired network (Sudanese system is through a wireless network).
- The connection between the modem and the computer is wireless.
- The temperature sensors are of a digital type (see Figure 7) (Sudanese sensors are of a gas type).

**Figure 7.** Digital temperature sensor (Iran)



**Table 1.** Comparison between the Sudanese and Iranian temperature recording systems

Criteria	Sudan	Iran
Population	36,000,000	70,000,000
Surviving infants per year	1,086,000	1,300,000
Total number of doses of all vaccines handled in 2007 and 2008	108,784,040	108,900,000
Vaccines used in the EPI program	Pentavalent was introduced in 2007	Traditional vaccines
National vaccine store situation	EVSM* certified in 2008	Assessed but not EVSM certified (2005)
Capacity of central store	25 m <sup>3</sup> above 0°C 6 m <sup>3</sup> below 0°C	152 m <sup>3</sup> above 0°C 13 m <sup>3</sup> below 0°C
Number of cold rooms and freezer rooms	Cold rooms = 10 Freezer rooms = 2	Cold rooms = 7 Freezer rooms = 2
Installation of temperature recording system	2008	2005

Criteria	Sudan	Iran
Temperature sensors	Gas type	Digital type
Connections	<ul style="list-style-type: none"> <li>• Wireless from sensors to hub</li> <li>• Wired from the hub to the computer and the modem</li> </ul>	<ul style="list-style-type: none"> <li>• Wired from sensors to hub</li> <li>• Wireless from the hub to the modem and the computer</li> </ul>
Notification of alarms	Connected to mobile phones	Connected to mobile phones
Audible alarm in central store	Yes	Yes
Installation	Managed by a foreign supplier	Managed by a local supplier
Costs	£52,000	Not available

\* Effective vaccine store management

## Conclusions and next steps

There is no doubt that an automatic temperature recording system has great benefits in large stores where the majority of vaccines are stored. The high price of vaccines justifies the cost of such equipment.

A list of standard components for both wireless and wired system, along with detailed guidelines for installation and maintenance should be developed. It is important to establish the cost difference and maintenance differences between wireless and wired temperature recording systems.

Criteria to assess the value of such systems should include the size of the store, the number of doses of vaccines handled, and the importance and location of the store. Such criteria exist for using cold rooms versus refrigerators. Similar criteria will help the program managers in their decision-making and allocation of funds. This will complement the existing WHO/PQS specifications (2006) on programmable electronic temperature and event logger systems with integral alarm and auto-dialer options (E06/TR03.1)

## Annex 1: Detailed information for Sudan

**Table 1.** Profile of the equipment

<b>Cold chain storage equipment in the National Vaccine Store, Khartoum, Sudan</b>	<b>Type of equipment</b>	<b>Net capacity (liters)</b>
Cold room 1	above 0°C	2,769
Cold room 2	above 0°C	2,769
Freezer room 3	below 0°C	2,769
Cold room 4	above 0°C	2,769
Cold room 5	above 0°C	2,217
Cold room 6	above 0°C	2,830
Freezer room 7	below 0°C	3,213
Cold room 8	above 0°C	4,177
Cold room 9	above 0°C	1,833
Cold room 10	above 0°C	1,833
Cold room 11	above 0°C	1,923
Cold room 12	above 0°C	1,833
Chest freezer 1	below 0°C	270
Chest freezer 2	below 0°C	270
Chest freezer 3	below 0°C	333
Chest freezer 4	below 0°C	333
Chest freezer 5	below 0°C	333
Chest freezer 6	below 0°C	333
Chest freezer 7	below 0°C	333
Chest freezer 8	below 0°C	270
Chest freezer 9	below 0°C	270
Chest freezer 10	below 0°C	270
Chest freezer 11	below 0°C	270
Chest freezer 12	below 0°C	270
Chest freezer 13	below 0°C	270

Total net above 0°C in 10 cold rooms = 25 m<sup>3</sup>

The smallest cold room has a net capacity of 2.22 m<sup>3</sup>

Total net below 0°C in 2 freezer rooms = 5.98 m<sup>3</sup>

The smallest freezer room has a net capacity of 2.8 m<sup>3</sup>

Data extracted from Sudan VSSM data file

**Table 2.** Vaccines handled at the National Vaccine Store, Sudan from 2006 to 2009 in doses

<b>Vaccines</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b> (as of 12 October 2009)	<b>Total</b>
<b>BCG</b>	2,828,600 (7)	1,688,000 (5)	983,000 (4)	2,007,000 (2)	7,506,600 (18)
<b>OPV*</b>	28,365,600 (14)	44,801,400 (17)	36,734,000 (11)	40,348,000 (26)	150,249,000 (68)
<b>Measles</b>	923,000 (5)	4,531,560 (5)	2,598,180 (5)	1,087,230 (2)	9,139,970 (17)
<b>TT</b>	3,229,000 (4)	1,303,000 (3)	5,919,000 (6)	664,000 (2)	11,115,000 (15)
<b>Pentavalent</b>		1,655,000 (2)	2,596,000 (4)	3,443,400 (10)	7,694,400 (16)
<b>Hepatitis B</b>	2,297,000 (2)	1,881,400 (2)	1,881,500 (1)		6,059,900 (5)
<b>DTP</b>	3,820,000 (6)	2,212,000 (3)			6,032,000 (9)
<b>Total</b>	41,463,200 (38)	58,072,360 (37)	50,711,680 (31)	47,549,630 (42)	197,796,870 (148)

Numbers in brackets represent number of shipments per year

Information extracted from: Haghgou M. Vaccine Vial Monitor (VVM) Availability and Use in the Eastern Mediterranean Region, an In-Depth Review in Three Countries, (Sudan, Syria, and Oman). Geneva: WHO; 2009.

## Annex 2: Detailed information for Iran

**Table 1.** All vaccines handled by the National Vaccine Store, Tehran, Iran, in 2007 and 2008

Vaccines	Vial presentation (dose/vial)	Total in 2007 and 2008 (in doses)
BCG	20	9,000,000
DTP	10 and 14	14,000,000
DT	14	400,000
dT	14	12,500,000
Hepatitis B	10	27,500,000
OPV	15	33,500,000
MMR	2 & 10	12,000,000
<b>Total</b>		<b>108,900,000</b>

Information provided by the Ministry of Health and Medical Education, Tehran, Iran

**Table 2.** Profile of the equipment

Cold storage equipment in the Iranian National Vaccine Store, Tehran	Net volume (liters)
Freezer room 1	6,660
Freezer room 2	6,660
<b>Total below 0°C</b>	<b>13,320</b>
Cold room 3	13,716
Cold room 4	10,453
Cold room 6	77,867
Cold room 7	11,117
Cold room 8	8,878
Cold room 9	8,557
Cold room 10	21,338
<b>Total above 0°C</b>	<b>151,926</b>

Information was extracted from Iranian VSSM data file