

Moving Towards Malaria Elimination: Tools for Strengthening Malaria Surveillance in Cambodia



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Annex 1 Draft format of Malaria Bulletin (using test data)

Front cover photos of Day 0 training for VMWs at Koh Sla, Kampot, Aug 2011

Summary

Background

Prior to 2009 the main source of malaria case data in Cambodia came from the National Health Information System (HIS) which provided aggregate data at operational district (OD) level. Whilst useful for reporting total cases, this data was not sufficient to support stratification of villages based on malaria incidence. Malaria risk stratification of villages in Cambodia had been conducted on the basis of distance from the forest relying on outdated maps.

Parallel to this system and since 2004, Village Malaria Workers (VMWs) funded by the Global Fund to Fight AIDS, Tuberculosis and Malaria have also been collecting individual case data in paper form and sending it to the national programme who aggregated the data manually by district for donor reporting.

In 2009, as part of the Bill & Melinda Gates Foundation funded project to contain artemisinin resistant malaria along the Thai-Cambodia border, Malaria Consortium (MC) was tasked to provide overall monitoring and evaluation (M&E) support and technical assistance for strengthening surveillance by developing efficient, timely systems for ongoing information management and feedback.

Data requirements of the malaria programme

The following data was determined as essential for the operation of the national malaria programme as it moves towards elimination and for the containment project:

- Demographic data of all at-risk villages for planning interventions such as bed net distribution;
- Monthly malaria data at village level to identify villages with high incidence and possible transmission. Data should include all individual (sex and age) simple, severe and death cases, treatments and referrals;
- Real time data about individual patients who are still parasitemic after 3 days (an indication of drug tolerance). Patients need to be investigated to identify possible sites of transmission;
- Real time data about all Pf (and ultimately Pv) cases as the programme moves towards elimination;
- Real time data about malaria outbreaks.

Developing innovative tools for malaria surveillance

In order to provide the required data for the national programme from the variety of conditions and transmission areas that exist in Cambodia it was clear that no single tool would be able to provide the mixture of routine and real time data necessary. Furthermore given the extreme resource constraints in funding, manpower in the field, and technical capacity at central level to develop and manage systems, there needed to be an emphasis on simple, sustainable and cost effective solutions.

Through a sub-grant from WHO, Malaria Consortium provided technical assistance to develop innovative tools to improve malaria surveillance and provide national and district staff with the information they need to respond to malaria outbreaks as well as responding to individual cases as they move towards elimination.

The malaria information system (MIS)

A database to process malaria data from VMWs, health facilities and data relating to bed net distribution and management (e.g., over 1.6 million nets distributed and re-treated since 2009). The database is installed

in all 44 target operational districts (ODs). Individual case data for all patients seen by VMWs and at public health facilities is entered into a simple ACCESS database at operational district level and updates are sent by email each month and automatically applied to the national database.

The software produces a variety of reports including the “Malaria Bulletin”; a comprehensive report on malaria status in Cambodia that integrates facility level malaria data from the online HIS with the VMW and bed net data contained in the malaria information system.

The database also produces a variety of maps in Google Earth including incidence rates for all villages in Cambodia that is used for the re-stratification of villages based on incidence.

Day 3 positive alert system

The day 3 positive alert system uses SMS to identify patients still parasitemic after 3 days and alerts appropriate district officials (based on the location of the village) to take action. The system uses open source software (FrontlineSMS) to link to the MIS and Google Earth to map day 3 positive cases in order to identify hotspots of potential resistance. The system was piloted in a number of villages and health centres as part of the overall day 3 positive monitoring system that has been evaluated separately.

Day 0 alert system

The day 0 alert system uses the model piloted by the Day 3 positive system. SMS are sent by VMWs and HC staff for Day 0 cases and the software automatically alerts appropriate district officials (based on the location of the village) to take action. The system is currently operating in 4 ODs and covers 184 VMWs and 17 health centres to report all cases of Pf and features a unique threshold system that allows it to be used in elimination settings to identify individual cases and in high transmission settings to identify possible outbreaks

As the day 0 alert system will be handling much more SMS than the day 3 system the software is web based and features a partnership with Mobitel (Cambodia’s largest telecommunications company) who provide free SIM cards and free SMS making the system extremely cost effective and easy to maintain.

Malaria drug stock out monitoring system

The current system for drug stock control at health centres is not adequate to flag and manage potential stock outs of malaria drugs. The malaria stock out monitoring system is being piloted in a number of health centres to report potential stock outs of malaria drugs by SMS. Health centres report the stock levels of malaria drugs by SMS every 2 weeks or when the stock level drops below a set threshold. All participating health centres are displayed on Google Maps and are colour coded to reflect the stock levels of malaria drugs to enable national staff to reallocate resources from over-stocked facilities to under-stocked facilities.

Conclusion

The Cambodian malaria programme now has a number of tools available to it that improve routine surveillance and are decentralized to the operational district level allowing district officials to have improved access to relevant information for their operational activities. At national level the tools allow for easier production of donor and other reports and for key tasks such as risk stratification.

The success of the innovative real time (day 0 and day 3) tools will depend to a large degree on the kind of action that can be mounted in response to the alert SMS generated by these systems.

1 Malaria surveillance in Cambodia prior to 2009

1.1 Health Information System (HIS)

Prior to 2009 the main source of malaria case data in Cambodia came from the National Health Information System (HIS) which gathered health related information at health facility level which was then sent to operational district (OD) level where the data was further aggregated and forwarded to provincial and national levels. It is a monthly reporting system using standardized reporting forms. Official reporting period is from the first to the last day of each month.

Standardized reporting forms are used at different levels:

HC1 and HO2 forms: The HC1 form is used at health centres (HCs) (OPD part) and former district hospitals (FDHs) (OPD+IPD parts) whereas the HO2 form is used at referral hospitals (OPD+IPD part). Malaria data from health posts is included in the HC1 form of the respective HC or FDH.

Aggregated malaria data is reported divided into simple and severe malaria cases stratified by four different age groups (0-4 yrs, 5-14 yrs, 15-49 yrs and ≥ 50 yrs) and by gender. The IPD part also contains information about the outcome (deaths) in severe cases using the same stratification whereas the OPD part additionally reports how many cases have been referred to the hospital stratified by sex.

There is a malaria specific laboratory part on both forms with separate information on slide and dipstick diagnosis. Plasmodium species (Pf, Pv or mixed infection) of all positive cases as well as all negative test results are reported stratified by the four age groups and by sex. This information is not directly linked to the case reporting part as different sources (patient register vs. lab register) are used to fill it in.

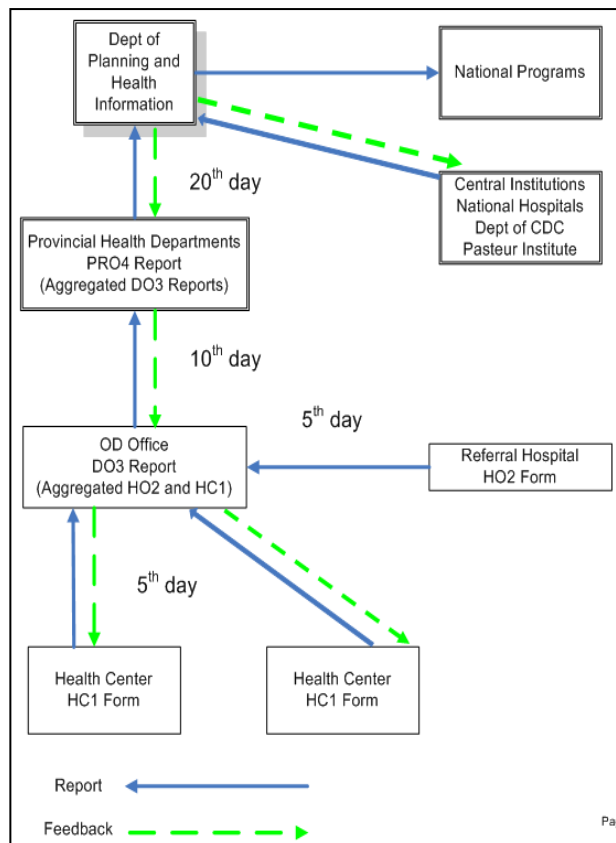


Figure 1 HIS Information Flow

In 2006 an ACCESS database was developed for use at the OD level data for the entry of HC1 and HO2. This DB was then sent to provincial and national level giving these levels direct access to facility level data for the first time. Whilst this HIS system did capture malaria cases treated through the public health facilities and was available down to health facility level the amount of time involved in collating and cleaning the data meant that it was not available to CNM until many months later so was not really useful for CNM.

As there was no reliable data flow from MOH to CNM the EPI Unit at CNM set up their own system by asking the ODs to report aggregated OD level HIS data by using a standardized excel sheet as reporting form. All malaria related information from the HIS DO3 report was entered into this excel sheet which was then directly sent to the EPI unit at CNM. As the excel sheet is not in a format which allows direct import into

statistical software programs the data has to be re-entered at CNM to allow analysis with STATA. The CNM EPI Unit exclusively works with this OD level data base using it for official presentations and reports.

Whilst useful for reporting total cases at facility level (HIS) and OD level (the CNM Epi system), data from both these systems was not sufficient to support stratification of villages based on malaria incidence and to provide the routine data needed at national and district levels to support ongoing operational activities.

1.2 Risk stratification

Malaria risk stratification of villages in Cambodia had been conducted on the basis of distance from the forest relying on outdated maps, circa 1996, which showed many areas to be forested that have subsequently been cleared. This stratification has been updated slightly using local knowledge from some of the more senior staff at CNM and in the provinces.

1.3 VMW System

Since 2004, Village Malaria Workers (VMWs) funded by the Global Fund to Fight AIDS, Tuberculosis and Malaria have also been collecting individual case data in paper form and sending it to the national programme who aggregated the data manually by district for donor reporting. The programme is located mainly in the east of country and the VMW report data on each RDT test including the name, age, sex of patient, whether testing positive for PF (only testing for PF), any treatments and whether the patient was referred.

1.4 Containment and Elimination

In 2009 a Bill & Melinda Gates Foundation funded project to contain artemisinin resistant malaria was initiated along the Thai-Cambodia border and Malaria Consortium (MC) was tasked to provide overall monitoring and evaluation (M&E) support and technical assistance for strengthening surveillance by developing efficient, timely systems for ongoing information management and feedback.

The containment project came about in response to fears that areas along the Thai-Cambodian border may be the source of artemisinin resistant malaria parasites and the project was initiated as an emergency response to this possibility. In addition to the need to strengthen routine surveillance and specifically in order to identify and react to areas of possible artemisinin resistance it is necessary to develop surveillance mechanisms that can identify, in real time, cases that are day 3 positive.

In early 2010 the Royal Government of Cambodia launched the new national strategic plan with the ambitious goal to stepwise eliminate malaria in Cambodia by 2025. Experiences from other countries have shown that for eliminating a disease the official HIS system is normally not sufficient any more to cover the data needs and the introduction of a disease specific case based surveillance system with its own data base is required. Furthermore as a country moves towards pre elimination and eventually elimination there is a need not only for case based reporting but case based reporting in real time to allow for direct response to each case as it is detected rather than waiting until the end of a particular 'reporting period'.

The need for more real time surveillance requires innovative solutions that use technologies that are appropriate to the extreme resource constraints in funding, manpower in the field, and technical capacity at central level to develop and manage systems, that exist in Cambodia. There needs to be an emphasis on simple, sustainable and cost effective solutions.

2 Communication infrastructure in Cambodia

2.1 Internet

Internet access in Cambodia has increased over the last few years and the cost has come down due to competition with 11 service providers now operating in the country ¹ yet there are currently only about 20,000² subscribers in Cambodia with some 150,000 people estimated to use Internet cafes. Internet access is available in all provinces, but the lack of a national fibre-optic cable network means that service is slow and unreliable by world standards. Outside of the major towns there is very little access to the internet using the traditional service providers.

Until recently the only way to access the internet was through the ISPs which required a land line and modem, or more recently in Phnom Penh and some provincial capitals using WiMAX (Worldwide Interoperability for Microwave Access). With the introduction of 3G mobile networks accessing the internet through a mobile phone (or 3G modem) is becoming more widespread and the mobile providers are moving quickly to extend their networks outside of Phnom Penh and the major cities. Even though today the average monthly subscription has dropped to about \$20 compared to \$100 a couple of years ago this is still high by world standards and way beyond the reach of the average Cambodian.

Most government offices at central and provincial levels have at least basic internet access but at district level the number of government offices that have internet access drops dramatically. Internet cafes are rarely seen outside of the major cities.

2.2 Telecommunications

Mobile phone penetration is surging in Cambodia with an estimated customer base of 62% of the population by 2010 according to a study in 2010.³

There are now 12 mobile operators in Cambodia with new operators launching on a regular basis. In addition the operators are setting up 3G networks (with limited but expanding coverage) which allow users to have access to the internet through their mobile phones and GSM modems albeit at a price that is way beyond the reach of the average Cambodian. The increased competition is driving down prices but the downside is that there is little cooperation and coordination between the operators and there have been instances of rival operators blocking calls between networks.

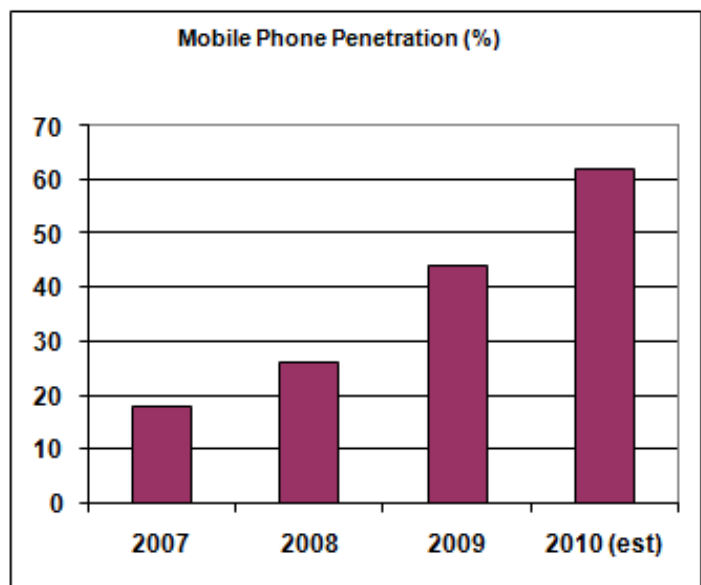


Figure 2 Mobile phone coverage in Cambodia

¹ Wikipedia

² <http://www.investincambodia.com/telecoms.htm>

³ www.companiesandmarkets.com

In terms of coverage there are no hard figures for the number of villages that have coverage but anecdotally it would seem that the coverage is good and getting better. A recent survey conducted by the National Malaria Centre in 2010 of 176 of the most remote villages in Battambang, Pursat and Pailin provinces with VMWs found that only 5 did not have coverage by at least one operator in some part of the village.

3 Improvements to routine malaria surveillance

In 2009, as part of the Bill & Melinda Gates Foundation-funded project to contain artemisinin resistant malaria along the Thai-Cambodia border, Malaria Consortium was tasked to provide overall monitoring and evaluation (M&E) support and technical assistance for strengthening surveillance by developing efficient, timely systems for ongoing information management and feedback.

An analysis of the existing data sources, infrastructure and HR capacity was undertaken at national and sub national levels as well as an analysis of the data requirements deemed as essential for the operation of the national malaria programme and the containment project which can be summarized as:

- Demographic data of all at-risk villages for planning interventions such as bed net distribution;
- Data relating to bed net distribution and treatment;
- Monthly malaria data at village level to identify villages with high incidence and possible transmission. Data should include all individual (sex and age) simple, severe and death cases, treatments and referrals;
- Village level malaria incidence rates for risk stratification of villages;
- Data relating to stock outs of essential malaria drugs and supplies;
- Real time data about individual patients who are still parasitemic after 3 days (an indication of drug tolerance). Patients need to be investigated to identify possible sites of transmission.

The following data was also identified as being required at a later stage of the programme as it moved towards elimination:

- Data relating to private sector outlets that may be used by Cambodians as an alternative to the government facilities;
- Real time data about all Pf (and ultimately Pv) cases as the programme moves towards elimination;
- Real time data about malaria outbreaks in high transmission settings.

As part of the containment project and through the Global Fund grants the number VMWs was increased through 2009 / 2010 to over 1500 thus increasing dramatically the flow of information from this programme. This increase in data from the VMWs required a better method of processing VMW data and as such it was decided that CNM needed to develop a database to process this data.

3.1 Malaria Information System (MIS)

As a result of the analysis and identification of the routine data requirements of the malaria programme the malaria information system (MIS) was developed to process malaria data from VMWs, health facilities and data relating to bed net distribution and management was developed and introduced at national level in 2009. After a short pilot period at national level the system was decentralized rapidly in 2009 / 2010 to all 44 targeted ODs.

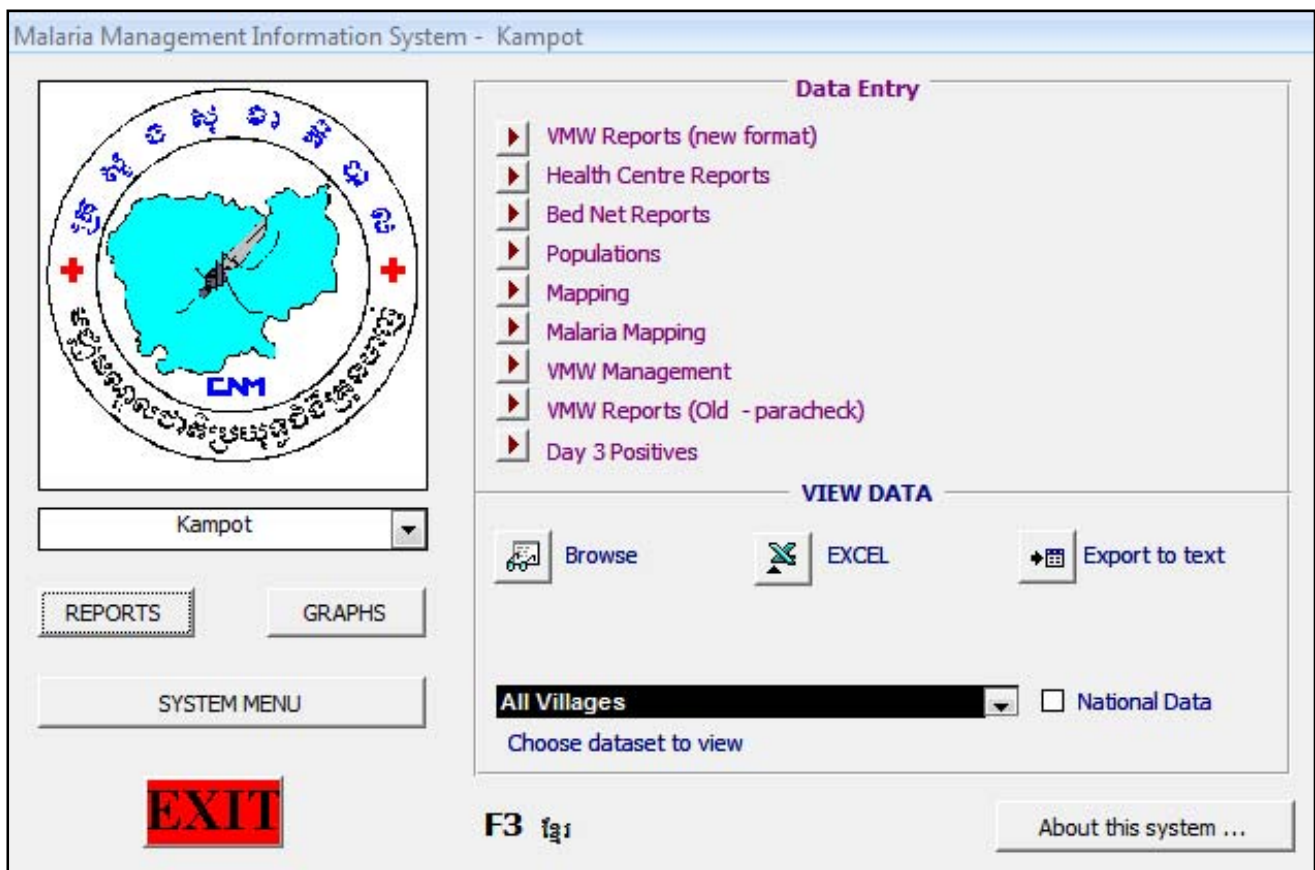
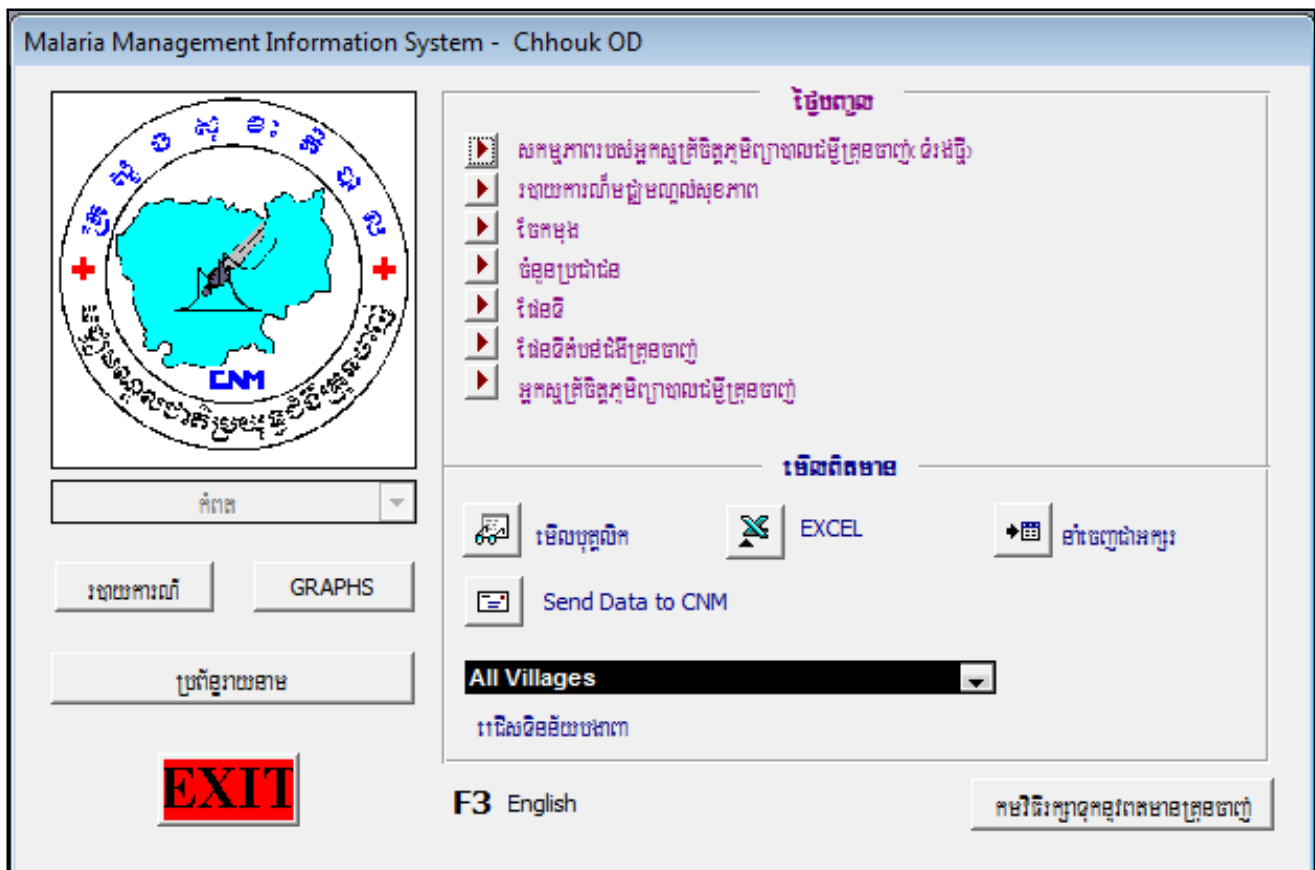


Figure 3 Main menu of the Malaria Information System (English and Khmer)

A new form was developed in a similar format to the existing VMW form to capture case data for positive patients from the existing health facility registers. Individual case data for all patients seen by VMWs and at public health facilities (using the new form) as well as bed net distribution data, demographic data about villages and data regarding the type and location of private sector outlets such a clinics and pharmacies is entered into a simple ACCESS database at operational district level. Updates are sent by email each month from each OD and automatically applied to the national database. The MIS also has comprehensive reporting, graphing of data and allows for exporting of raw data and mapping of data using Goggle Earth.

Data Entry

There are a number of data entry screens:

- All VMW test data (both positive and negative tests) using the format of the existing VMW reporting formats;
- Individual positive cases taken from health facility registers (figure 4) using the format of the newly created case reporting forms for all health facilities;
- VMW personal details such as villages age, sex, training etc;
- Village listing including location, distance from nearest facility, official census population and current estimated population and whether the village has a VMW or VHV (Village Health Volunteer);
- Health facility listing including type of facility and location;
- Type and location of private sector clinics and pharmacies;
- All day three positive cases (for validation and editing at national level only). This is linked to the day 3 positive alert system described below.

HealthCentre: Ang RorMeas		MONTHLY REPORT: 2010 / 07				No Cases <input type="checkbox"/>	Fever Cases <input type="text" value="62"/>				
Cannot edit in this screen as it was entered in the district						Total Cases <input type="text" value="13"/>	Pf <input type="text" value="13"/>	Pv <input type="text" value="0"/>	Mix <input type="text" value="0"/>	UC <input type="text" value="0"/>	
	ភូមិ	ភេទ	អាយុ	M/Y	មាន ប្រពន្ធ ចំនួនប៉ុន្មាន?	ធ្ងន់	លទ្ធផល	ទម្រង់	បញ្ជូន	ស្លាប់	
	Village	Sex	Age	M/Y	Pregnant MTHS	Severe	Result	Treatment	Referred	Dead	
▶	Trapeang Bei	M	19	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Chhuk / Takaen / Trapeang Bei
	Trapeang Bei	M	21	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Chhuk / Takaen / Trapeang Bei
	Trapeang Bei	F	26	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Chhuk / Takaen / Trapeang Bei
	Trapeang Bei	M	27	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Chhuk / Takaen / Trapeang Bei
	Kaoh Ruessei	F	21	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Chhuk / Trapeang Bei / Kaoh Ruessei
	Kaoh Ruessei	M	31	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Chhuk / Trapeang Bei / Kaoh Ruessei
	Snao Touch	M	21	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Dang Tong / Angkor Meas / Snao Touch
	Bar Knong	F	21	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Dang Tong / Angkor Meas / Bar Knong
	Baeun	M	22	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Dang Tong / L'ang / Baeun
	Damnak Ampil	M	21	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Dang Tong / L'ang / Damnak Ampil
	Damnak Ampil	M	31	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Dang Tong / L'ang / Damnak Ampil
	L'ang	M	24	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Dang Tong / L'ang / L'ang
	Damnak Trach	M	32	Y		<input type="checkbox"/>	F	A5M	<input type="checkbox"/>	<input type="checkbox"/>	Kampot / Kampot / Kandal / Damnak Trach

Figure 4 Data entry screen for individual cases from health facilities

Reporting

There are a large number of reporting options. Most reports are customizable by place (down to village level) and time and include:

- VMW test data aggregated by Village, OD, province and national;
- Health Facility positive case data aggregated by Village, OD, province and national;
- VMW personal details such as villages age, sex, training etc;
- Village listings including location, distance from nearest facility, official census population and current estimated population and whether the village has a VMW or VHV (Village Health Volunteer);
- Health facility listing including type of facility and location;
- Listing of private sector clinics and pharmacies;
- Bed net distribution by Village, OD, province and national and zone (figure 5);
- Comparison between the new online HIS (described below) and the MIS for data quality checking. The MIS is linked to the new online HIS.

Province	Villages**	Population****	HH	Survived*	LLIN	LLIHN	Conv.	Retreated
Banteay Meanchey	77 of 131 59%	64,717 of 110,829 58%	24,403	9,280	21,546	0	4,390	29,501
Battambang	243 of 331 73%	153,905 of 324,888 47%	72,446	11,978	138,359	34,849	0	3,568
Kampong Cham	113 of 427 26%	142,859 of 414,240 34%	86,960	42,375	3,822	0	55,750	40,912
Kampong Chhnan	61 of 105 58%	28,626 of 66,790 43%	14,404	6,695	905	0	14,464	6,562
Kampong Speu	219 of 271 81%	116,753 of 141,715 82%	29,000	6,986	58,990	0	9,963	40,814
Kampong Thom	136 of 261 52%	47,353 of 167,901 28%	34,657	1,927	22,000	0	23,112	314
Kampot	127 of 165 77%	122,426 of 195,257 63%	42,588	16,720	59,429	12,859	7,587	38,690
Kep	15 of 20 75%	of 36,303 45%	7,336		6,500	0	6,520	3,348
Koh Kong	89 of 143 62%	37,829 of 90,602 42%	18,594	5,165	23,887	0	4,953	3,824
Kratie	87 of 217 40%	46,300 of 182,858 25%	35,672	15,031	0	0	22,395	8,874
Mondul Kiri	17 of 148 11%	3,530 of 72,133 5%	14,417	1,045	2,042	0	0	443
Oddar Meanchey	226 of 359 63%	95,964 of 188,721 51%	39,300	14,014	37,965	0	8,465	35,520
Pailin	107 of 116 92%	66,305 of 86,937 76%	21,002	11,664	42,853	16,247	0	11,788
Preah Vihear	208 of 268 78%	99,323 of 192,407 52%	39,223	8,959	44,533	0	4,782	41,049
Pursat	52 of 120 43%	31,979 of 107,797 30%	22,930	4,880	21,720	2,442	5,070	309
Ratanak Kiri	226 of 329 69%	61,148 of 172,876 35%	32,264	35,204	0	0	8,143	17,801
Siem Reap	189 of 230 82%	98,556 of 182,816 54%	36,073	9,200	68,921	0	10,296	10,139
Sihanoukville	77 of 119 65%	67,084 of 130,011 52%	26,680	9,999	33,645	0	17,203	6,237
Stung Treng	70 of 159 44%	30,840 of 123,963 25%	23,678	11,028	2,474	441	11,413	5,925
Takeo	56 of 63 89%	28,109 of 47,806 59%	11,266	1,964	5,000		13,026	8,119
	2395 of 3982 60%	1,359,974 of 3,036,850 45%	632,893	224,114	594,591	66,838	227,532	313,737

* No of nets assumed to survive from previous years (100% for 3 years, 0% in fourth year)
 ** No. of villages that have distributed bed net for this year
 **** Population coverage this year and previous survived (based on coverage ratio 1 net per 1 persons)

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Figure 5 Bed net distribution by zone

Many of the reports can be printed both in Khmer and English

Graphing and exporting of raw data

The MIS can export data graphically in a format that can be cut and pasted into WORD or EXCEL and can export the raw data in a number of formats which can then be analyzed by statistical software.

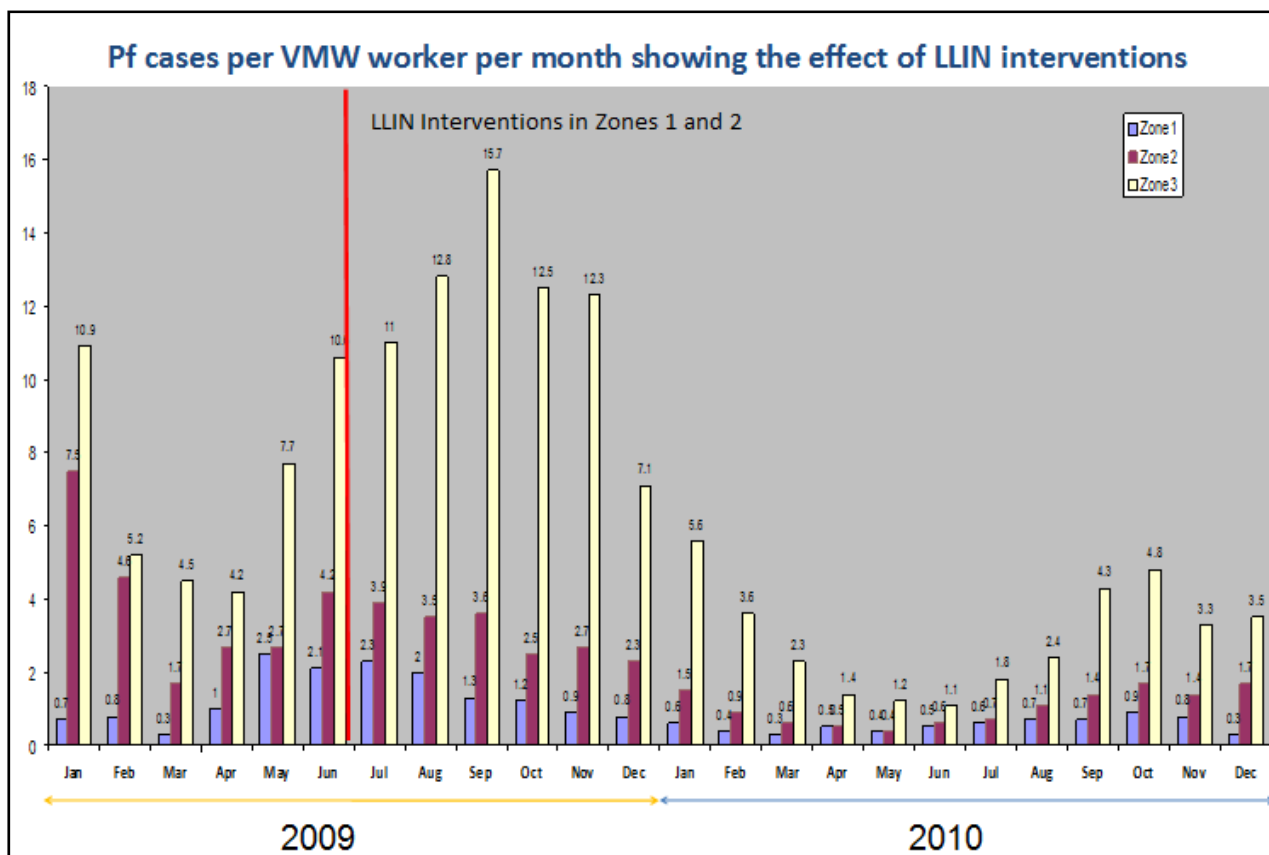


Figure 6 Example of a graph from the MIS

Mapping

All data within the MIS including village locations, health facilities and private sector outlets is geo coded and can be displayed in Google Earth. Malaria can be mapped at village level by incidence or number of cases, by species and location with the results being displayed in Google Earth. The use of Google Earth enable more people to access the maps as it does not require sophisticated software or a high level of skills although it does require internet access. Maps can also easily be emailed to other people.

The exact parameters for the re-stratification of malaria villages are not yet finalized but are expected to be based upon incidence and as such it is expected that the process can be largely automated using the MIS

Malaria Mapping

Period: 2011

Province: [Dropdown]

Operational District: [Dropdown]

Number of Cases:

- Zero: 0
- Low: > 0
- Med: >= 3
- Mod: >= 17
- High: >= 33 (Set Default)

Species: PF4PV, PF, Pv

Source: VMW + HC, VMW, HC

Map type: Incidence, Cases

Figure 7 Malaria incidence mapping in the MIS

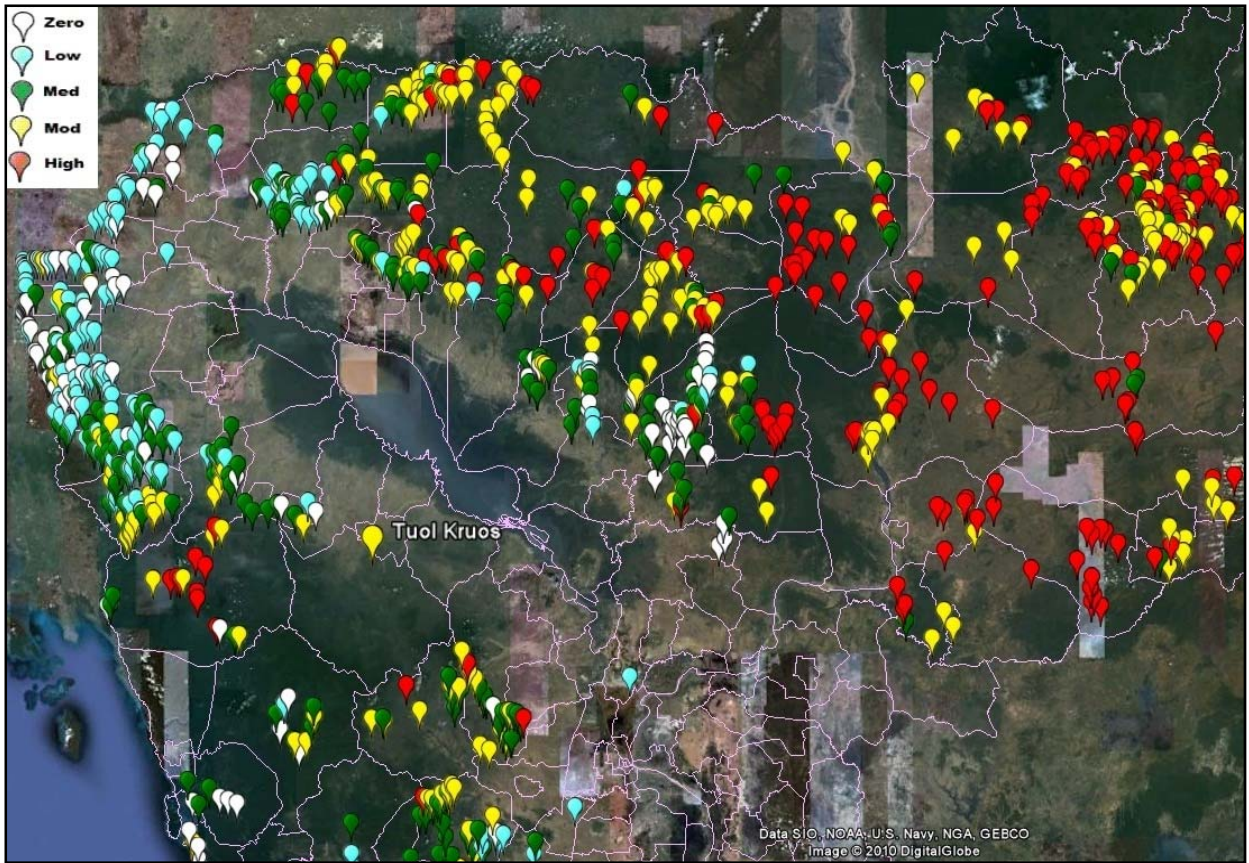


Figure 8 Mapping of malaria incidence by village with the MIS

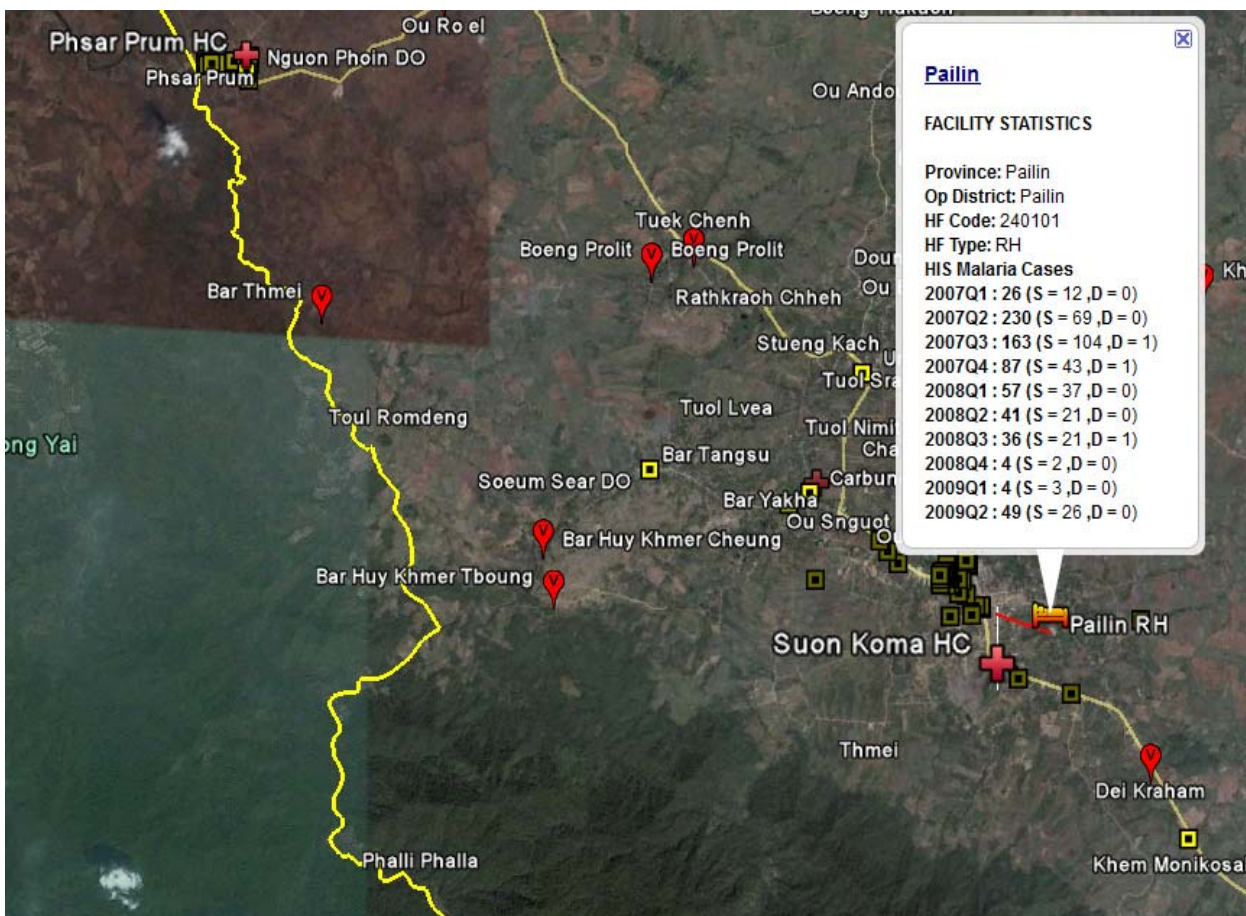


Figure 9 Mapping of health facilities using the MIS

3.2 New online HIS

Whilst not specifically initiated by the malaria programme, the HIS was moved online during 2010 and the ODs now enter the data online. This is a significant development and gives the malaria programme prompt and direct access to facility level HIS malaria data. The initial format was not user friendly enough for the programme to efficiently extract the HIS malaria data in a useful format so MC staff worked with the developers to create a mechanism for exporting the malaria data directly from the online system into the MIS. This makes it easier to combine the HIS with the MIS data (see the section below) and for the Epi unit of CNM to gain access to facility level data in format that they need. The new online system effectively removes the need for CNM staff to collect data from the ODs separately and frees them up to concentrate on data quality issues.

3.3 The malaria bulletin

The ability to link the MIS data (particularly from the VMW programme and bed net data) with the online HIS data gives us the opportunity for the first time to produce a comprehensive “Malaria Bulletin”, a 5 page report summarizing the malaria situation in Cambodia at any point in time. An example of a proposed format for this bulletin is shown in annex 1 (note that this is just a draft format and the data used is test data). The bulletin is just another report that can be produced automatically from the MIS.

4 Real time malaria data for direct action

In addition to the routine data requirements of the programme for reporting and to support operational activities the programme needs specific real time data that cannot be captured by the routine data collection tools. The containment project developed a number of innovative tools to address these requirements which are currently being piloted in parts of the country.

In developing these tools great care was taken to ensure the any tools should use the most simple technologies and be simple and easy to maintain bearing in mind the HR capacity of the programme and the need to keep the cost of maintaining any systems as low as possible. For these reasons, and in light of the fact that SMS is fast becoming the de facto standard for surveillance in resource challenged environments, it was decided to base these tools around simple SMS rather than more complicated (and expensive) internet solutions.

4.1 Day 3 positive alert system

In order to contain the spread of artemisinin resistant parasites it is essential to track the emergence of these cases in real time as they occur. As part of a larger pilot to try to identify day 3 positive cases in the community by using the VMWs to take slides at day 0 and day 3; the day 3 positive alert system was developed.

This unique system uses SMS to identify patients still parasitemic after 3 days and alerts appropriate district officials (based on the location of the village) to take action. The system uses open source software (Frontline SMS) to link to the MIS and Google Earth to map day 3 positive cases in order to identify hotspots of potential resistance. The system was piloted in a number of villages and health centres as part of the overall day 3 positive monitoring system that has been evaluated separately.

Slides from VMWs and health centres are read by health facility staff who send a simple coded SMS to the Frontline SMS software. This software links with the MIS to determine the location of the patient, using the

village code, and sends a customized SMS to the appropriate (based on the location of the village) local district malaria officer to take action. The day 3 positive cases are mapped with Google Earth to identify potential day 3 hotspots. A number of these hotspots have been followed up in the Focal Screening and Treatment (FSAT) programme described elsewhere.

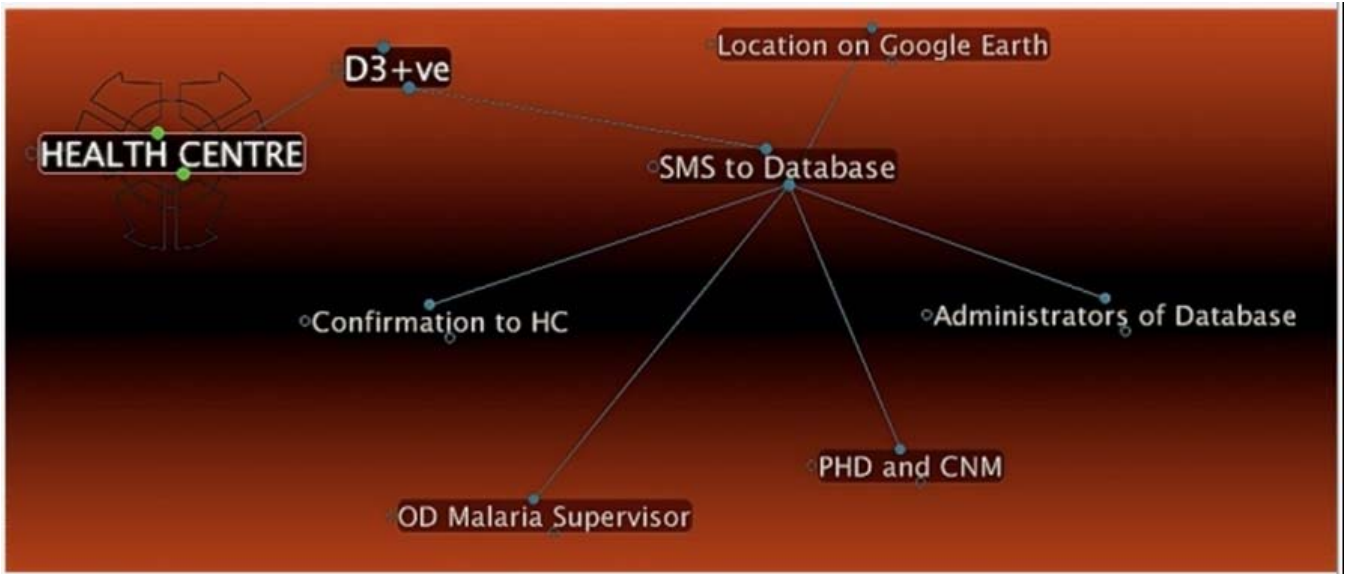


Figure 10 Data flow of day 3 positive data from a health centre Source: WHO

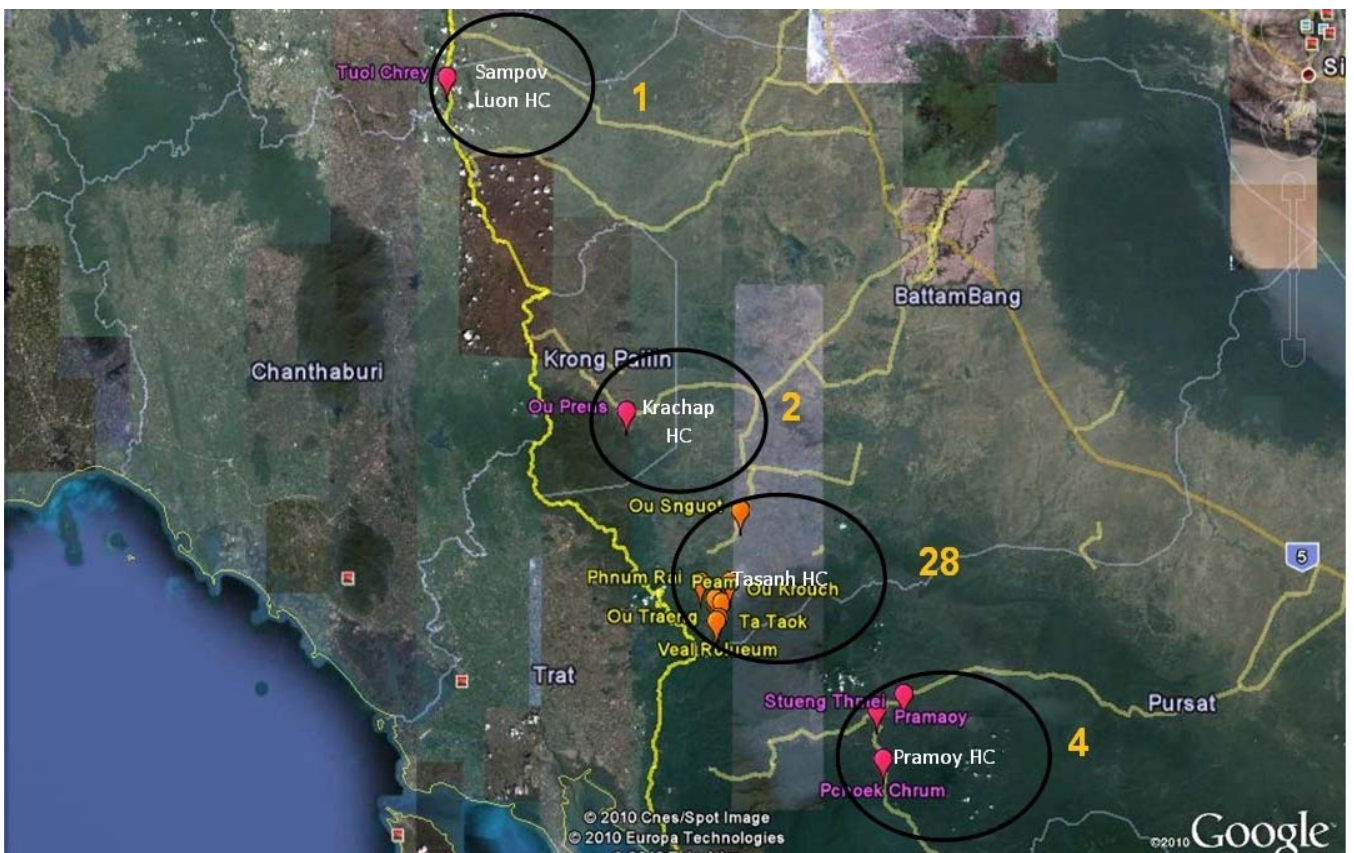


Figure 11 Mapping of day 3 positive hotspots

4.2 Day 0 alert system

As the malaria programme moves towards elimination phase there will be a need to react promptly to every PF case (and ultimately every Pv case) immediately and not wait for information to flow through the routine system. Building upon the success of the SMS model of reporting cases in the day 3 positive system it was decided to implement a pilot day 0 reporting system.

The day 0 alert system uses the model piloted by the Day 3 positive system. Simple SMS (figure 12) are sent by VMWs (4 digits) and HC staff (12 digits) for Day 0 cases and the software automatically alerts appropriate district officials (based on the location of the village) to take action. The system is currently operating in 4 ODs and covers 184 VMWs and 17 health centres to report all cases of Pf.

Species (F,M,V)	Age	Sex (F,M)	Village code for current address
_	_ _	_	_ _ _ _ _ _ _ _ _ _ _ _

Figure 12 Format of SMS sent by the health centre and VMW (VMWs do not include Village code)

As the day 0 alert system will be handling much more SMS than the day 3 system the software is web based and features a partnership with Mobitel (Cambodia’s largest telecommunications company) who provide free SIM cards and free SMS making the system extremely cost effective and easy to maintain. The software was designed by Malaria Consortium and CNM staff and was developed by InSTEDD, a Cambodia based NGO specialising in innovative surveillance solutions in the public health sector.

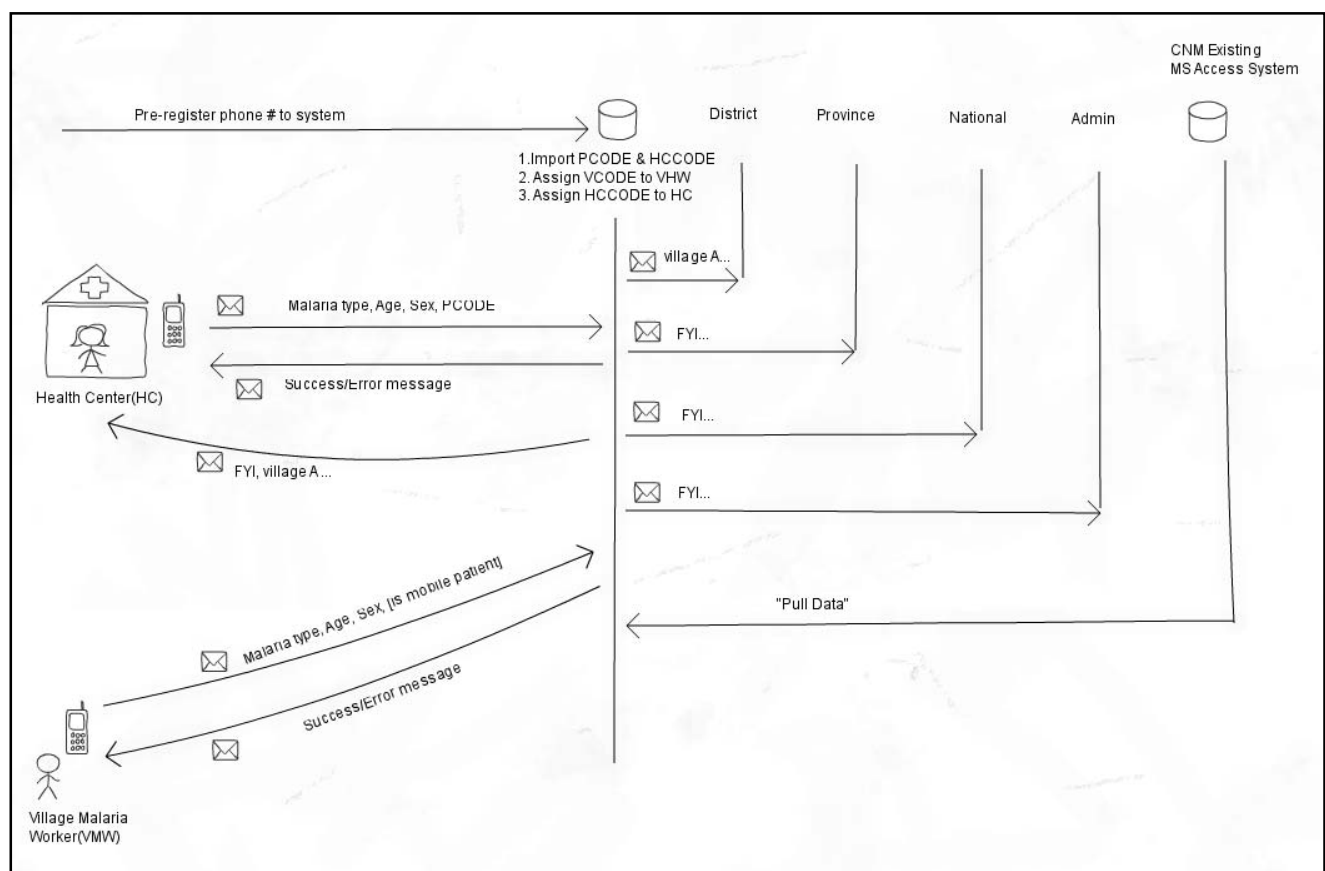


Figure 13 Day 0 reporting data flow

The system can be extensively customized in a number of ways through the web based interface (figure 14) as follows:

- Phones can use Khmer script or English and the software can send SMS to all, or defined groups of users (such as health information messages to all VMWs in a province) for free;
- Threshold alerts (at district, OD, health facility and village levels) to allow for differing alert rules to reflect different transmission settings (each case in low transmission settings, multiple cases in a defined time period for high transmission settings to detect potential outbreaks).

The screenshot shows the 'Day 0 message centre' interface. At the top, there are logos for 'malaria consortium' and 'InSTEDD'. The user is logged in as 'admin@md0.com'. The interface is divided into several sections:

- Navigation:** 'You are here: National' and a search bar.
- Filters:** 'All messages', 'Error messages', 'Last error message per sender per day', 'Duplicated me'.
- Provinces:** A list of provinces including Banteay Meanchey, Battambang, Kampong Cham, Kampong Chhnang, Kampong Speu, Kampong Thom, Kampot, Kep, Koh Kong, Kratie, Mondul Kiri, Oddar Meanchey, Paln, Preah Vihear, Pursat, Ratanak Kiri, Siem Reap, Sihanoukville, Stung Treng, and Takeo.
- Users:** A list of user groups: Province users (0), OD users (5), HealthCenter users (8), and Village users (191).
- Message List:** A table displaying 1477 messages. The table has columns for Date, Sender, Sender number, Text, Type, Age, Sex, Mobile?, Reported at, Health Center, and Village. The messages are sorted by time, with the most recent at the top.
- Actions:** A 'Send SMS' button at the bottom.

Figure 14 Day 0 message centre

SMS messaging can be extensively customized using a series of templates and can be sent in Khmer to phones that support Khmer fonts

The screenshot shows the 'setting message templates' interface. It displays two templates for individual case reports:

- Template for individual case report from a village malaria worker:**

```
នៅភូមិ{village}បានរកឃើញមេរោគគ្រុនចាញ់ប្រភេទ{malaria_type}ភេទ{sex}អាយុ{age}។សំរាប់ព័ត៌មានលម្អិតសូមទាក់ទងទូរស័ព្ទលេខ{contact_number}
```
- Template for individual case report from a health center:**

```
{health_center} Health facility has reported a case of {malaria_type} malaria from {village} village Sex: {sex}, Age:{age}, contact {contact_number}
```

Both templates include a 'Parameters:' section listing the variables used in the template: {test_result}, {malaria_type}, {sex}, {age}, {village}, {contact_number}, and {health_center}.

Figure 15 setting message templates using web interface

The system features web based mapping of day 0 cases using Google Maps, user can drill down through the levels to reach a map displaying cases at village level.

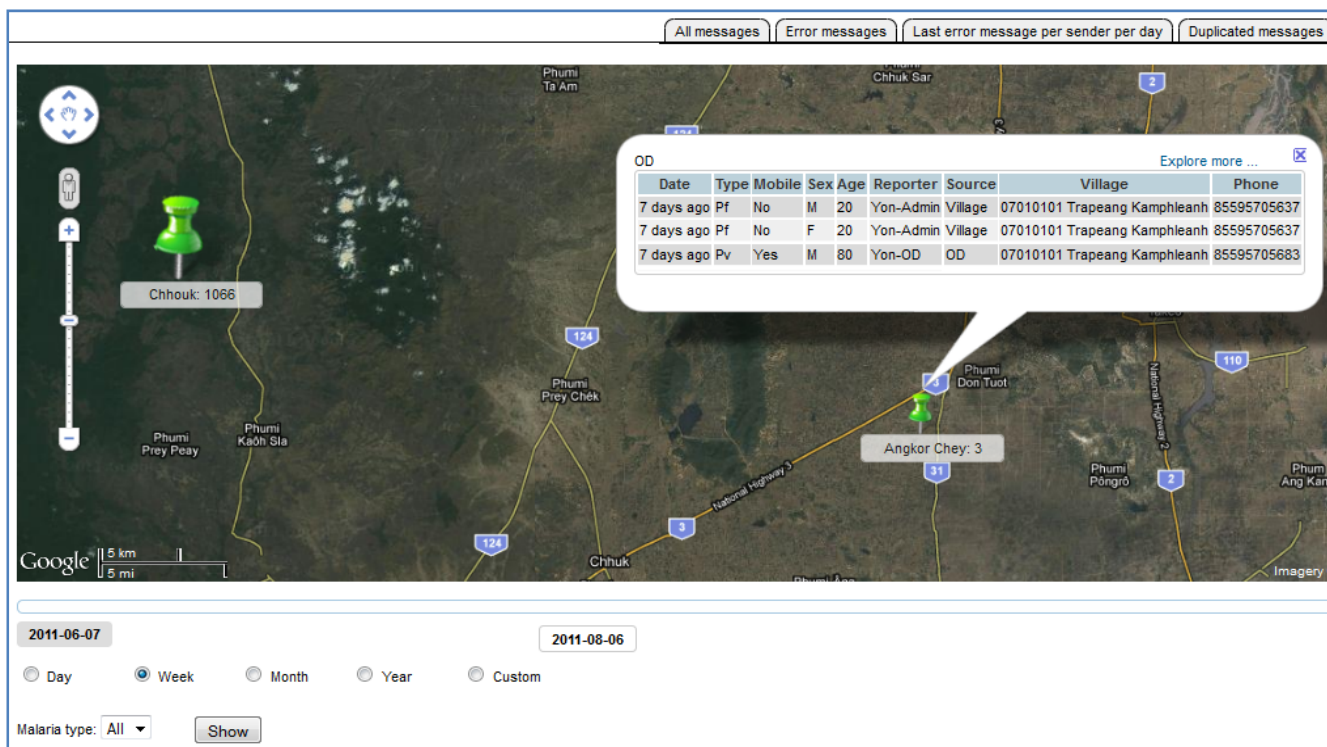


Figure 16 Mapping of day 0 cases

As the system is much simpler and easier to implement than the Day 3 system, mainly because the VMWs don't have to take slides, it would be very easy to scale up (at approximately \$100 per user for equipment) and Mobitel have committed to supply all VMWs and health facilities with free SIM cards and SMS.

The equipment required for the day 0 system is very basic and consists of:

- Simple mobile phone ;
- Instructions for phone use and how to send an SMS;
- Log book for the user to records SMS sent;
- Reminder cards for VMW and HC staff how to format and send the SMS;
- Solar charger (not essential).

Ongoing costs are minimal and include the hosting of the website (currently \$35 a month).



Figure 17 Equipment required for Day 0 system

As there are some villages without Mobitel coverage and some users may choose to use their own SIM cards it is important to explore similar deals with other large telecommunications companies in Cambodia.

4.3 Malaria drug stock out monitoring system

The current system for drug stock control run by the Ministry of Health at health centres is not adequate to flag and manage potential stock outs of malaria drugs as it reports only monthly and CNM to not have adequate and timely access to this system.

The malaria stock out monitoring system is being piloted in a number of health centres to report potential stock outs of malaria drugs by SMS. Health centres report the stock levels of malaria drugs by SMS every 2 weeks or when the stock level drops below a set threshold (figure 18). All participating health centres are displayed on Google Maps and are colour coded to reflect the stock levels of malaria drugs to enable national staff to reallocate resources from over-stocked facilities to under-stocked facilities.

The system is based on a freely available open source called Dynamic Resource Mapper software (<http://resourcemap.instedd.org/app>) developed by InSTEDD⁴ in cooperation with CNM and MC staff.

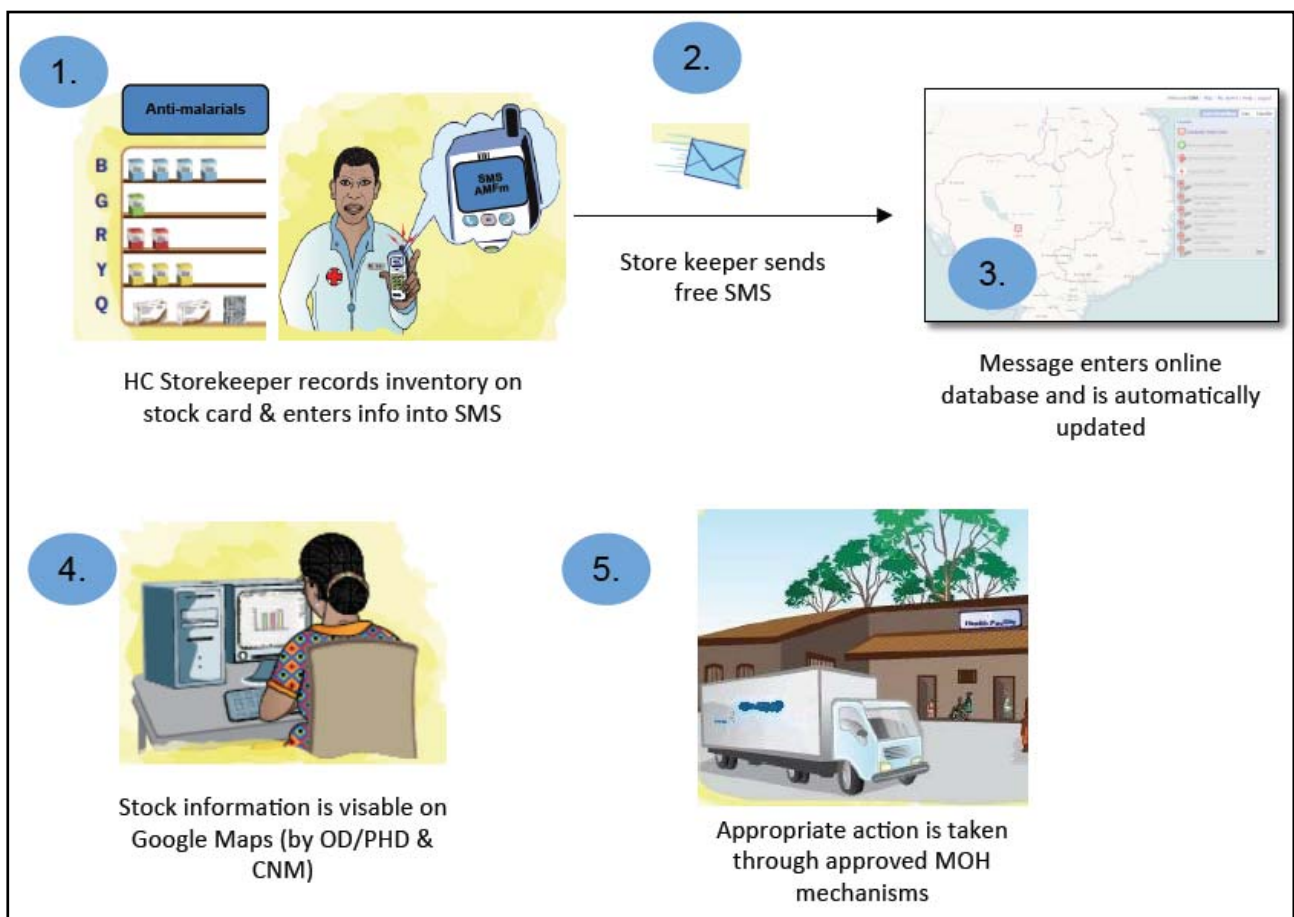


Figure 18 Stock out system information flow (data flow chart adapted from SMS For Life documentation)

⁴ www.instedd.org

ANNEX 1 - CAMBODIA MALARIA BULLETIN (draft format using test data)

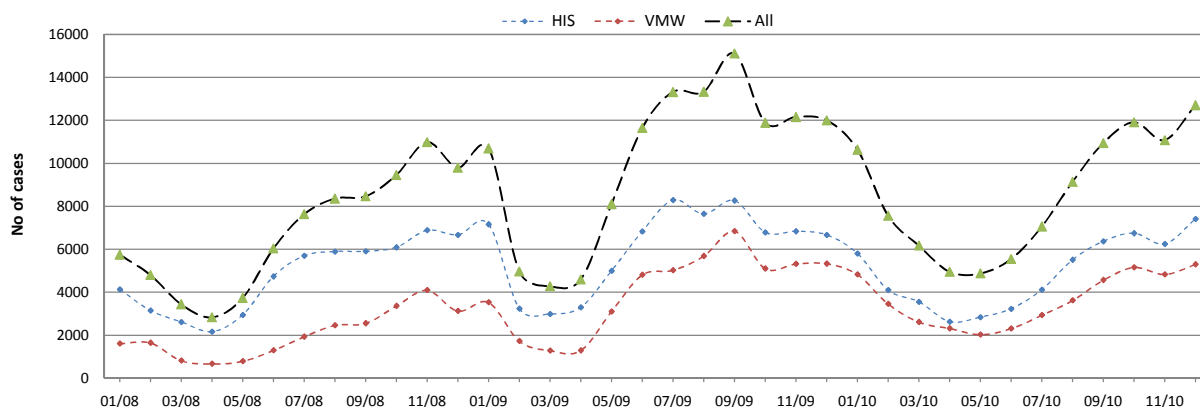
DECEMBER 2010 BULLETIN, DATA TO 4TH QUARTER, CNM, CAMBODIA

Estimated coverage (possession) with LLIN or retreated bed net	
No. of persons at risk of malaria (pop of target villages)	2,991,198
No. of LLIN distributed YTD	217,351
No. of nets retreated YTD	22,252
No. of LLIN distributed in previous 3 years	1,033,177
No. of nets retreated in last 12 months	22,252
Estimated coverage with LLIN / treated net (1 net / 2 pers)	71%

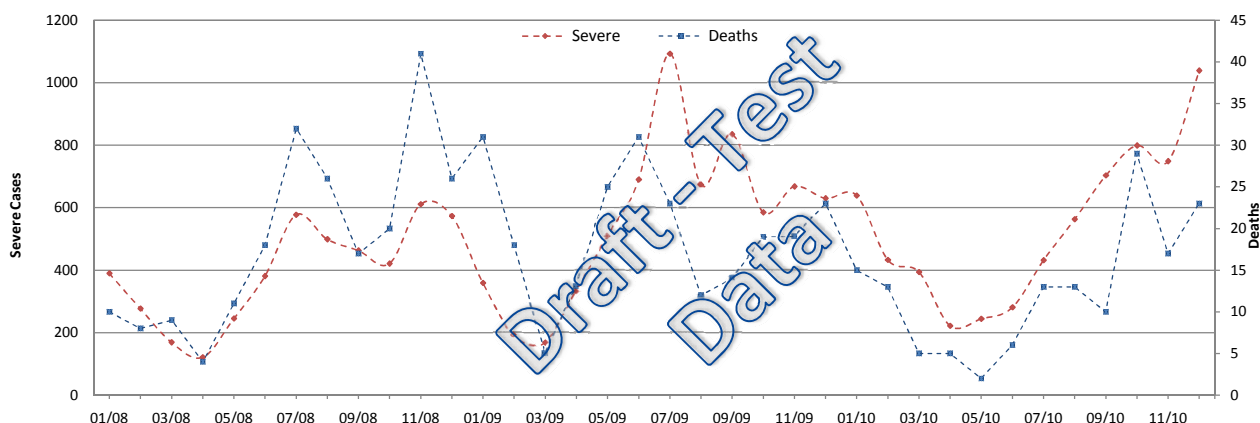
Indicators	HIS			VMW			Total		
	2009	2010	Change	2009	2010	Change	2009	2010	Change
Total malaria cases	73,079	58,621	-20%	48,838	44,364	-11%	121,917	102,985	-16%
Severe malaria cases	6,731	6,498	-3%				6,731	6,498	-3%
Malaria deaths	233	151	-35%				233	151	-35%
Test positivity rate				44%	36%	-19%	44%	36%	-19%

TRENDS IN SURVEILLANCE

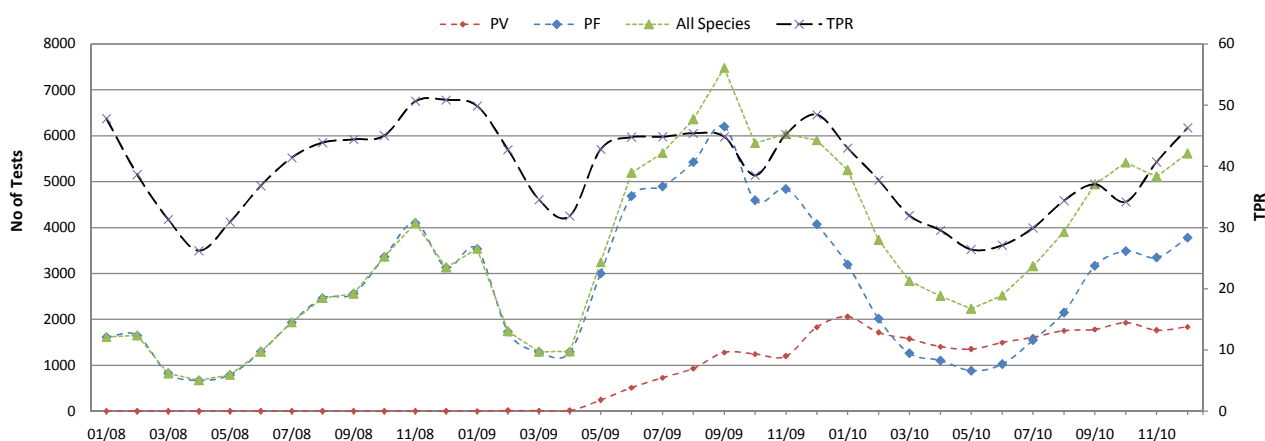
Treated malaria cases from HIS and VMW by month



Severe malaria cases and deaths from HIS by month



VMW test results by month

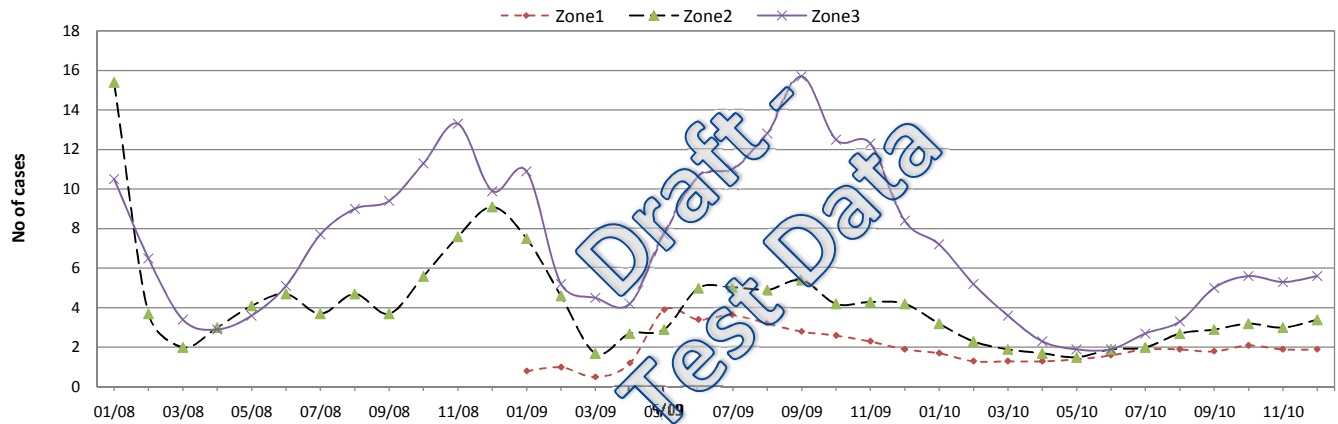


CONTAINMENT INDICATORS

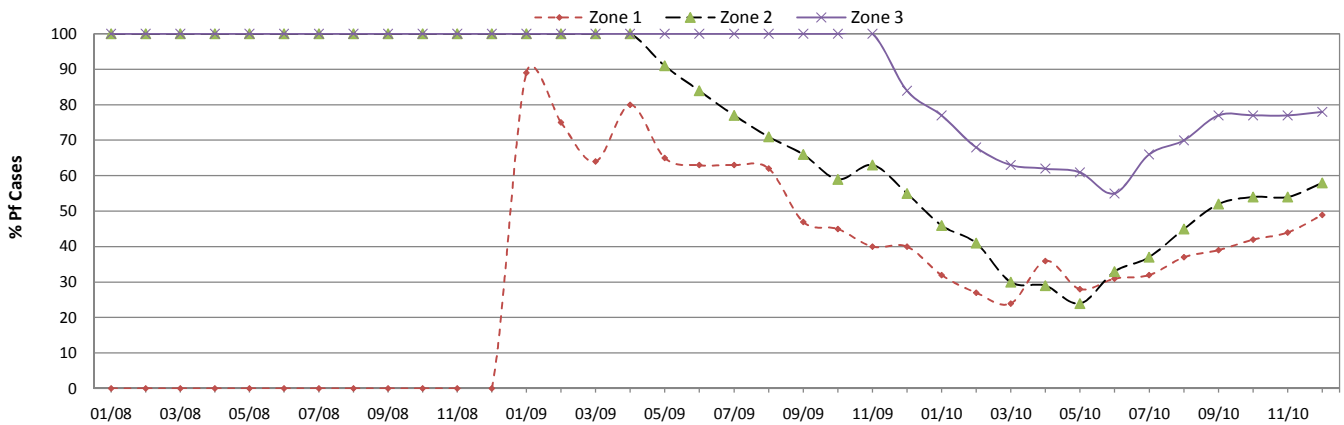
Estimated coverage (possession) with LLIN or retreated bed net					VMW RDT tests						
Indicators	Zone 1	Zone 2	Zone 3	All Zones	Zone	TPR			%Pf		
						2009	2010	Change	2009	2010	Change
No. of persons at risk of malaria (pop of target villages)	365,987	1,224,775	1,400,436	2,991,198	Zone 1	34%	30%	-11%	54%	36%	-34%
No. of LLIN distributed YTD	130	62,946	154,275	217,351		Zone 2	40%	32%	-21%	71%	45%
No. of nets retreated YTD	0	4,705	17,547	22,252	Zone 3		49%	41%	-16%	98%	72%
No. of LLIN distributed in previous 3 years	215,070	473,000	345,107	1,033,177							
No. of nets retreated in last 12 months	0	4,705	17,547	22,252							
Estimated coverage with LLIN / treated net (1 net / 2 pers)	118%	78%	52%	71%							

National Surveillance data for the period Jan - Dec												
Indicators	HIS treated cases			VMW treated cases			Total treated cases			Incidence (per 1000 pop)		
	2009	2010	Change	2009	2010	Change	2009	2010	Change	2009	2010	Change
Z1 Total malaria cases	4,979	5,338	7%	3,197	4,706	47%	8,176	10,044	23%	22.34	27.44	23%
Z1 Severe malaria cases	758	327	-57%				758	327	-57%	2.07	0.89	-57%
Z1 Malaria deaths	7	4	-43%				7	4	-43%	0.02	0.01	-43%
Z2 Total malaria cases	25,360	17,443	-31%	15,803	16,274	3%	41,163	33,717	-18%	33.61	27.53	-18%
Z2 Severe malaria cases	1,547	1,628	5%				1,547	1,628	5%	1.26	1.33	5%
Z2 Malaria deaths	62	33	-47%				62	33	-47%	0.05	0.03	-47%
Z3 Total malaria cases	30,438	25,984	-15%	29,838	22,872	-23%	60,276	48,856	-19%	43.04	34.89	-19%
Z3 Severe malaria cases	3,697	3,339	-10%				3,697	3,339	-10%	2.64	2.38	-10%
Z3 Malaria deaths	149	96	-36%				149	96	-36%	0.11	0.07	-36%
Z4 Total malaria cases	12,302	9,856	-20%	0	2	200%	12,302	9,858	-20%	n/a	n/a	n/a
Z4 Severe malaria cases	729	1,204	65%				729	1,204	65%	n/a	n/a	n/a
Z4 Malaria deaths	15	18	20%				15	18	20%	n/a	n/a	n/a

Malaria Cases per VMW by month



Percentage of Pf cases diagnosed by VMW per month



Surveillance Data by District, Jan-Dec 2010

Province / Op. District	Population (x1000)		Health Facility (HIS)									Village Malaria Workers															Incidence (per 1000 pop)							
			All Cases			Severe			Deaths			All Cases			Treated Pf			Treated Pv			Referred Pf			Referred Pv			TPR							
			2009	2010	Change	2009	2010	Change	2009	##	Change	2009	2010	Change	2009	2010	Change	2009	2010	Change	2009	2010	Change	2009	2010	Change	2009	2010	Change	2009	2010	Change		
Kralanh	82	83	521	601	15%	17	16	-6%	1	1	0%	275	767	179%	146	375	157%	6	29	383%	13	7	-46%	110	356	224%	13%	17%	29%	8.20	12.05	47%		
Siem Reap	341	346	2800	1488	-47%	289	126	-56%	40	13	-68%	1494	1270	-15%	806	554	-31%	159	193	21%	19	37	95%	510	486	-5%	48%	35%	-28%	11.04	6.45	-42%		
Sot Nikum	257	261	3256	1318	-60%	305	113	-63%	7	0	-100%	1779	1171	-34%	1730	747	-57%	43	393	814%	6	0	-100%	0	31	3100%	41%	42%	2%	19.59	9.43	-52%		
Ankor Chhum	195	198	1840	2099	14%	1	62	6100%	0	0	0%	1539	1019	-34%	973	410	-58%	142	32	-77%	77	58	-25%	347	519	50%	43%	26%	-40%	15.18	12.86	-15%		
Siem Reap	910	924	8417	5506	-35%	612	317	-48%	48	14	-71%	5087	4227	-17%	3655	2086	-43%	350	647	85%	115	102	-11%	967	1392	44%	39%	29%	-27%	13.65	8.91	-35%		
Sihanouk	223	226	199	380	91%	21	22	5%	2	5	150%	93	159	71%	91	85	-7%	2	72	3500%	0	1	100%	0	1	100%	31%	49%	57%	1.31	2.37	81%		
Sihanoukville	225	228	199	380	91%	21	22	5%	2	5	150%	93	159	71%	91	85	-7%	2	72	3500%	0	1	100%	0	1	100%	31%	49%	57%	1.30	2.35	81%		
Steung Treng	112.69	114.42	2737	1669	-39%	224	120	-46%	13	6	-54%	6230	4167	-33%	6135	2925	-52%	81	1225	1412%	12	4	-67%	2	13	550%	48%	42%	-13%	79.45	50.86	-36%		
Stung Treng	113.39	115.14	2737	1669	-39%	224	120	-46%	13	6	-54%	6230	4167	-33%	6135	2925	-52%	81	1225	1412%	12	4	-67%	2	13	550%	48%	42%	-13%	78.96	50.54	-36%		
Chi Phu	0.00	0.00	52	29	-44%	0	4	400%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0%		
Romeas Hek	0.00	0.00	104	84	-19%	43	36	-16%	1	0	-100%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0%		
Svay Rieng	0.00	0.00	40	61	53%	10	30	200%	2	2	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0%		
Svay Rieng	490.22	497.77	196	174	-11%	53	70	32%	3	2	-33%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0.40	0.35	-13%
Ang Rokar	117.44	119.25	665	671	1%	57	46	-19%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0%		
Bati	184.68	187.53	48	30	-38%	1	1	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0%		
Daun Keo	187.24	190.12	177	102	-42%	52	23	-56%	5	2	-60%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0%		
Kirivong	229.78	233.32	185	130	-30%	17	9	-47%	1	0	-100%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0%		
Prey Kabass	138.61	140.74	130	50	-62%	32	0	-100%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0%		
Takeo	857.92	871.13	1205	983	-18%	159	79	-50%	6	2	-67%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	1.40	1.13	-20%
Samraong	187.24	190.12	7777	3363	-57%	24	247	929%	1	2	100%	4801	5541	15%	2314	1102	-52%	1197	4153	247%	182	91	-50%	1108	195	-82%	48%	38%	-21%	60.29	45.33	-25%		
Oddar Meanchey	188.68	191.59	7777	3363	-57%	24	247	929%	1	2	100%	4801	5541	15%	2314	1102	-52%	1197	4153	247%	182	91	-50%	1108	195	-82%	48%	38%	-21%	59.83	44.98	-25%		
Kep	36.30	36.86	130	145	12%	20	26	30%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	0%	0%		
Kep	36.30	36.86	130	145	12%	20	26	30%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0%	0%	0%	0%	3.58	3.93	10%	
Pailin	71.46	72.56	515	575	12%	43	11	-74%	0	0	0%	769	560	-27%	473	99	-79%	244	425	74%	48	29	-40%	4	7	75%	26%	29%	10%	17.24	15.15	-12%		
Pailin	71.57	72.67	515	575	12%	43	11	-74%	0	0	0%	769	560	-27%	473	99	-79%	244	425	74%	48	29	-40%	4	7	75%	26%	29%	10%	17.21	15.12	-12%		
National Total	13601.96	#####	73079	58621	-20%	6731	6498	-3%	233	151	-35%	53568	47683	-11%	44751	26446	-41%	4087	17918	338%	824	628	-24%	3906	2691	-31%	44%	36%	-19%	8.96	7.46	-17%		