Assessment of a remote alarm system for vaccine storage in Albania

July 2011

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OPTIMIZE Immunization systems and technologies for tomorrow

PATH World Health Organization

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Executive summary

Until recently, vaccine storage temperatures have been monitored using a simple thermometer and relying on twice-daily manual measurements. The inaccuracy and inadequacy of this system has resulted in the introduction in many countries of the 30-day logger, incorporating high and low time-and-temperature alarms. Although the benefits of this technology improvement are established, twice-daily inspections are still required, and the logger cannot transfer or report the temperature data. Between March and December 2010 this study assessed the marginal managerial advantages of using a global system for mobile communications/short message service messaging to transmit the alarms of the 30-day logger to health workers and their supervisors and to transfer temperature data in 24 health centers of the district of Shkodra, Albania.

The main findings of the study were that the short message service alarms alerted health workers to cooling failures at all times, even when the health centers were closed, enabling them to respond promptly. Secondly, the awareness and involvement of supervisors reinforced the process of seeking solutions and, in particular, replacing inadequate equipment. Finally, temperature plots and performance data were collected on refrigerator models, enabling wiser procurement choices. As transmission of alarms and temperature data become more feasible and affordable, remote alarm systems and central oversight of vaccine storage may be adopted progressively throughout distribution systems.

Background

Temperature monitoring of vaccine storage has always been and remains a vital process of the cool chain for vaccines. By monitoring the temperature of cooling equipment, the user can avoid excursions of temperature outside the prescribed limits. The user reviews temperature data to assess accidental excursions of temperature after they have taken place, and system managers can detect malfunctioning equipment and poorly performing equipment models.

Until recently, temperatures were continuously recorded only in large vaccine stores where alarms are routinely provided. The rest of the cool chain system depended on ordinary thermometers for the monitoring process. Now these thermometers are being progressively replaced by 30-day recorders that signal when high-temperature and low-temperature limits have been exceeded by a set margin. Fridge-tag®, manufactured by Berlinger & Co. AG, Switzerland, was the first temperature monitoring device to meet the World Health Organization (WHO) Performance, Quality and Safety (PQS) standard specifications for a "30 day electronic refrigerator temperature logger."[1] The Fridge-tag is placed inside the vaccine storage compartment[i] and records temperatures, visually displaying current, high- and low- temperature excursions beyond preset limits over a rolling 30-day period.

In 2009, the Institute of Public Health in Albania in collaboration with WHO conducted a study[2] of the impact of the introduction of Fridge-tag devices in 20 randomly selected health facilities. The main conclusion of the study was that the Fridge-tags alarms and temperature history represent a significant improvement over thermometers in helping health workers to detect cool chain failures, assess exposure of vaccines, and take remedial action.

Two major attributes of the Fridge-tag device influenced this conclusion:

- Visual alarms set against high and low time-and-temperature thresholds gave a clear managerial message to health workers and storekeepers that assessment and remedial action must be undertaken, urgently.
- A 30-day record of past alarms and temperatures reached permits the user and the supervisor to check the history of temperature events when the refrigerator was not attended or following one or more failures.

These and other results led to the introduction of Fridge-tag throughout the Albanian cool chain. However, to detect failures, twice-daily visual inspections are still needed and appropriate corrective action has to be taken by the health worker. At the 45th National Immunization Conference[3] of the US Centers for Disease Control and Prevention in March 2011, it was noted that compliance of health workers with monitoring and intervention procedures is low and that remote alarm systems and transfer of temperature data to supervisory levels of the system are expected to raise the quality of monitoring and response to failures.

At central and major intermediate vaccine stores it is now common to install temperature logging systems that incorporate remote alarms systems using a global system for mobile communications telephone (short message service [SMS]/general packet radio service

[i] Berlinger now offers the option for a remote sensor, allowing the thermometer to be attached outside the refrigerator.

data transfer and messaging). These systems ensure that both the storekeeper and the supervisors are immediately informed of breaks in the cool chain, enabling them to agree on corrective actions to be taken and ensuring a more rapid response. Affordable technology now exists to bring this level of temperature monitoring oversight to the facility level and for supervisors to be informed of problems at the facilities.

Objectives of the study

The study assessed the value of potential managerial benefits of a GSM/SMS-based remote alarm system in association with Fridge-tags relative to the use of similar facilities using Fridge-tag alone.

Specifically, the study assessed whether:

- The time delay between the alarm and detection and response by the health worker will be shortened by direct transfer of the alarm to a health worker's portable telephone, even on holidays and during non-business hours.
- Health workers or storekeepers are empowered by being contacted by supervisors via telephone to discuss appropriate follow-up after a reasonable delay has elapsed without action.
- Compliance by health workers with the temperature monitoring procedure will be enhanced by the knowledge that supervisors are informed automatically regarding temperature excursions.
- The creation of a permanent record and reporting of failures and refrigerator performance at supervisory levels of the system accelerates and reinforces corrective actions including the replacement of equipment.

Methodology

The study took place over ten months (March 2010 to the end of December 2010) in 24 health facilities of the district of Shkodra, Albania. During this period, high- and low-temperature alarms were automatically sent by SMS from each refrigerator, via a central server, to the appropriate health workers, storekeepers, and supervisors. Supervisors visited each site once a month and collected recorded temperature data.

Study site selection

The district of Shkodra was chosen for the study for the following reasons:

- Shkodra is also the focus of a second major activity of project Optimize in Albania, the integrated management information system for birth registration and immunization services.
- Shkodra has particularly motivated and experienced staff with a very low turnover rate.

Twenty-four health facilities of the district of Shkodra that store and administer vaccines participated in the study. Shkodra district has 16 communes, with 108 villages, and 40 health centers reporting to the district level. There are 12 urban health centers out of which 6 (50%) are responsible for 2 or 3 neighborhoods, and 28 rural health centers out of which 10 (35%) are responsible only for their own village and 18 (65%) are responsible for 2 to 11 villages. The distribution of participating health facilities in the

Shkodra district is presented in the map below (Figure 1). A list of the refrigeration equipment installed in each facility appears in Annex 1.

Figure 1. Health facilities participating

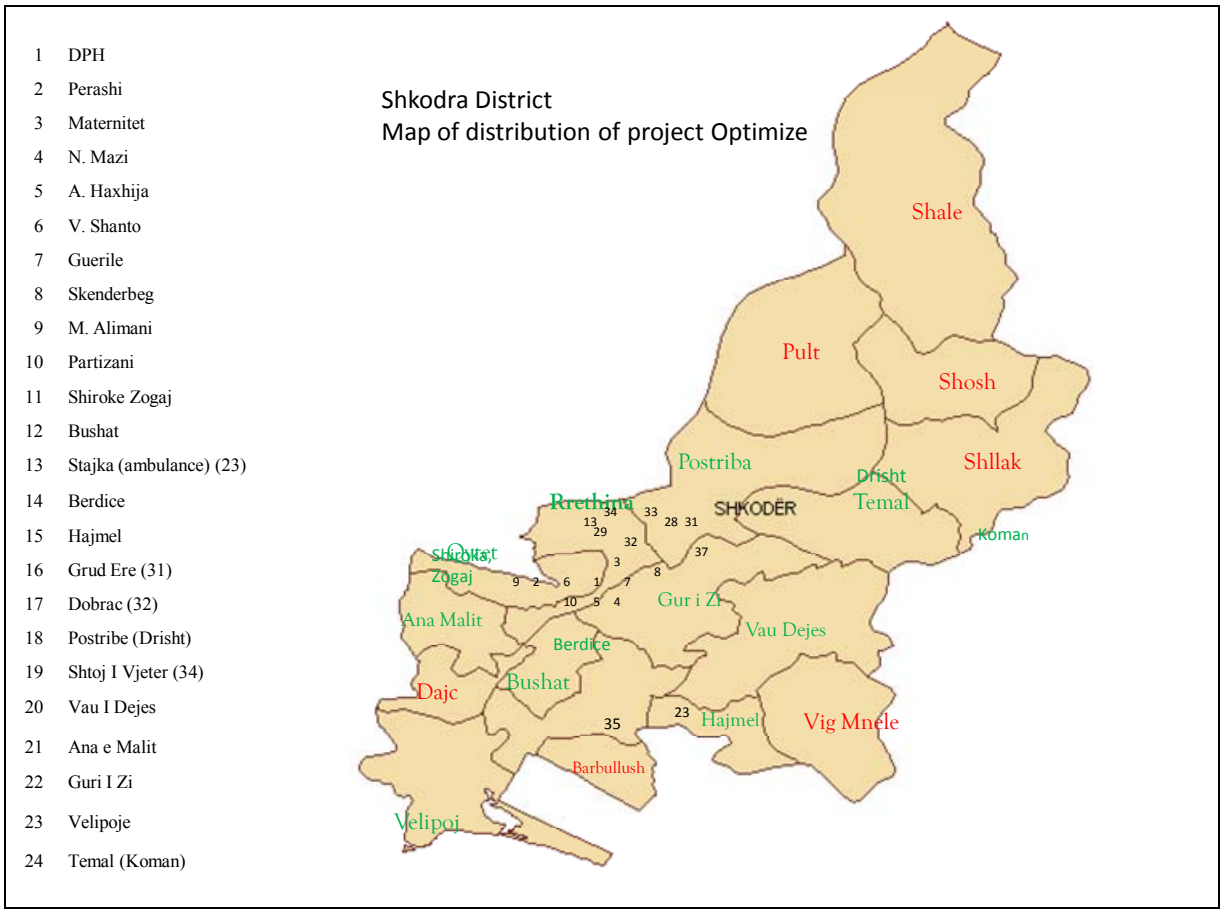


Table 1. Shkodra district annual birth cohort

	Annual surviving infants															
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
Total (urban)	1,450	1,380	1,420	1,264	1,238	1,314	1,205	1,063	1,072	1,029	1,008	915	916	867	853	16,994
Total (rural)	1,964	1,651	1,541	1,547	1,294	1,368	1,361	1,222	1,192	1,114	1,038	1,029	946	838	899	19,004
Total	3,414	3,031	2,961	2,811	2,532	2,682	2,566	2,285	2,264	2,143	2,046	1,944	1,862	1,705	1,752	35,998

Equipping of health centers

The 24 health centers were equipped with refrigerators (See Annex 1 for inventory). During the baseline assessment phase of the project, LogTag® recording devices were placed in each refrigerator to assess the performance of the refrigerators one month before the study intervention began.

When the temperature data had been collected from these refrigerators, the LogTag® recorders were removed, and each refrigerator was provided with the following monitoring equipment for the study:

- A Fridge-tag 30-day temperature recorder (see Figure 2) incorporating visual alarms.
  - For high temperatures exceeding 8°C for more than 10 consecutive hours.
  - For low temperatures below -0.5C for more than 60 consecutive minutes and set to take temperature readings every 10 minutes.
- A Libero PDF Logger®[ii] temperature recorder (see Figure 3) with temperature sensor installed in the refrigerator close to the Fridge-tag and set to take temperature readings every 10 minutes (equivalent to 110 days) to match the Fridge-tag.
- An SMS generator linked to the Libero to transmit an alarm at the above thresholds to selected health workers and supervisors via a central control server.

The Libero and the SMS generator simulated the functionality of a single combined monitoring device based on the Fridge-tag. Figure 2 shows that the sensor of the Libero was always located as close as possible to the Fridge-tag. An upgrade to Fridge-tag with this functionality will be undertaken by Berlinger if the results of this study show sufficient benefits for the management of vaccines and cool chain equipment.

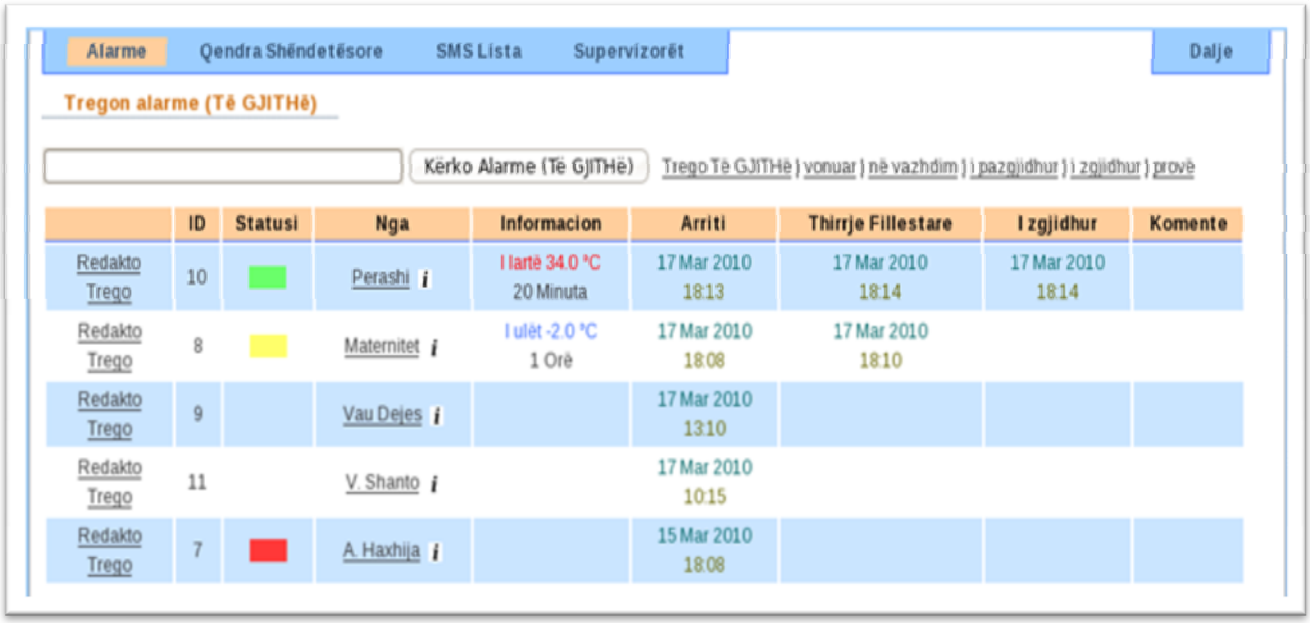
Figure 2. Fridge-tag 30-day recorder stored with the vaccine load

[ii] Libero PDF Logger is a registered trademark of Elpro-Buchs AG.

Figure 3. Libero temperature logging device with audible and visual alarms

The function of the central server located at the Public Health Directorate was to collect the SMS alarm messages, record them for action by the supervisor, and relay them on to the cellular telephone of the health worker and the supervisor. The server application should have been web-enabled but this feature was not operational for the period of the study. Figure 4 shows the dashboard at the server, warning supervisors of every alarm and keeping track of delays in response.

Figure 4. Server alarm "dashboard"



	ID	Statusi	Nga	Informacion	Arriti	Thirrje Fillestare	I zgjidhur	Komente
Redakto Trego	10		Perashi	I lartë 34.0 °C 20 Minuta	17 Mar 2010 18:13	17 Mar 2010 18:14	17 Mar 2010 18:14	
Redakto Trego	8		Maternitet	I ulët -2.0 °C 1 Orë	17 Mar 2010 18:08	17 Mar 2010 18:10		
Redakto Trego	9		Vau Dejes		17 Mar 2010 13:10			
Redakto Trego	11		V. Shanto		17 Mar 2010 10:15			
Redakto Trego	7		A. Haxhija		15 Mar 2010 18:08			

The system

The standard operating procedure for health facility staff to use Fridge-tag to monitor refrigerator temperatures before the study was to:

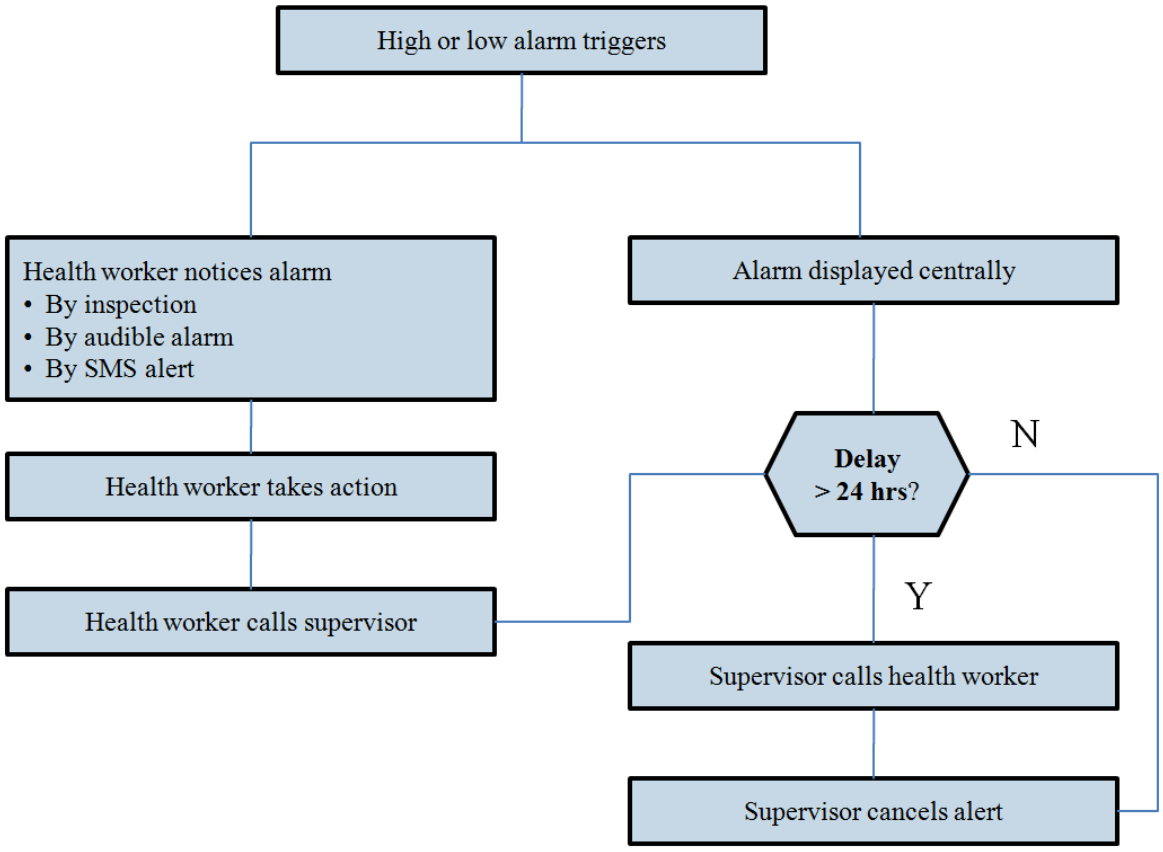
1. Visually check Fridge-tag for alarms at least twice a day in the morning and evening.
2. If the low-temperature alarm is triggered, a) conduct the shake test to check that the freeze-sensitive vaccines have not been harmed, and b) adjust the thermostat until the low-temperature risk has been eliminated.
3. If the high temperature alarm is triggered, a) check if the electricity supply has been interrupted and, if not, b) check if the refrigerator is running properly and, if not, manually adjust the thermostat (if possible) or call a technician.

The above procedure was supplemented in this study by an alarm system that triggers:

- An SMS alert to a server at the district supervision center.
- An SMS alert sent to the cellular telephone of the responsible health worker.
- An audible alarm within the health facility.

The supervisor was required to monitor incoming alarms on the server and check (by telephone or, if necessary by a physical visit) that adequate corrective action was taken. The health facility staff should confirm to the supervisor (by telephone) within a maximum of a day (24 hours) that action has been taken. Otherwise, the server provides a visual warning to the supervisor that no action has been taken for more than a day. A flowchart of this process is shown in Figure 5.

Figure 5. Flowchart of the alarm monitoring procedure



The central server acted both as a record of incoming alarms and also as a transaction manager, presenting the supervisors with a screen to view and to enter details of actions taken.

The health facility staff were instructed to follow the usual standard operating procedure for the Fridge-tag and to record information on the form including (See Annex 2 for alarm reporting form):

- The date/time of new alarm.
- The date and time that the new alarm was discovered.
- Corrective action taken.
- Calls made to and received from the supervisor.

Project milestones

The study was conducted with the following milestones:

- Meeting to present and finalize study protocol, PATH, Ferney, April 7, 2009.
- Training for technicians and supervisors at ELPRO, Buchs, Switzerland, January 5 to 7, 2010.
- Training for study supervisors and health workers, Shkodra, Albania, March 16 to 19, 2010.
- Installation and testing of monitoring equipment February 20, 2010 to March 21, 2010.
- Study launch March 22, 2010.
- Monthly supervision visits to all health centers.
- Focus group discussions at a meeting in Shkodra, September 1, 2010.
- Meeting to present results and discuss with health workers January 28, 2011.

Training

Two training sessions were organized. The first was a three-day training conducted (January 5 to 7, 2010) for technicians and supervisors of the study on the the Elpro, premises manufacturer, of the Libero and the SMS alarm system in Buchs, Switzerland. At this session, the detailed function, installation, and settings were explained by the manufacturer, and the equipment was shipped to Tirana, Albania, shortly after.

The second session was conducted in Shkodra for health workers and was facilitated by managers and supervisors of the study. Supervisors were briefed on the preparation day before the training using Annex 2, translated into Albanian. The health worker training (one day) included a review and demonstration of the use of Fridge-tag, the shake test, and vaccine vial monitor s(VVMs), and a detailed briefing on project procedures for health staff. The training was well received and quickly understood by the health staff.

Installation of equipment

Following the training of the technicians in Switzerland, the health facility equipment was supplied and installed at the 24 health facilities. At the time of the launch of the study, the computer server dedicated to the alarm system was installed and tested. Four randomly picked health facilities around the district of Shkodra were visited to check the installation. The results of the tests showed SMS messages were sent to cellular

telephones as planned, and the correct recording and display were shown on the server. A user's manual was prepared for the server-alarm application.

Supervision

Routine monthly visits were planned for all participating health facilities during which alarm events were to be discussed, the refrigerators were to be inspected, and the SMS alarm system was to be tested. Supervisors were asked to work with the notes and records kept by the health workers and to create their own journal of events by health facility.

Results

Baseline assessment of refrigerator performance

Sixteen refrigerators, 64% of the total included in the study (n=25) were the domestic type and were not prequalified for vaccine storage. Several domestic refrigerators were fitted with aluminium boxes designed to hold vaccine inside the refrigerator. Although some improvements of the temperature range was achieved, it was not sufficient to avoid excursions (See Annex 3). The refrigerators were also aged, 72% were more than 10 years old and one was more than 19 years old.

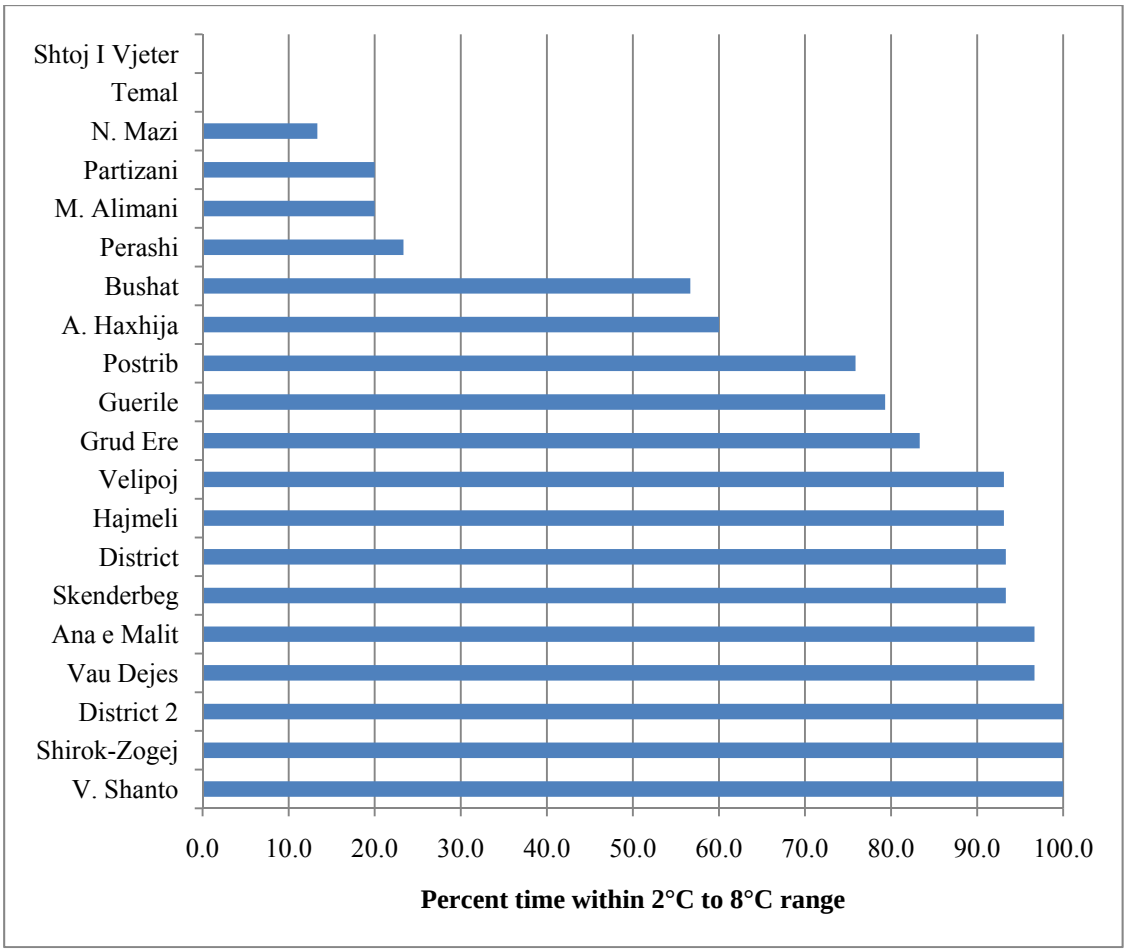
Table 2 presents the results of the storage-temperature monitoring in these refrigerators over a single month. The table shows that 5 out of the total of 21 refrigerators monitored at 17-minute intervals had excursions of temperature above 8°C on 3 or more days, triggering two alarms, and each spent more than 10 consecutive hours over 8°C. The temperature in one refrigerator dropped below -0.5C twice for longer than one hour triggering two alarms. Figure 6 shows that half of the refrigerators were incapable of remaining within the vaccine storage recommended range of 2°C to 8°C.

Table 2. Summary of baseline monitoring of refrigerators

Facilities	Temperature > 8°C		Temperature < -0.5°C	
	Number of days	Number of alarms	Number of days	Number of alarms
	Excursions > 8°C	> 8°C for 10 hours	Excursions < -0.5°C	< -0.5°C for 1 hour
Shirok-Zogej	30	0	0	0
Partizani	24	1	0	0
Bushat	11	1	0	0
Perashi	9	0	0	0
Grud Ere	4	0	0	0
A. Haxhija	3	0	0	0
N. Mazi	3	0	0	0
Vau Dejes	3	0	0	0
M. Alimani	2	0	0	0
Temal	2	0	0	0
Velipoj	2	0	0	0
District	2	0	0	0

Facilities	Temperature > 8°C		Temperature < -0.5°C	
	Number of days	Number of alarms	Number of days	Number of alarms
	Excursions > 8°C	> 8°C for 10 hours	Excursions < -0.5°C	< -0.5°C for 1 hour
Guerile	1	0	0	0
V. Shanto	0	0	0	0
Skenderbeg	0	0	0	0
Hajmeli	0	0	0	0
Postrib	0	0	2	2
Ana e Malit	0	0	0	0
Shtoj I Vjeter	0	0	0	0
District	0	0	0	0

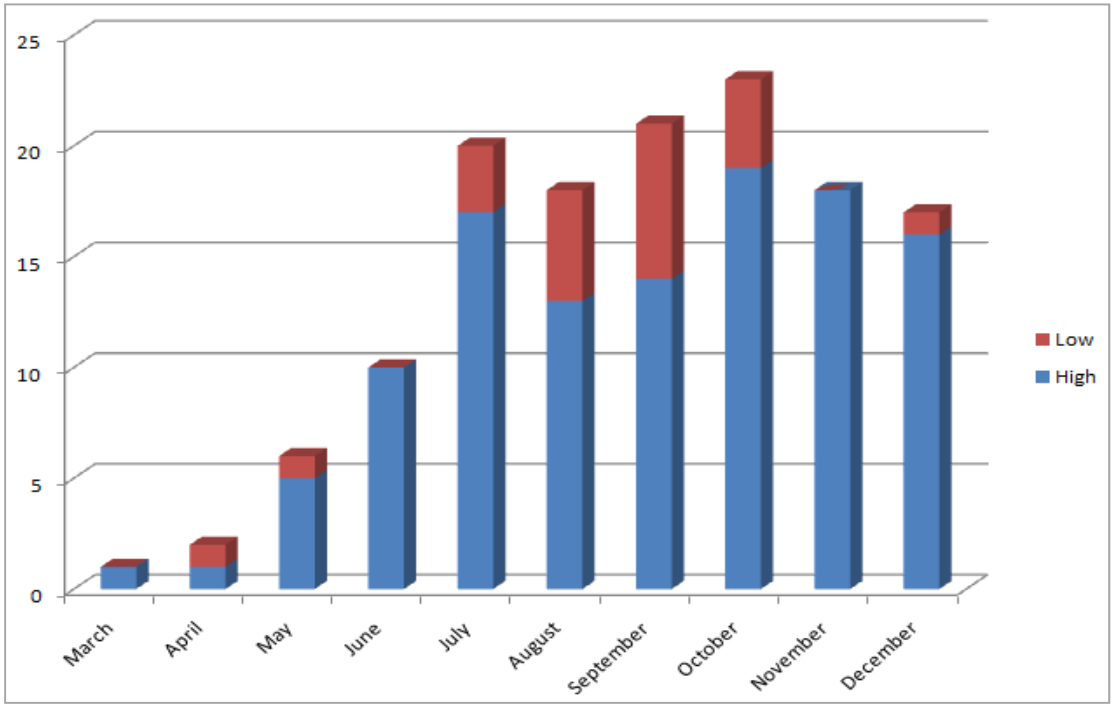
Figure 6. Percentage of time that refrigerators remained within the temperature range of 2°C to 8°C



Frequency of alarms

There were a total of 291 alarms registered on the central server during the ten months of the study, including 155 alarms that were manually triggered by supervisors to test the operation of the system. The 136 remaining alarms signaling incidents comprised 22 low-temperature alarms and 114 high-temperature alarms.[iii] Figure 7 shows the evolution of the alarms over the study period with a higher rate of alarms in July to October. This was probably due to higher ambient temperatures in the summer months and the absence of staff during holidays.

Figure 7. Frequency of alarm events over the duration of the study



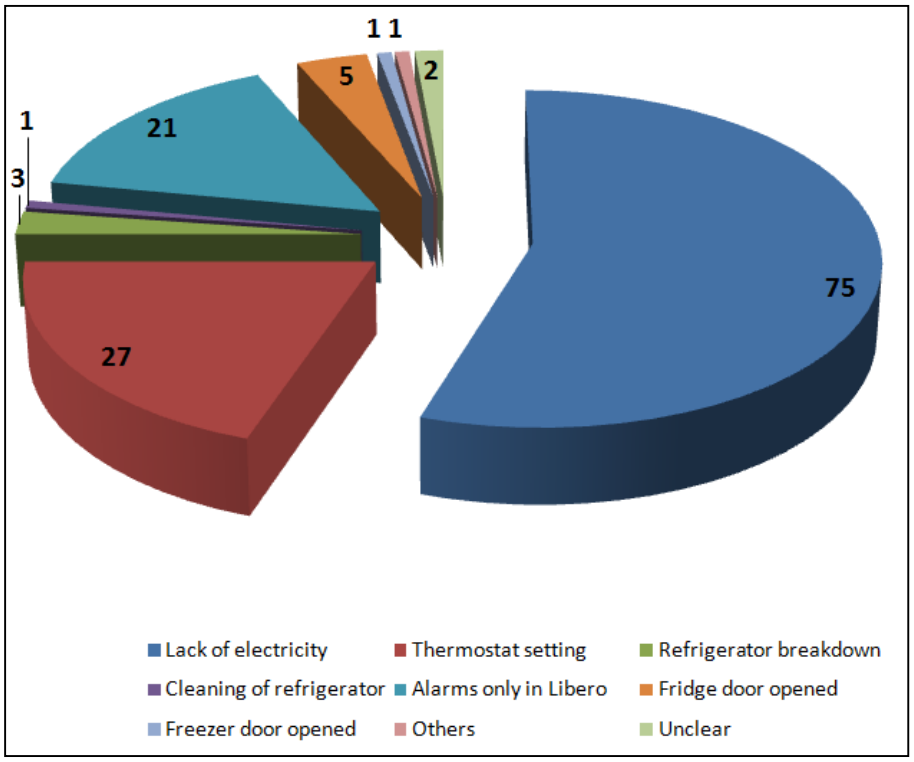
Although the overall frequency of alarms was different in this study compared to the earlier Fridge-tag study; the incidence is so concentrated on a few locations that comparison is not feasible.

Cause of alarms

Figure 8 shows alarm events by cause. The major cause (75/136 or 55% of alarms) was failure of the electricity supply, usually for a short period of a few hours. However, the refrigerators were all of the domestic type, poorly insulated, and quick to warm up when power was interrupted (see Annex 3).

[iii] Twenty-one of these alarms were registered only in the Libero, not in the Fridge-tag, due to differences in temperature measurement between the Fridge-tag and the sensor of the Libero.

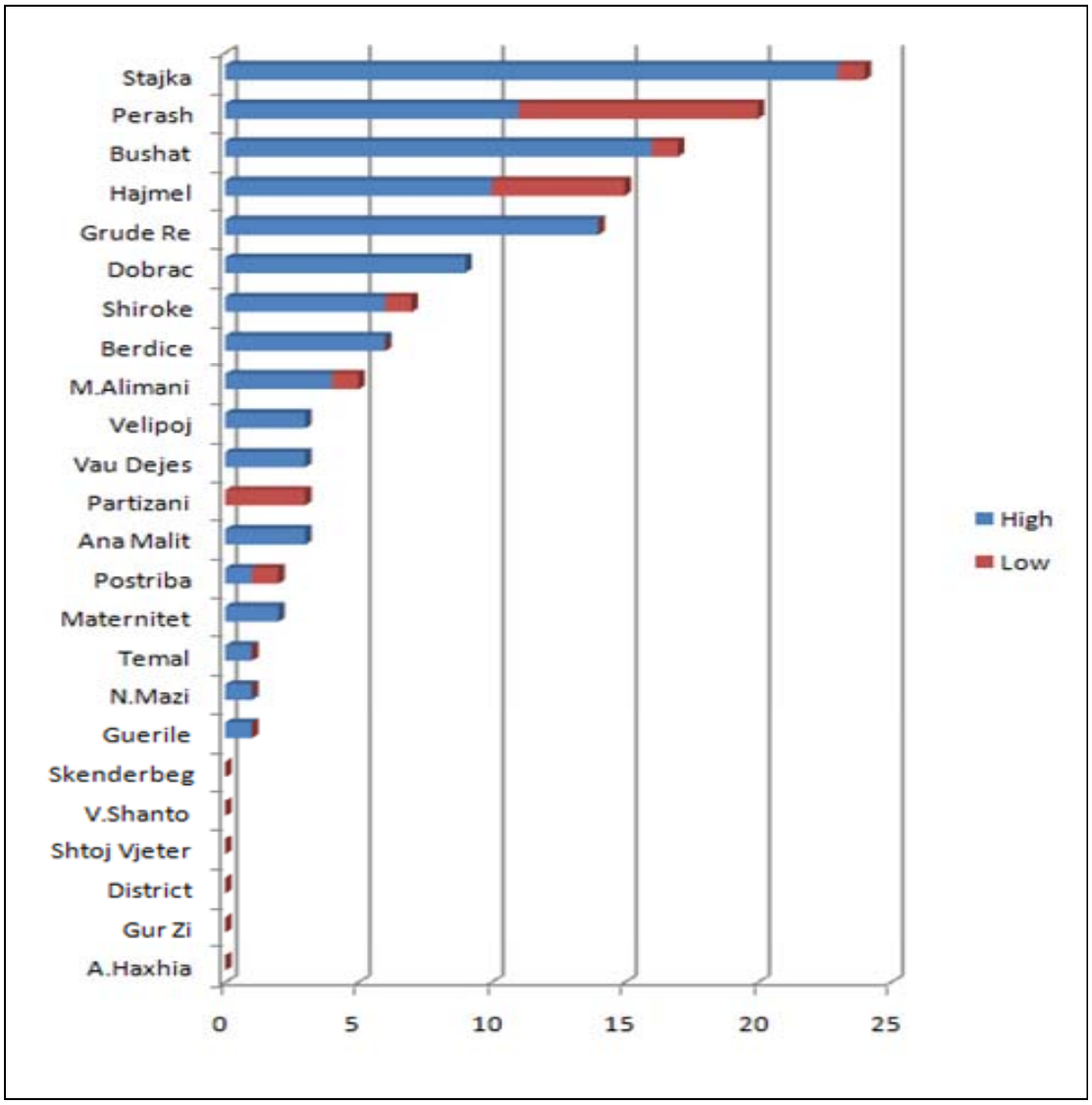
Figure 8. Alarm events by principle cause



The rest of the alarms were caused by poor management of the refrigerator (mainly the maladjustment of the thermostat (27/136 or 20 %). But they were also affected by the age of many of the refrigerators and their poor state of repair. Of the 24 refrigerators 18 were more than ten years old and should be replaced.

The distribution of alarms among the health facilities participating in the study is shown in Figure 9 and reveals a concentration of alarm events in 5 of the 24 health facilities (having more than 10 alarm events in the study period). Six facilities had no alarms at all during the study. Seventeen alarms occurred in areas affected by flooding in November and December 2010.

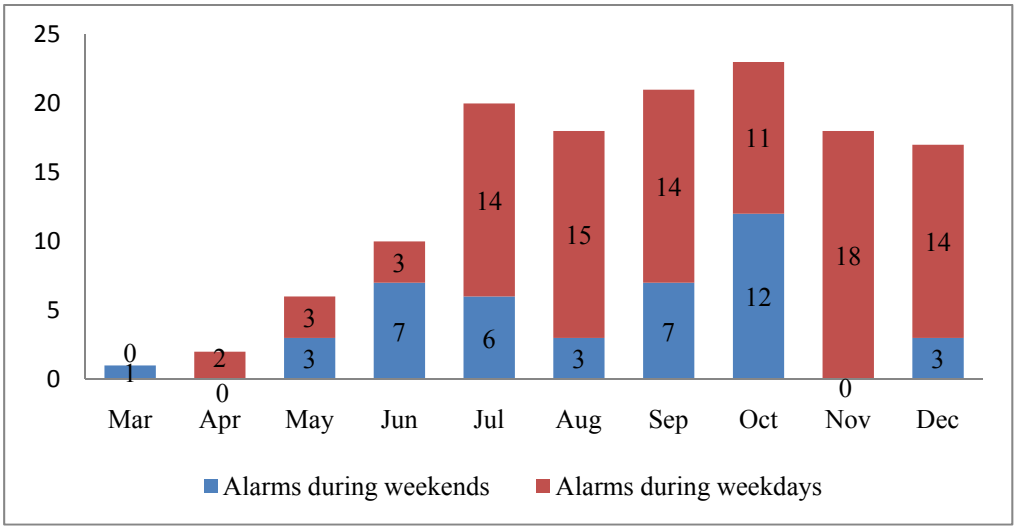
Figure 9. Distribution of alarm events among the 24 participating health facilities



Response to alarms

Figure 10 shows that 69% of alarms occurred on weekdays when staff were in the health facilities and could attend to alarms. But 31% of alarms occurred on weekends and national holidays when the facilities are often closed. The remote alarms to the cellular telephones of health workers and supervisors enabled them to respond even when facilities were closed.

Figure 10. Alarm events during weekends and holidays by month



The response rate was therefore high, 120 of 136 alarms were responded to within 24 hours (see Figure 11), and most responses were managed by storekeepers and health workers themselves without the consultation or intervention of supervisors. Figure 12 suggests that over the period of the project storekeepers and health workers resolved a growing proportion of alarms themselves although supervisors were regularly consulted by telephone (26%) and occasionally asked to intervene (15%).

Figure 11. Delay in response to alarms

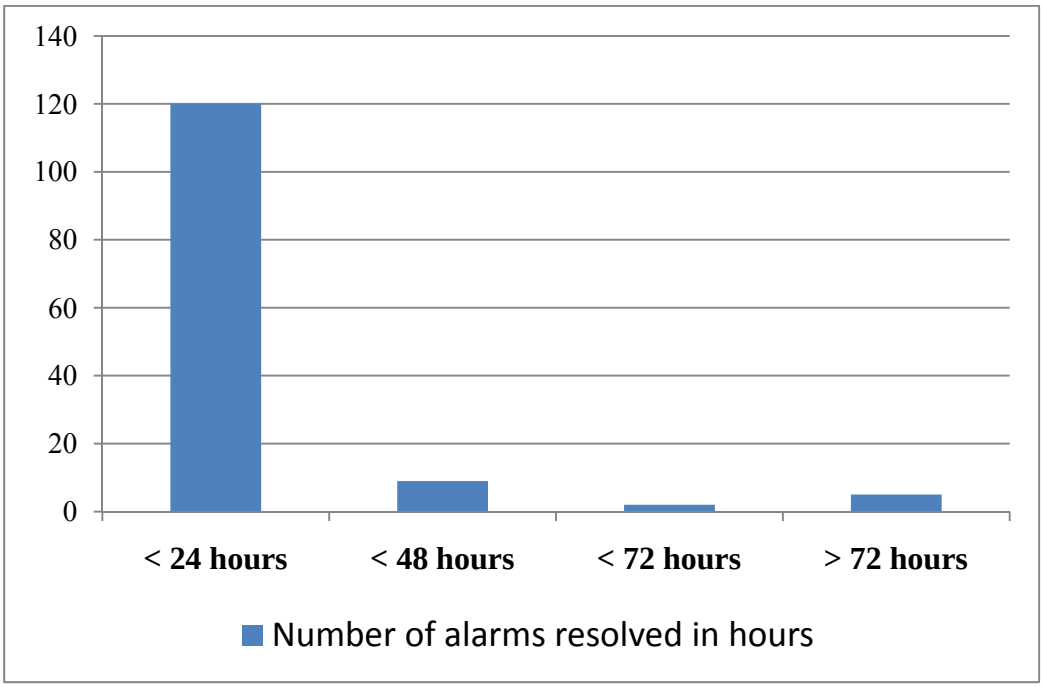
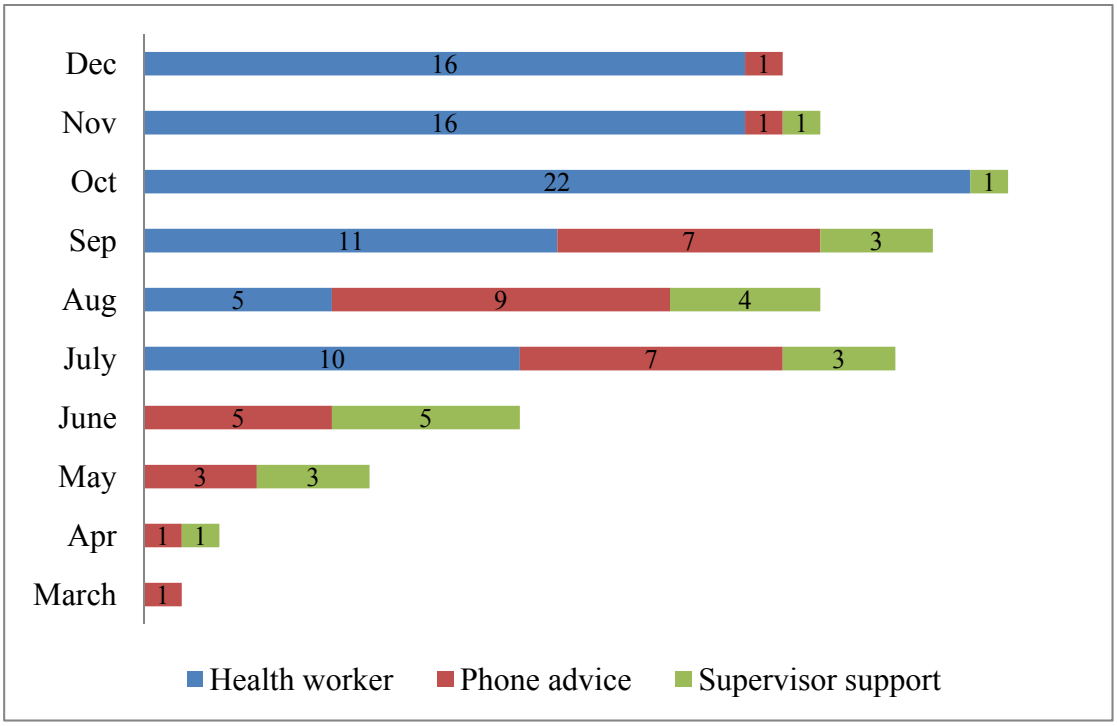
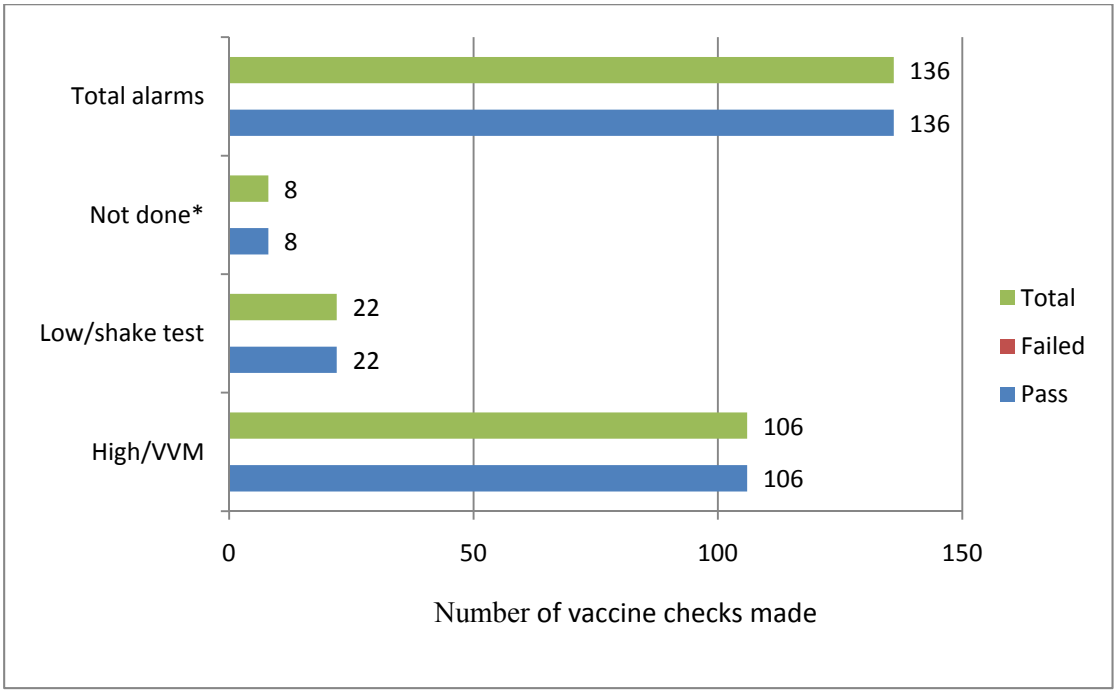


Figure 12. Response to alarms with and without supervisor consultation



According to the standard operating procedure, vaccines were checked using the "shake test" for low alarms and the VVMs for high alarms. In 100% of these tests the vaccines was cleared for use, and no damage was apparent (See Figure 13).

Figure 13. Number of tests conducted following alarm events



* No checks were made when a) the alarm was only in the Libero or b) when the vaccine had been removed from the refrigerator due to flooding.

Performance of refrigerators

The incidence of alarms indicates either equipment-management inadequacy or equipment-performance failure—or both of these. The Libero temperature logger kept a continuous record of temperatures in the refrigerators. This data and a summary report in pdf format was collected each month by the supervisor. The graphic temperature charts for the five health facilities having more than ten alarm events during the study are shown in Annex 4. The charts show that in addition to the excursions of time and temperature that triggered the alarms there were frequent smaller excursions. These smaller excursions demonstrate the instability of the refrigerator temperatures which is a feature of old or inadequate equipment.

In these five health facilities a total of 74 high and 16 low alarms occurred (excluding test alarms). One of the five facilities, Stajka experienced so many power cuts that they halted monitoring early in October and moved their vaccine elsewhere. Altogether, six old refrigerators (Bushat, Postriba, Dajc, Perash, Manush Alimani, and Partizani) have been replaced by WHO-prequalified refrigerators (See Figure 14).

Figure 14. Old (left) and new (right) refrigerators in Perash

Supervision of the study

A total of 265 monthly supervision visits were made to the 24 participating health facilities of Shkoder, approximately one each per month.

Each visit included:

- Inspection of alarm event forms.
- A discussion of current issues at the facility.
- The resolution of alarms.
- The downloading of pdf data files from the Libero logger.

During the last trimester of the study the forms were better completed, and it appeared that less alarms were due to mismanagement of the refrigerator, particularly the

thermostat adjustment. Health workers showed awareness of problems and self-confidence in resolving the problems.

Discussion

The study was conducted in facilities that were run by knowledgeable, compliant, and dedicated staff, but one cool chain weakness became quickly apparent. The domestic refrigerators used to store vaccines in most of the facilities were not able to perform well enough to store vaccines, exposing them to freezing temperatures, rapidly warming them up during power cuts, and failing to maintain stable storage temperatures when the ambient temperature changed.

Logging the temperatures and creating a monthly report, though it was not transmitted by SMS, served an important function by bringing a formal, quantified assessment of failing and inadequate refrigerators to the attention of senior managers who were empowered and motivated to arrange replacements. Six refrigerators were replaced during the study as a result of their assessments. This recording and reporting function would be an important addition to the functionality of Fridge-tag.

The SMS alarm system detected these and other problems, rapidly informing staff and supervisors. A significant proportion of alarms (31%) took place at times when staff would not have been present at the facility, but they came to attend to the alarm from their homes in 100% of these alarm events. This level of response would not be achieved by Fridge-tag alone.

Health workers and storekeepers were able to respond to alarms and take corrective action without the assistance of supervisors in more than half of the alarm events. Health workers admitted a low level of reporting of alarms in the past due to several factors.[iv] But when reporting of alarms was automated, telephone advice and personal visits were made by supervisors in 41% of the alarm events, and all alarm events were registered and displayed at the central supervision facility, enabling the situation to be continuously tracked throughout the district.

Routine temperature inspection was regularly carried out for Fridge-tag in the previous study, but the procedure has a poor record of compliance worldwide. The involvement and oversight of supervisors in the monitoring system has proved to be motivating for health workers, but the key factor could be that alarms are now reported formally by the system and, according to the server "dashboard," they have to be processed and actions have to be completed before they disappear.

The marginal managerial benefit of remote transmission of alarms and sharing of temperature data has been clearly visible during the study, though it is hard to quantify. In this case, the key question is whether the investment is worth implementation for the countries. Until a commercial version of the 30-day recorder with alarm and data transmission is available, the purchase cost will not be clear. But the recurrent cost of maintaining the communications system may be more important. In Albania, senior managers felt that if the quantity and value of vaccine stored justifies it, then it will be

[iv] Factors included insignificant vaccine quantity in the refrigerator, problems that were easily and rapidly solved, cause attributable to their own fault, and no reaction of VVMs.

introduced and sustained. So the country may be more interested in adoption at the district level with national oversight than at the health center with district oversight.

Next steps

Two commercial temperature-monitoring devices now exist that meet the WHO/PQS requirements for 30-day recorders, and others may emerge soon. The requirements do not currently include an option to add the necessary accessories for global positioning system/SMS transmission of alarms and temperature data. Whether or not the requirements are modified in this respect, the manufacturers may choose to invest in this capability and when they do, Albania will have the opportunity to purchase and install equipment.

The equipment that has been installed in Albania may be managed in the following ways:

- Fridge-tag, due to run out of battery energy in 2011 and should be replaced.
- Libero data loggers, due to run out of battery energy early 2012 and will be discarded.
- Elpro SMS transmitters have the potential to generate SMS messages from multiple channels, currently unused, and they may be relocated to act at the district level for the SMS monitoring of multiple refrigerators.
- The Shkodra central server would become a central message management device.

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Annex 1. Refrigerator inventory

Distribution of the reporting health entity and refrigerator types with respective year of installation for each health center.

No	Reporting entity name	Refrigerator type	Installation date
1	A. Haxhija	Liebherr no box	1994
2	Perashi	Liebherr no box	1994
3	N. Mazi	Vestfrost MK 074	2000
4	V. Shanto	Vestfrost MK 074	2008
5	Guerile	Vestfrost MK 074	2008
6	Skenderbeg	Vestfrost MK 074	2008
7	M. Alimani	Liebherr no box	1994
8	Partizani	Liebherr no box	1994
9	Shirok-Zogej	Liebherr no box	1994
10	Vau Dejes	Liebherr with box	1994
11	Hajmeli	Liebeherr no box	1994
12	Gur I zi	Vestfrost MK 074	2000
13	Postriba	Liebherr with box	1994
14	Stajka (ambulance)	Electrolux RE 2000EL	1992
15	Temal	MK074	2000
16	Berdic	Liebherr no box	1994
17	Ana e Malit	Liebherr with box	1994
18	Velipoj	Liebherr with box	1994
19	Bushat	Liebherr no box	1994
20	Grud Ere	Travel cooler (12 volt)	2009
21	Dobrac	Ignis	2003
22	Shtoj I Vjeter	Vestfrost MK 074	2008
23	Maternitet	Schub Lorenz	2006
24	District	Vestfrost MK 304	2000
24/1	District	Vestfrost MF 304 (freezer)	2000
24/2	District	Vestfrost MK 074	2008

Annex 2. Training standard operating procedure flowchart

Procedure for Health Facility Staff when an Alarm occurs

(Draft 25/02/2010)

Step	Action
0	An alarm is indicated by: • A 'X' on the Libero or, • An SMS sent to the health worker or, • An alarm buzzer next to the Libero that sounds
1	Press the "ARRIVED" button on the Libero for more than 3 seconds
2	Press the "TRANSIT" button on the Libero for more than 3 seconds • Alarm 'X' on the Libero changes to a tick and stops ringing
3	Check and record the date/time on a new line of the Alarms Form (Column 'A' in Figure 1)
4	Read the Fridge-tag data for the day when the SMS reached you and complete the Alarms Form: • Press 'READ' on the Fridge-tag • Record Max temp. on form column 'B' • Record How long on form column 'C' • Record an 'ALARM' or 'OK' in form column 'D' • Press 'READ' on the Fridge-tag again • Record Min temp. on form column 'F' • Record How long on form column 'G' • Record an 'ALARM' or 'OK' in form column 'H'
5	If a high ALARM or high temperature shows: • Check the status of all VVMs • If any are stage '3' or '4', discard the vials • Record the no. vials discarded in the form 'E' If a low ALARM or a low temperature shows: • Call the district supervisor and ask him/her to perform the 'Shaketest' • Together, conduct the shake test on sample vials of HepB • If no HepB vials are found to have been frozen, no need to test other vaccines • If any HepB vials are found to have been frozen, then test DTP, TT, DT & Td vaccines • If any vials fail the test, check all vials and discard failing vials • Record the no. vials discarded in the form 'I' • Record the date when you performed the shake-test 'J'
6	• Telephone the district supervisor and read to him/her last row of data in the Alarms form: discuss with him: • Whether the alarm was shown in the Libero AND the Fridge-tag OR only the Libero? • What was the probable cause of temperature exposure (see table 2)? • Is the refrigerator functioning normally again (within the range +2/+8C) now? • If the refrigerator is still not functioning, agree what action to take with the supervisor

Layout of the Alarms Registration Record

ALARMS FORM Name of facility:									
	▲High temperature				▼Low temperature				
Date/time "Arrived"	Max. temp. DegC	How long? Hrs:mins	Alarm or O.K?	No. Vials discarded VVM=3,4	Min. temp. DegC	How long? Hrs:mins	Alarm or O.K?	No. Vials discarded Shaketest	Shaketest Performed Date
A	B	C	D	E	F	G	H	I	J

Some possible causes of exposure

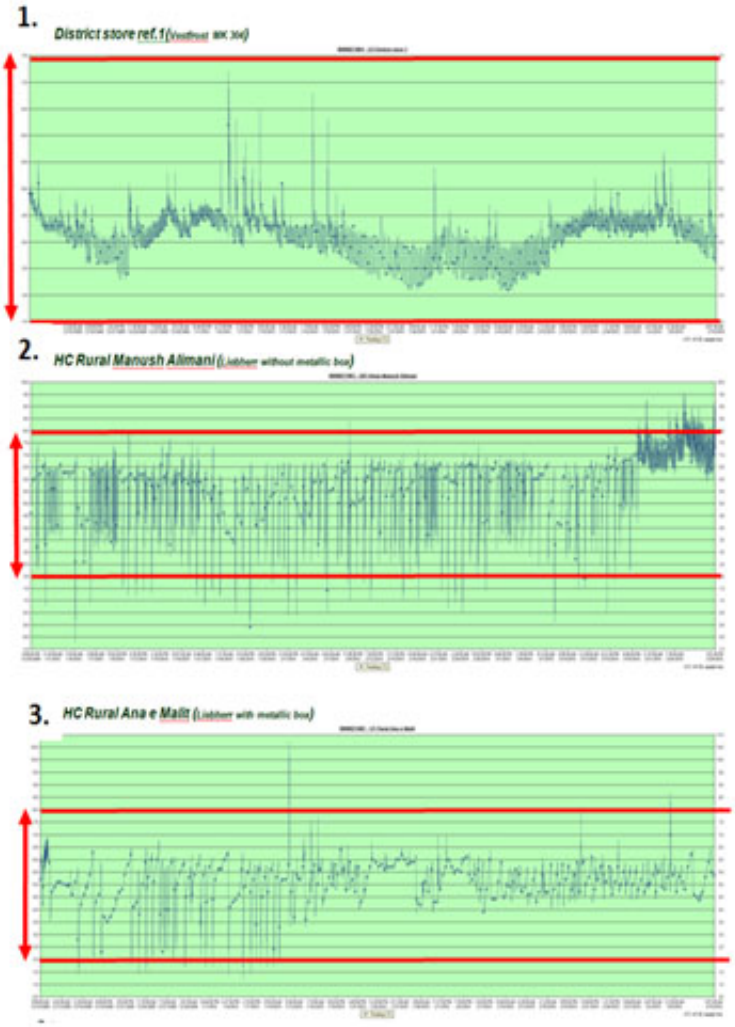
	Possible causes	Suggested actions
1	Power cut	First check how long is the cut: if long, then move vaccines into vaccine carrier with cool packs
2	Automat key down	Push key up after resolving the problem
2	Fridge not plugged in	Plug fridge in
3	Voltage too low and no stabilizer	Order stabilizer
4	Stabilizer exists, but is not working	Get stabilizer repaired
5	Too many icepacks in freezer compartment	Reduce the number of icepacks in freezer
6	Door not closed	Close the door
7	Insufficient ventilation in room	Increase ventilation
8	Fridge too close to wall	Move fridge away from wall (>15cms)
9	Fridge not cooling (evaporator plate not very cold)	Call a repair technician
10	Thermostat broken	Replace the thermostat
11	Door seal broken	Replace door seal
12	Freezing compartment door broken	Mend the door or replace it

Annex 3. Temperature control in domestic-type refrigerators compared to WHO-prequalified refrigerators

1. WHO prequalified refrigerator for vaccine storage stays well within temperature range

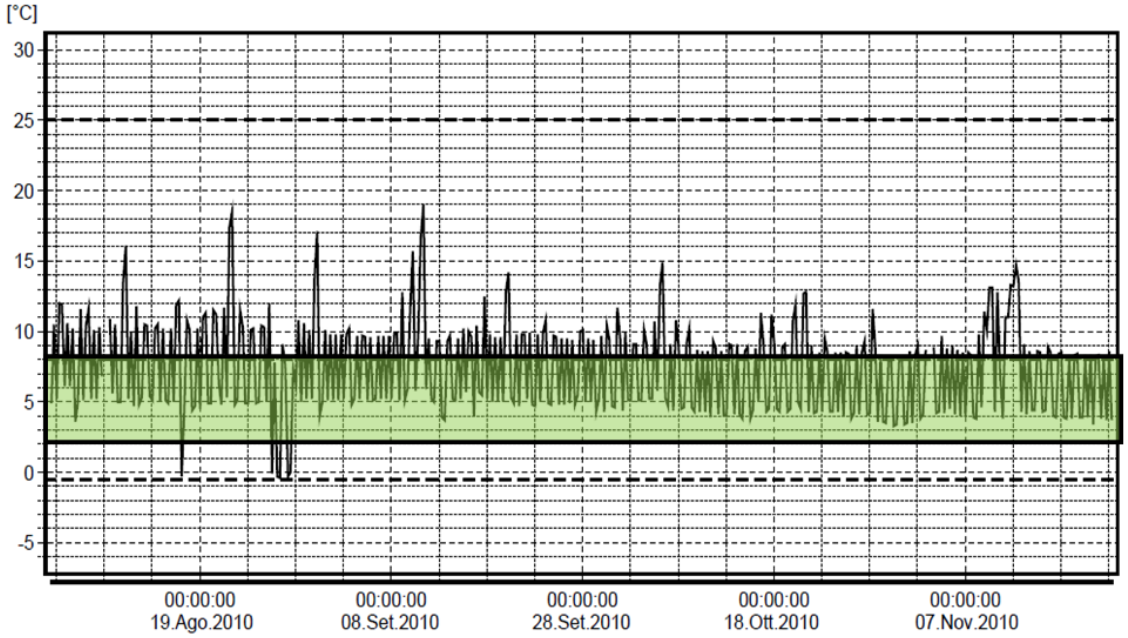
2. Domestic refrigerator without internal "vaccine box" has wide temperature range, many excursions

3. Domestic refrigerator with internal "vaccine box" shows slight improvement, but excursions remain

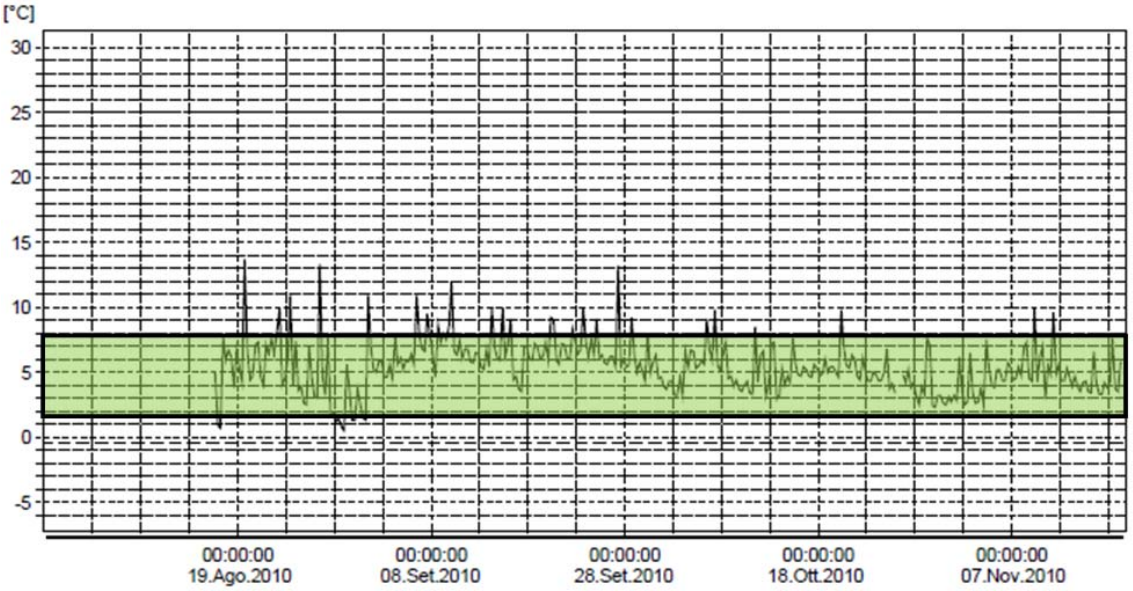


Annex 4. Temperature charts in five stores with greater than ten alarms

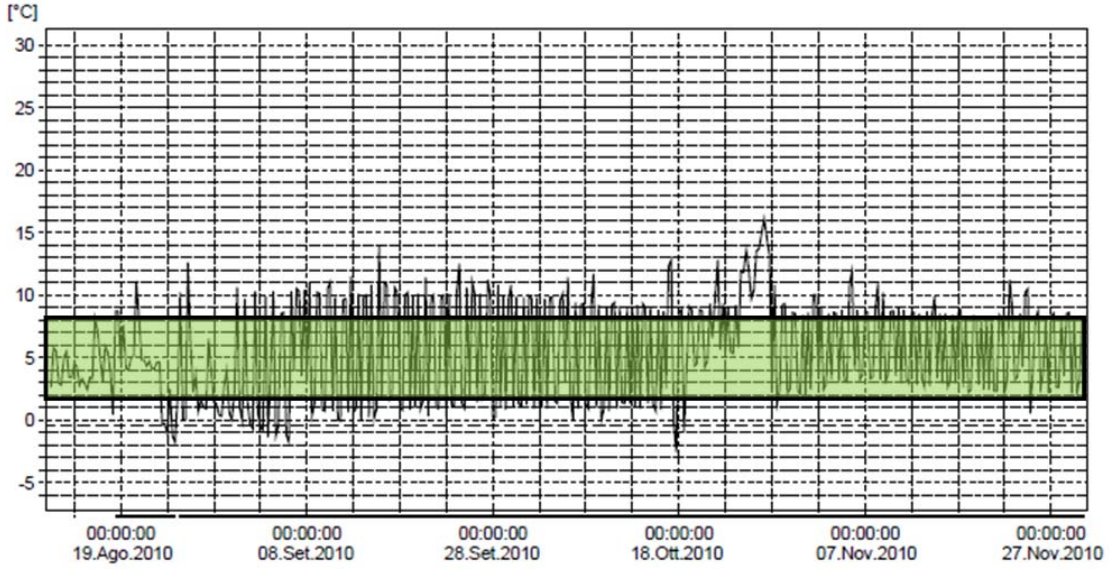
Bushat (March 24 to November 23)



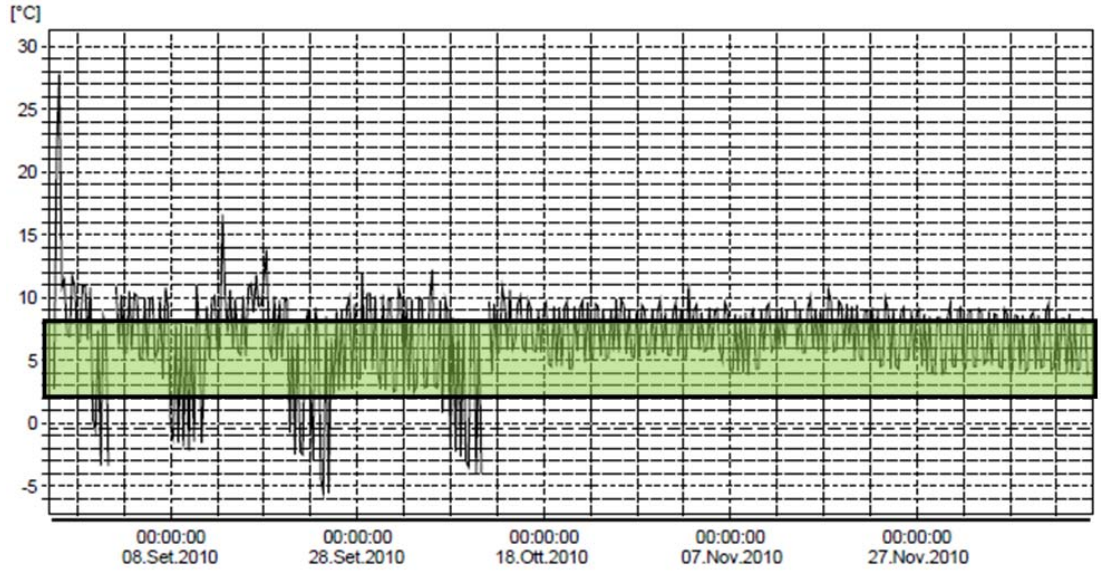
Grude Re (March 30 to November 23)



Hajmel (March 22 to November 30)



Perash (March 23 to December 15)



Stajka (March 20 to October 22)