Report on work towards a village-based malaria stratification system for Cambodia

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1. Introduction

This report provides details of work carried In May and June 2012 towards the development of an updated national stratification system for Cambodia based on observed malaria incidence.

This work has primarily involved developing suitable data analysis approaches that can combine data from a range of sources to produce viable village-level estimates of malaria incidence. In developing these approaches it has been possible to show that existing sources of information (specifically as reported by the Malaria Database (MDB) system, as well as the VMW network) provide suitable data for stratification. In addition, the spatial coverage of these systems is appropriate for developing products at the national level.

Based on inclusion/exclusion criteria defined in this document it is currently possible to derive specific incidence rates (for 2011) for 80% of villages across the current area of interest. Efforts to develop suitable approaches for estimating incidence in the "missing" 20% are ongoing; initial activities and plans for further analysis in the remainder of 2012 are documented here.

2. Spatial coverage of the malaria database (MDB)

The malaria database (MDB) has been installed in 44 ODs (of 78 ODs total in Cambodia). VMWs operate in 34 of these ODs (Figure 1).

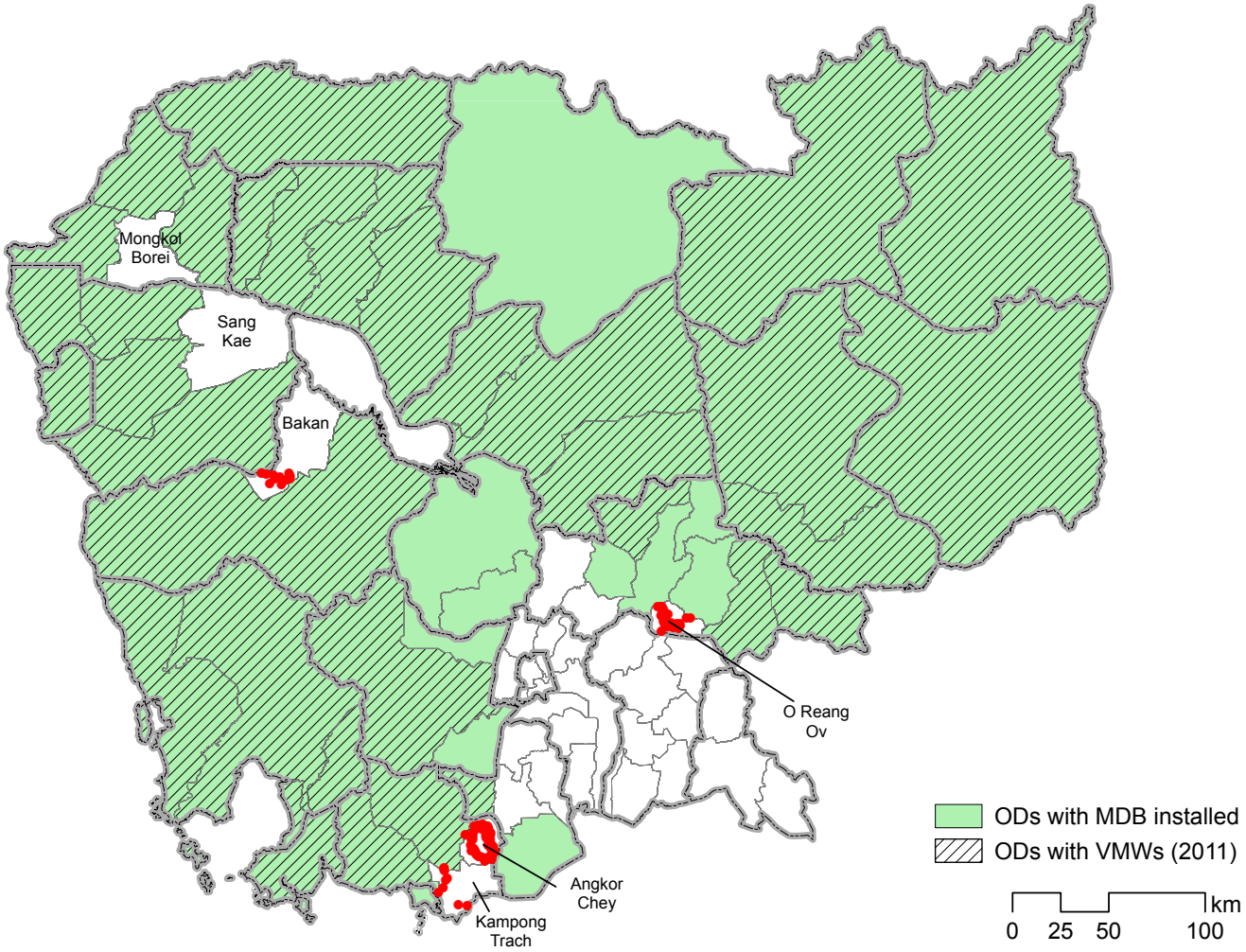
Of the 15,342 registered villages in Cambodia, 9,976 (65%) fall within the MDB ODs. 229 of these are "annex" villages. There are a small number of risk category 1-3 villages falling outside the MDB ODs (n=111) and these are all located in Angkor Chey and Kampong Trach ODs in Kampot, O Reang Ov OD in Kampong Cham and Bakan OD in Pursat (see Figure 1, where the villages are indicated in red).

The MDB incorporates data from 705 health facilities out of a total of 1,148 that exist nationally (Table 1). Most of these (628/705) are health centres (HC) or former district hospitals (FDH), and data from these are routinely included in OD data returns. In addition there are 30 health posts (HP) and 47 referral hospitals (RH) in the MDB ODs but reporting from these facility types is patchy (see below). The subsequent analysis presented in this report only includes data from HCs and FDHs. However, following discussions with CNM it has been decided that any data reported by participating HPs and RHs will be included in subsequent iterations of the stratification.

3. Completeness of the MDB

Of the 705 facilities included in the MDB system, 611 (87%) reported data at some point in 2010-12 (Table 2). The remainder have never reported. Taken together, 92% of FDHs and HCs reported data at some point in 2010-12.

Figure 1. Spatial coverage of MDB system and VMW network in Cambodia in 2011. Villages which have an allocated risk category, but which lie outside MDB ODs, are indicated in red



The MDB was rolled out to individual ODs over a period of several months but all ODs were asked to retrospectively collate village-level data going back to the beginning of 2010. This means that for all health facilities there should be 24 monthly reports available up to the end of 2011. In reality the overall reporting rate for all facilities in the MDB system was 75% in 2010-11 (or 80% when considering HCs and FDHs on their own) (Table 3). Reporting rates were substantially higher in 2011 (at 80.5% overall and 85.8% for HCs and FDHs) than in 2010 (69.5%). It is recommended, therefore, that the stratification is limited to data for 2011.

A plot of the monthly distribution of reporting across all MDB health facilities (Figure 2) shows a marked increase in the overall reporting rate between 2010 and 2011 - but also a fairly dramatic fall in levels of reporting from January 2012. The reasons for this decline need to be determined and addressed if the MDB is to represent a viable method of producing regularly updated stratifications.

Table 1. Health facilities included/not included in MDB, listed by type

Type	Not in MDB	In MDB	Total
FDH	36	65	101
HC	362	563	925
HP	0	30	30
NH	10	0	10
PH	1	0	1
RH	38	47	85
Total	**447**	**705**	**1,152**

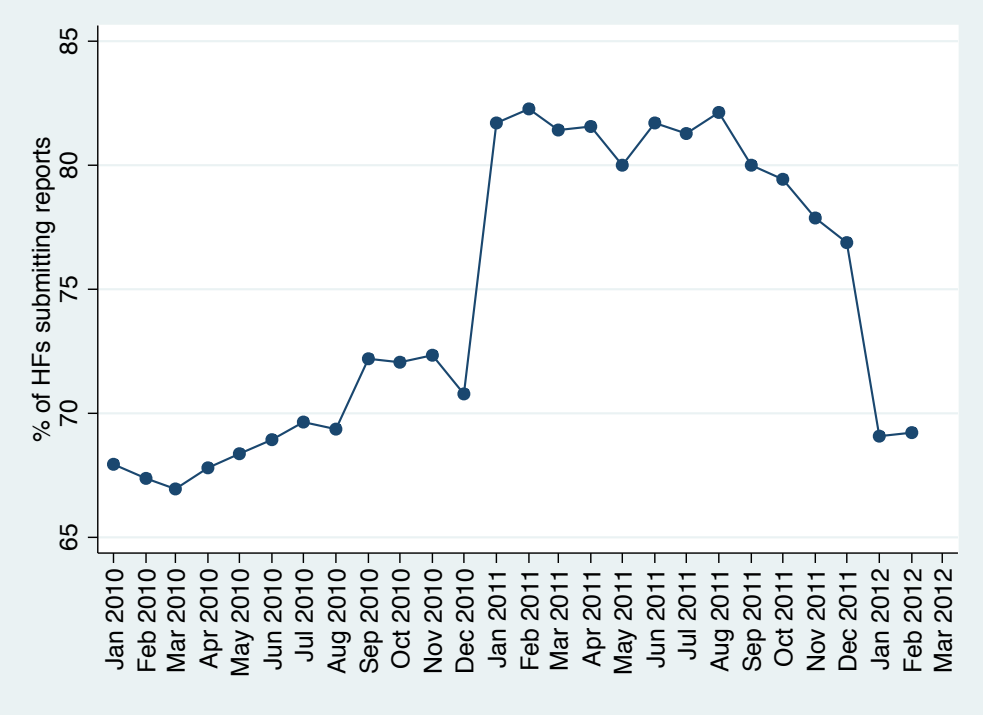
Table 2. Number (and percentage) of health facilities that have reported/never reported, listed by type

	Ever reported?		
Type	**No**	**Yes**	**Total**
FDH	4 (6.15)	61 (93.85)	65 (100)
HC	49 (8.7)	514 (91.3)	563 (100)
HP	21 (70)	9 (30)	30 (100)
RH	20 (42.55)	27 (57.45)	47 (100)
Total	**94 (13.33)**	**611 (86.67)**	**705 (100)**

Table 3. Reporting rate among individual health facilities, differentiated by facility type and reported for 2010, 2011 and the combined period 2010-11

	Reporting rate		
Type	**2010**	**2011**	**2010-2011**
FDH	76.0	86.4	81.2
HC	74.0	85.7	79.9
HP	13.3	16.4	14.9
RH	42.0	51.1	46.5
All types	69.5	80.5	75.0
FDH and HC only	74.2	85.8	80.0

Figure 2. Monthly pattern of reporting rate for all health facilities in the MDB from January 2010-February 2012. The y-axis indicates the proportion if individual facilities submitting reports in any given month



Health facility reporting rates are not uniform across provinces or ODs. OD-specific reporting rates are presented in Figure A1 and Table A1 (Appendix) and temporal patterns of reporting at province level are shown in Figure A2 (Appendix). These indicate a number of "problem" ODs - notably Ratanakiri, Preah Vihear, Stong (Kampong Thom), Sre Ambel (Koh Kong) and Prey Chhor (Kampong Cham).

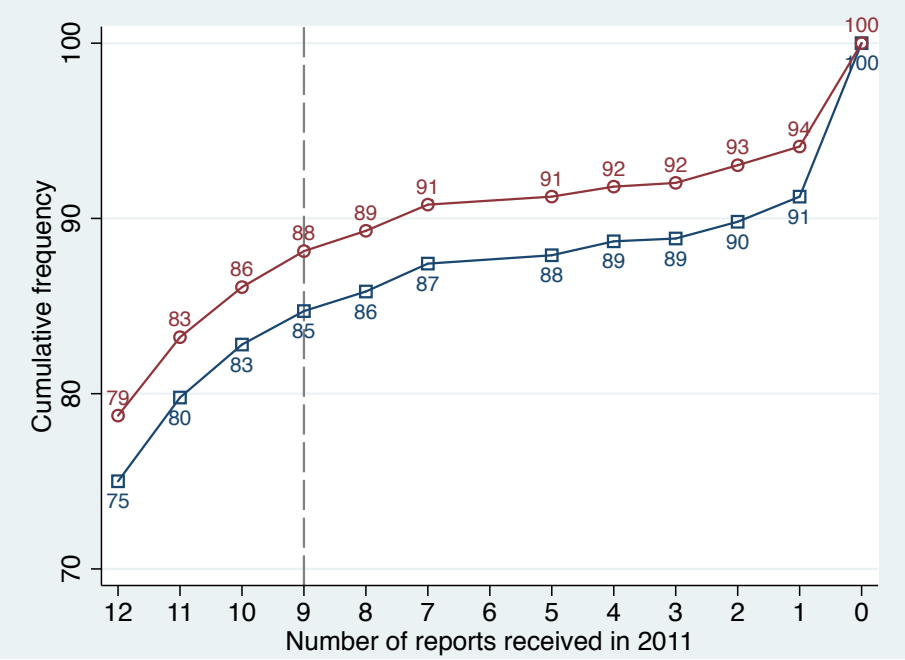
As would be expected, VMW reports within the MDB are relatively complete over the 2010-11 period. The overall reporting rate among all VMWs was 92.5%. Just under three-quarters of VMWS (72%) submitted 12 reports in 2011, while 90% submitted nine or more reports.

4. Inclusion/exclusion criteria for MDB data

For the purposes of the stratification it is clearly optimal to include data from as many villages/health facilities as possible so as to minimise gaps in the spatial coverage of the final product. However, as is evident from Table A1 (Appendix), the percentage of health facilities that can be included in the stratification depends on what is considered "adequate" in terms of data completeness.

The potential trade-off between (a) the number of villages/health facilities that can be included in the stratification on the one hand; and (b) the quality of village-level incidence estimates on the other, is illustrated in Figure 3. The y-axis on the graph indicates the proportion of either health facilities (blue line) or villages (red line) that can be included in the 2011 stratification; the x-axis indicates various data completeness thresholds that can be applied.

Figure 3. Cumulative rate of reporting for all HCs and FDHs in the MDB system in 2011



At one extreme, applying a very strict decision-rule under which only data from facilities with complete reporting (i.e. 12 reports in 2011) is included would mean that 79% of villages (75% of facilities) could be incorporated in the stratification. Making this rule slightly less strict - to include facilities that reported data in 9 or more months - increases the proportion of villages and facilities that can be included in the stratification to 88% and 85% respectively. This fairly substantial increase in coverage would arguably be achieved with little risk to the quality of the resultant village-level incidence estimates. Beyond this, however, “relaxing” the inclusion requirements does not bring about any substantial increase in the number of villages that the stratification would cover, but would probably result in unreliable incidence estimates for some localities.

For the initial stratification product it is therefore recommended that all facilities reporting data for nine months or more be included in the stratification. This threshold may be further refined after discussions with CNM and other stakeholders.

5. Incorporating seasonality

Existing HIS data (2006-11) and VMW data (2008-11) were analysed to determine seasonal patterns in malaria cases (this analysis has so far been restricted to *Pf*. Case data). For both datasets the 6-month window with the highest number of total cases begins in July and around three-quarters of all cases occur in a 7-month period between July and January (Figure 4). To ensure reliable incidence estimates it is therefore important to ensure that a minimum number of contributing months come from this high transmission window. To supplement the main threshold of nine reports over the calendar year (see above) it is suggested that at least five reports should come from within the July-Jan season.

Figure 5 indicates the percentage of health facilities in each OD which meet these combined inclusion criteria (individual facilities and their inclusion/exclusion status are also marked). There is substantial variability between ODs, with some relatively endemic areas (e.g. Ratanakiri, Stung Treng, Preah Vihear) having major gaps in coverage.

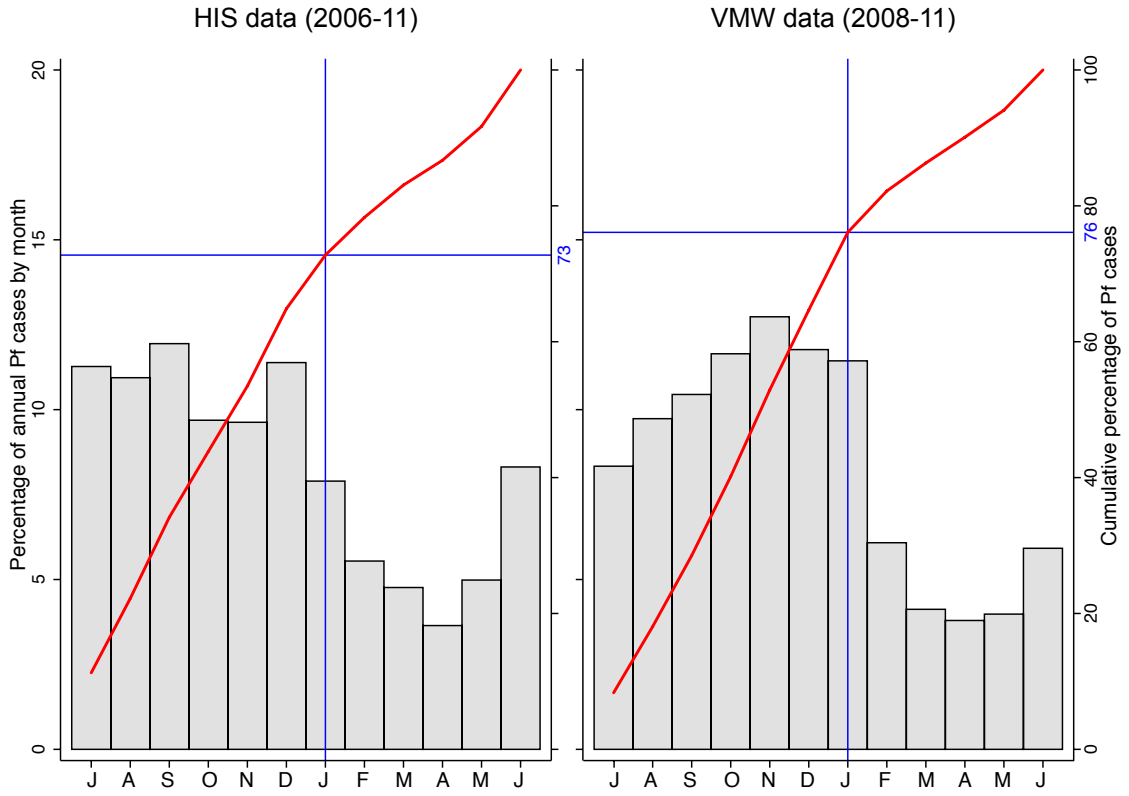
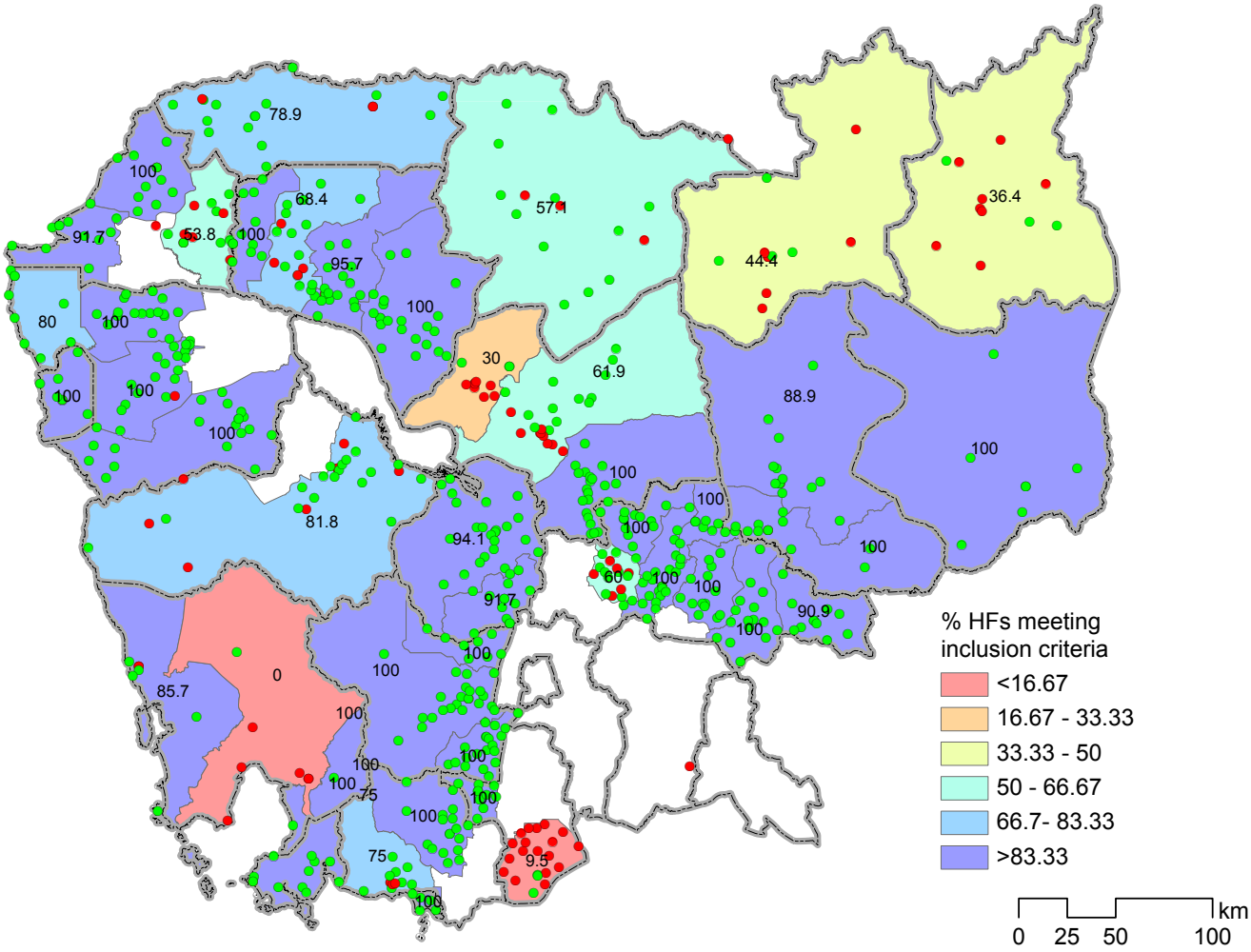


Figure 4. Seasonality plots for Pf based on (a) HIS and (b) VMW data

Figure 5. Percentage of health facilities meeting stratification inclusion criteria, summarised by OD. Points indicate individual facilities (green=included; red=excluded)



6. Matching reported cases to facility- and village-codes

A significant challenge in building up incidence-based stratifications is accurately matching all reported cases to individual facilities and villages. It is inevitable that data will be lost in this process, not least as a result of non-matching identifier unique codes.

Table 4 details the "loss" of case data that occurs as various required datasets are matched up in the stratification process. In 2011 33,218 cases were reported through health facilities according to the MDB. Of these 503 (1.5% of the total) had not been allocated a proper 10-digit village code and as such could not be linked to an individual village. A small number of cases were either not associated with a definitive diagnosis (n=185) or could not be linked to a database village based on their village code (n=21). In addition, 159 cases originated from villages outside the 44 MDB ODs (i.e outside the bounds of the current stratification). The largest sources of loss, however, came about either from (a) cases coming health facilities that had been excluded because of incomplete reporting (n=2,092); or (b) because individual villages lacked population estimates (the denominator for calculating village-level incidence; n=757). The aggregate loss of cases reported through health facilities was 3,717 - or about 11% of the total number of cases reported.

Table 4. Table summarising the total number of malaria cases (all species) reported through health facilities and VMWs and the various sources of data loss during the stratification process

	HF		VMW	
	Cases	Loss	Cases	Loss
Total reported in 2011	33,218		49,058	
Of which have 10-digit village code	32,715	503 (1.5%)	49,058	
Of which have definitive diagnosis	32,530	185 (0.6%)	49,058	
Of which can be linked to a village in DB	32,509	21 (0.1%)	49,058	
Of which lie inside MDB ODs	32,350	159 (0.5%)	49,058	
Of which have submitted 9+ reports	30,640	1,710 (5.6%)	46,632	2,426 (5.2%)
Of which have submitted 5 "key" reports	30,258	382 (1.3%)	46,239	393 (0.8%)
Of which have population data	29,501	757 (2.6%)	44,234	2,005 (4.5%)

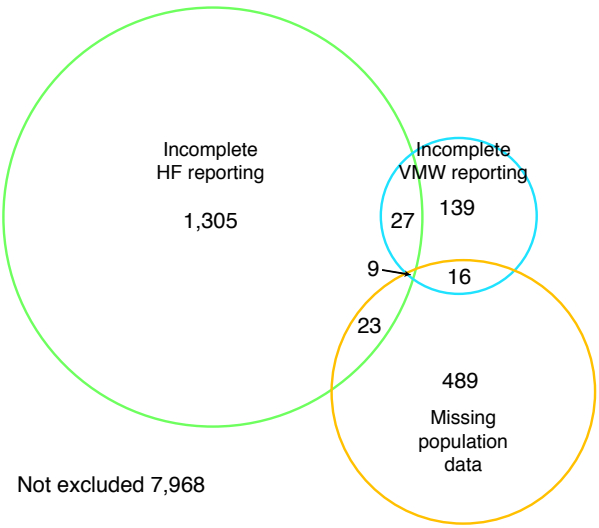
The total number of cases reported through VMWs in 2011 was 49,058. All cases could be matched to individual villages within the MBD zone and all had a definitive diagnosis (Table 4). But a large number of cases (2,771, 5.6% of the total) could not contribute to the stratification because VMWs for those villages had submitted an insufficient number of reports over the year. In addition a large number of VMW villages do not have population estimates, which means incidence cannot be calculated.

Overall, the number of individual villages “lost” from the stratification was 868 (facility data) and 131 (VMW data), representing 16% and 9% of the total number of villages under each reporting system respectively.

7. Preliminary analysis of matched data

Village level incidence rates were calculated for all villages with sufficiently complete case reporting (as per the criteria described above) and a village-specific population estimate. Out of the 9,976 villages within the MDB zone, 2,008 (20%) were excluded from further analysis because of either incomplete HF/VMW reporting or missing population data (Figure 6). Note that 489 villages with sufficiently complete reporting were excluded because of missing population data; these gaps should be relatively easy to fill.

Figure 6. Diagram summarising villages excluded from stratification, with reasons for exclusion

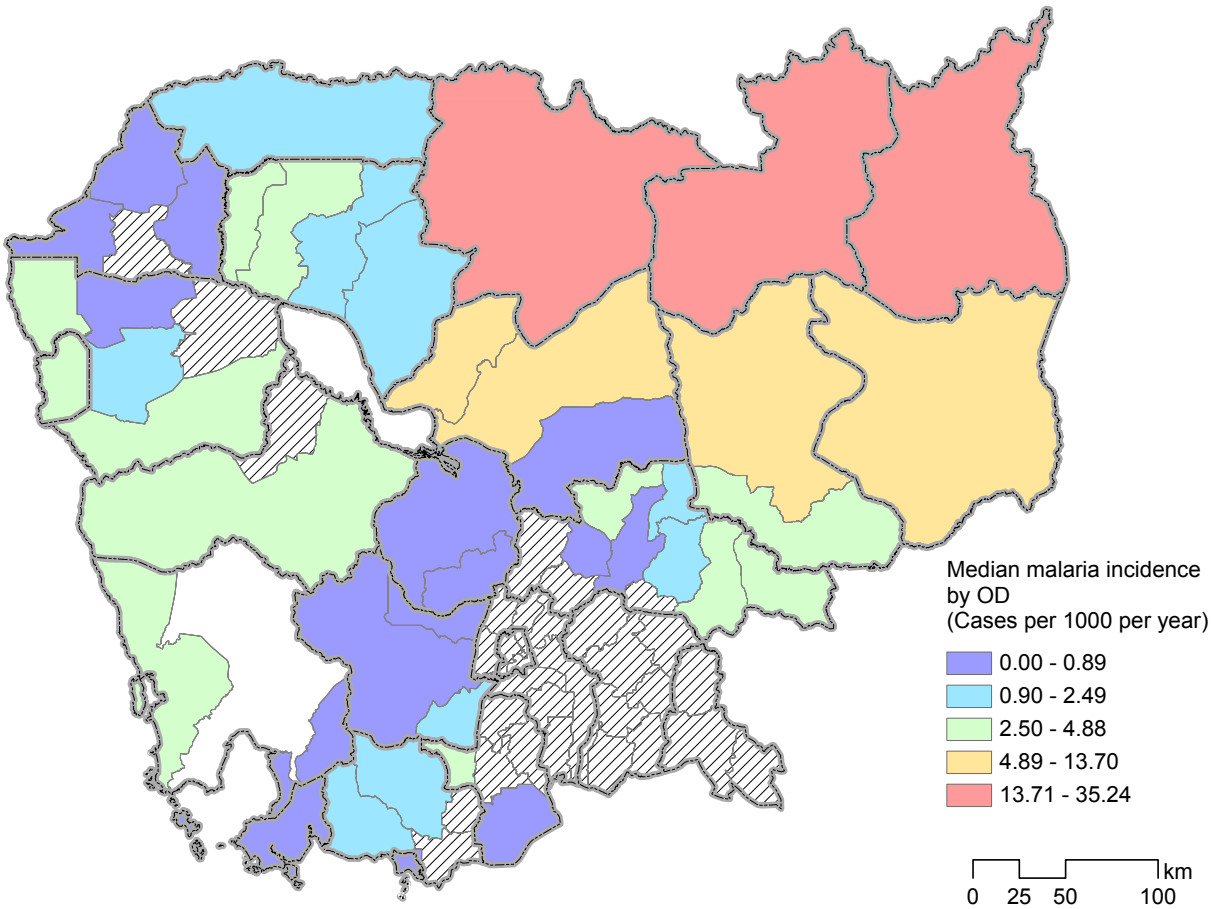


After exclusions there are 7,968 villages that can be included within the initial stratification product. A breakdown of the number of villages falling in various incidence categories is included in Table 5. Almost half of the stratification villages have an annual malaria incidence (any species) of less than 1 case per 1,000 population per year. Around a quarter (24.2%) have an incidence rates in the range 1-5 cases per 1,000 per year, while the remainder (31.4%) have an incidence greater than 5 cases per 1,000 per year. Figure 7 shows median malaria incidence rates by OD and indicates that rates are generally highest in the central-north and northeast areas of the country.

Table 5. Breakdown of incidence categories for stratification villages

Incidence category (Cases per 1000 per yr)	Frequency (%)
<1	3,543 (44.5)
1-5	1,930 (24.2)
5-20	1,434 (18.0)
20-50	538 (6.8)
>50	523 (6.6)
Total	7,968 (100.0)

Figure 7. Median malaria incidence (cases per 1,000 population per year) summarised by OD. Hatched areas indicate ODs falling outside the MDB system



8. Targeting of the MDB and VMW systems

A key early consideration in the stratification process is working out whether the data collection systems that are used as inputs for the stratification actually cover all relevant areas. In the current case that means gauging whether the MDB and VMW systems are appropriately targeted.

To test this, data from the Cambodia HIS (not the MDB) and from the VMW system were combined to provide OD-specific tallies of the total number of malaria cases treated in 2011. The results are shown in Table 6, where ODs are ranked in descending order of the total number of cases treated in that year (any species). The table also indicates whether or not each OD is included in either the MDB system or the VMW system.

Results are encouraging. The top ranked 22 ODs in Cambodia are all included in both the MDB and VMW systems, while none of the 18 lowest ranked ODs host either of these systems. In the mid-range, however, there are some cases that might warrant further investigation. For example two ODs in Banteay Meanchey (Preah Net Preah and Thma Puok) have VMW networks and are included in the MDB, despite having relatively low numbers of treated cases (these ODs are ranked 57 and 60 respectively). Bakan, on the other hand, reports 9-10 times as many cases but has neither VMWs nor a MDB installed.

9. Data interpolation

The stratification exercise has so far demonstrated that (i) current efforts to capture village-level malaria data (through the MDB and the VMW system) are appropriately targeted; and (ii) that within this zone malaria incidence rates can be estimated for a large majority of villages. Within the stratification zone there will always be gaps, however, where village-level incidence cannot be calculated. As reported in Section 7, currently 20% of villages in the target area cannot be allocated an incidence category either because of incomplete reporting or because we do not have population data for these localities. It is therefore necessary to develop a strategy where incidence for these villages can be imputed using other means.

The next stage of the stratification work (in Q3 and Q4 2012) will focus on exploring the best methods for estimating incidence for village where either data for reported cases or village population are missing. Currently there are four main options for doing this:

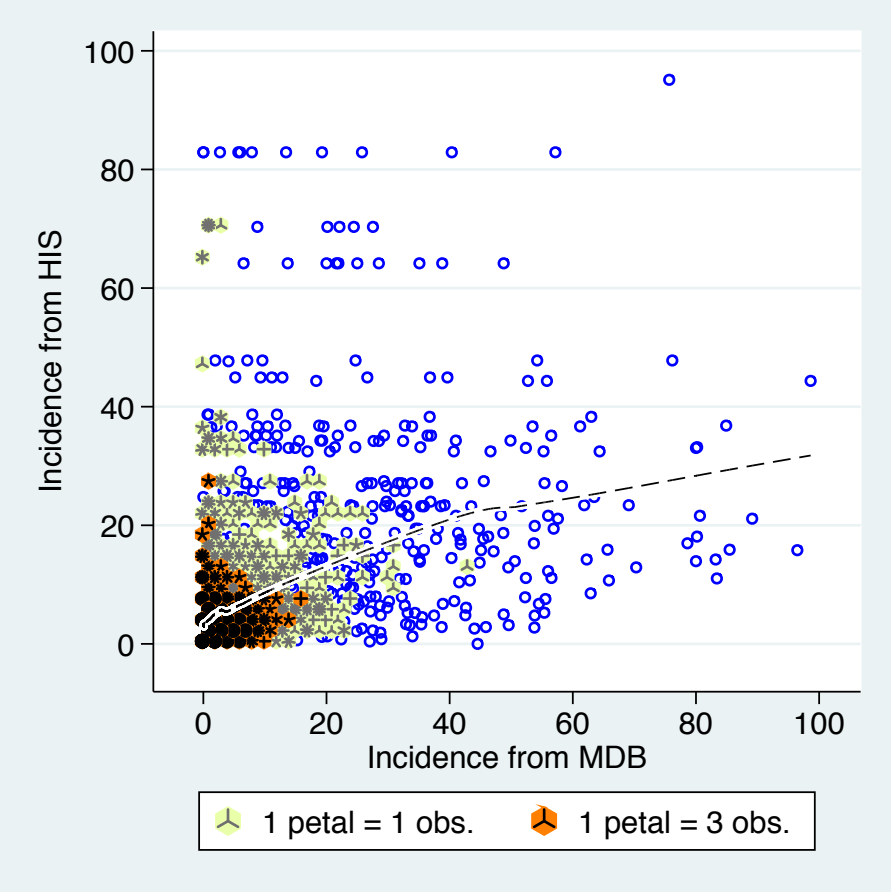
1. Interpolate using data from the routine HIS system

Technically this is probably the easiest solution to implement as it essentially involves calculating an aggregated incidence value across a single health facility catchment. The main disadvantage of this approach is that all villages within a health facility catchment will necessarily have to be allocated to the same incidence category - and this might be unrealistic given the marked spatial heterogeneity that characterises malaria transmission in Cambodia. In addition, because of the way that HIS data are collated, reliable species-specific data are not usually available. Finally, this approach will only work where a reliable catchment population estimate is available (i.e. it will not fill in all the existing gaps).

Table 6. Table showing Cambodia ODs ranked according to total number of malaria cases treated by VMWs or health facilities in 2011. The mean number of cases treated per health facility (including supervised VMWs) is also indicated. Grey shading indicates whether an individual OD is included in the MDB system or VMW network (in 2011)

Rank	Province	OD	MDB?	VMW?	Total treated	No. treated per HF
1	Ratanak Kiri	Ratanakiri	1	1	15,031	1,253
2	Preah Vihear	Tbeng Meanchey	1	1	9,274	442
3	Kratie	Kratie	1	1	8,155	453
4	Stung Treng	Steung Treng	1	1	7,720	772
5	Pursat	Sampov Meas	1	1	7,331	319
6	Oddar Meanchey	Samraong	1	1	5,928	282
7	Kampong Speu	Kampong Speu.	1	1	4,615	201
8	Kampong Thom	Kampong Thom	1	1	4,153	189
9	Mondul Kiri	Sen Monorom	1	1	3,685	461
10	Kampot	Chhouk	1	1	3,585	199
11	Battambang	Battambang	1	1	3,283	137
12	Siem Reap	Sot Nikum	1	1	2,947	123
13	Siem Reap	Siem Reap	1	1	2,915	146
14	Siem Reap	Ankor Chhum	1	1	2,343	130
15	Kampong Cham	Ponhea Krek - Dambae	1	1	2,138	126
16	Kampong Speu	Ou Dongk	1	1	1,778	178
17	Kratie	Chhlong	1	1	1,767	196
18	Kampot	Kampot	1	1	1,567	121
19	Battambang	Mong Russei	1	1	1,516	108
20	Koh Kong	Smach Mean Chey	1	1	1,204	151
21	Sihanoukville	Sihanouk	1	1	1,187	91
22	Kampong Thom	Baray and Santuk	1	1	1,179	59
23	Kampong Speu	Kong Pisey	1	0	1,119	56
24	Kampong Cham	Chamkar Leu - Stueng Trang	1	1	1,105	74
25	Kampong Cham	Memut	1	1	1,013	84
26	Takeo	Ang Rokar	1	1	1,010	92
27	Kampong Cham	Tbong Khmum - Kroch Chhmar	1	0	939	55
28	Kampong Thom	Stong	1	1	928	84
29	Pailin	Pailin	1	1	883	126
30	Siem Reap	Kralanh	1	1	842	84
31	Pursat	Bakan	0	0	832	76
32	Phnom Penh	MOH Central Office	0	0	817	82
33	Battambang	Sampov Luon	1	1	805	89
34	Kampong Chhnang	Kampong Chhnang	1	0	703	41
35	Koh Kong	Srae Ambel	1	1	699	117
36	Kampong Chhnang	Kampong Tralach	1	0	565	47
37	Kampong Chhnang	Boribo	1	0	482	40
38	Kampong Cham	Kampong Cham - Kampong Siem	1	0	441	18
39	Kampong Cham	O Reang Ov - Koh Soutin	0	0	399	40
40	Kandal	Saang	0	0	358	28
41	Kampong Cham	Prey Chhor - Kang Meas	1	0	347	22
42	Phnom Penh	Kandal	0	0	264	53
43	Takeo	Kirivong	1	0	262	12
44	Kampong Cham	Kroch Chhmar - Stueng Trang	1	0	261	22
45	Banteay Meanchey	Ou Chrov	1	1	245	19
46	Battambang	Thma Koul	1	1	242	13
47	Kampong Cham	Choeung Prey - Batheay	0	0	228	14
48	Banteay Meanchey	Mongkol Borei	0	0	210	10
49	Kampot	Kampong Trach	0	0	196	15
50	Takeo	Daun Keo	0	0	179	11
51	Prey Veng	Kamchay Mear	0	0	150	13
52	Kep	Kep	1	0	135	27
53	Battambang	Sangkae	0	0	123	8
54	Svay Rieng	Romeas Hek	0	0	111	11
55	Kampong Cham	Srei Santhor - Kang Meas	0	0	102	7
56	Prey Veng	Preah Sdach	0	0	99	10
57	Banteay Meanchey	Preah Net Preah	1	1	97	7
58	Svay Rieng	Svay Rieng	0	0	90	4
59	Kandal	Muk Kam Poul	0	0	87	11
60	Banteay Meanchey	Thma Puok	1	1	86	7
61	Kampot	Angkor Chey	0	0	79	7
62	Kandal	Takhmau	0	0	79	5
63	Takeo	Prey Kabass	0	0	74	5
64	Kandal	Ksach Kandal	0	0	66	5
65	Kandal	Koh Thom	0	0	66	5
66	Prey Veng	Peareang	0	0	56	3
67	Prey Veng	Neak Loeung	0	0	51	3
68	Takeo	Bati	0	0	46	3
69	Svay Rieng	Chi Phu	0	0	39	4
70	Phnom Penh	Tbong	0	0	34	6
71	Kandal	Kean Svay	0	0	31	2
72	Phnom Penh	Lech	0	0	29	5
73	Prey Veng	Mesang	0	0	23	2
74	Prey Veng	Prey Veng	0	0	20	1
75	Prey Veng	Kampong Trabek	0	0	16	1
76	Kandal	Ang Snuol	0	0	9	1
77	Kandal	Ponhea Leu	0	0	4	0
78	Phnom Penh	Cheung	0	0	2	0

Figure 8. Sunflower scatter plot showing the relationship between malaria incidence estimates for 2011 derived either from MDB data (x-axis) or routine HIS data



These issues are currently being explored. Figure 8, for example, shows a scatterplot of malaria incidence for individual villages estimated using either village-specific data from the MDB (x-axis) or catchment-level data taken from the routine HIS system (y-axis). The graph only shows villages where (a) no VMW system exists; (b) where estimated incidence is less than 100 cases per 1,000 per year (essentially to aid visual interpretation). The graph indicates that incidence estimates derived from HIS, catchment-level data tend to be substantially lower than corresponding estimates from the MDB system. When these incidence estimates are used as a basis for allocating villages to the incidence classes presented in Table 5, there is 50% agreement between the two methods. However, in 35% of cases villages are allocated to a lower incidence category when using MDB data as an input, compared to when HIS data are used.

The matrix in Table 7 shows the agreement/disagreement between the incidence categories allocated to individual villages depending on whether village-specific MDB data or catchment-wide HIS data are used as an input. The resultant kappa statistic from this matrix is 0.27, indicating “fair” agreement only.

Work is currently continuing to further validate this approach.

Table 7. Matrix showing agreement/disagreement between incidence classification of individual villages using MDB and HIS data inputs. The resultant kappa coefficient is 0.27, indicating a "fair" level of agreement between the estimates

Incidence class (MDB estimate)	Incidence class (HIS estimate) 1	2	3	4	5
1	1,785	1,230	388	59	19
2	324	980	436	65	5
3	59	422	526	118	8
4	4	32	124	72	14
5	0	3	24	34	3

2. Spatial interpolation

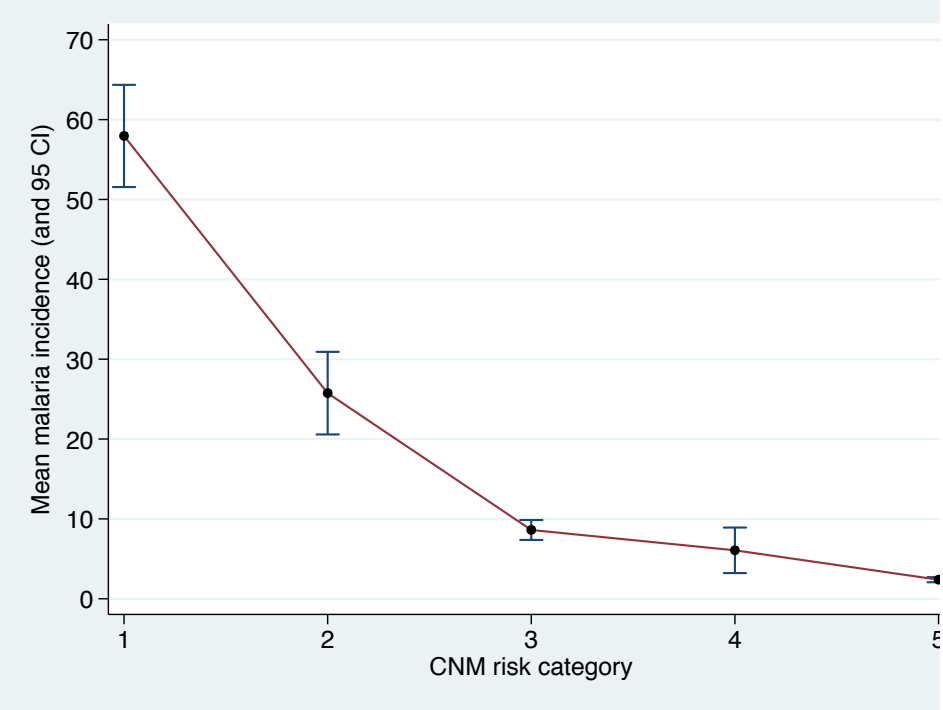
Given the distinct and defined spatial structure of malaria risk in Cambodia, there may be some value in exploring spatial statistical methods (e.g. Kriging) as a means of interpolating incidence for villages currently missing estimates. The potential advantage of this approach is that is represents an objective, repeatable method that takes into account existing spatial patterns in transmission. However, it may be that this approach is not well suited to situations where data are missing from large geographical tracts (as may be the case where catchments are large, or where several contiguous catchments with missing values exist). Also, this approach may only be viable if environmental covariates are included in the spatial model – in which case it is unlikely to be suited to routine implementation.

3. Using existing risk categories

Cambodia already has a stratification system under which all villages in relevant ODs are allocated a risk status based on expert opinion. The disadvantage of this approach is that it is subjective and not easily reproducible (hence the rationale for a new data-informed stratification based on observed incidence). However, there may be some scope for maintaining the current approach and using it (a) as a primary method for gap-filling; and (b) as a comparator for incidence-based risk categories.

There are currently four main risk categories under the current stratification system in Cambodia ("1" indicates highest risk; "4" lowest). Originally these were based on village distance to forest, but over time the system has been refined to take on more nuanced perceptions of local transmission risk. Interestingly, when malaria incidence estimates (from MDB data) are plotted against the existing CNM risk system (Figure 9) there is very strong agreement. Moreover, the observed ranges of incidence for each risk category match closely the categories of incidence used previously (in Table 5).

Figure 9. Variation in mean malaria incidence in 2011 with current village risk categories allocated under the existing CNM stratification system



4. Developing new approaches to incorporating expert opinion
In the coming months we will work with CNM to explore each of the primary potential approaches for gap filling as outlined above. In parallel it is necessary to develop a routine, reproducible approach for user-refinement of any incidence-class estimates that are generated both from the primary MDB data and from whatever method is used to impute missing data. Ideally this would involve participation of stakeholders at OD level as well as CNM staff members.

10. Summary and next steps
Work to date has focused on developing data analysis approaches that can combine information from a range of sources to produce viable village-level estimates of malaria incidence. As part of this process it has been demonstrated that existing sources of information (the MDB village-level reporting system and the VMW network) provide suitable data for stratification and that the spatial coverage of these systems is appropriate for developing products at the national level.

Based on inclusion/exclusion criteria defined in this document it is currently possible to derive specific incidence rates (for 2011) for 80% of villages in the 44 ODs that currently represent the limits of the required stratification. Work to develop suitable approaches for estimating incidence in villages that currently lack sufficient case data or population estimates is ongoing. Work in the next quarter will focus on refining these approaches and developing core functionality within the MDB to automatically generate updated incidence estimates (in tabular and map form). Parallel discussions with CNM staff will focus on developing standard approaches for incorporating stakeholder expert opinion as a means of refining village risk estimated generated via the MDB system. Discussions will also focus on how best to ensure the sustainability of the MDB system (and associated stratification products) going forward.

Appendix

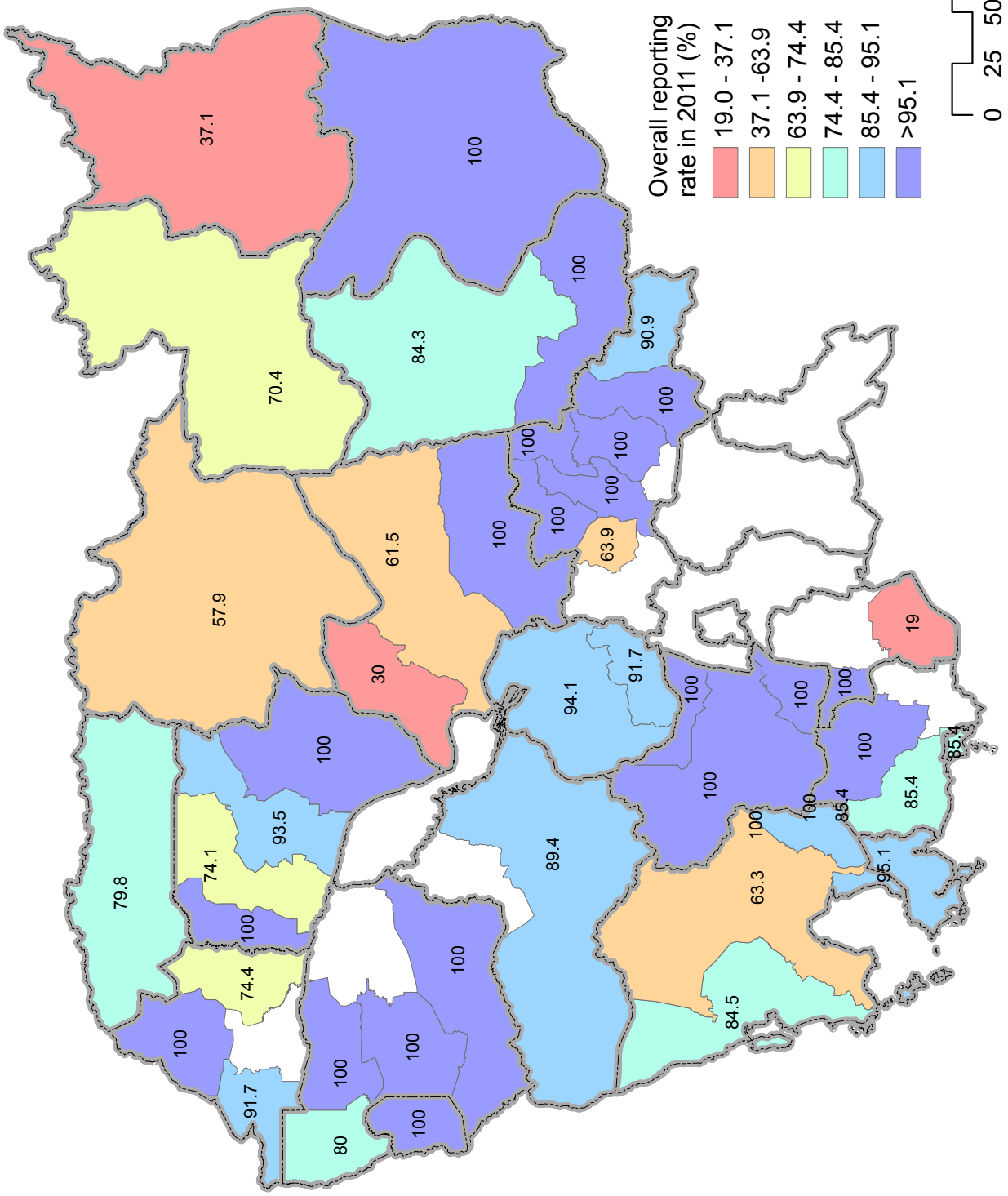


Figure A1. Reporting rates per OD in 2011. The map shows the combined percentage of reports received taking into consideration HCs and FDHs only.

Table A1. Percentage of HCs and FDHs in each OD reporting data for 12 months, 9+ months, 6+ months or 1+ months in 2011

Province	OD	No. of facilities	12 months		9+ months		6+ months		1+ months	
			HFs	%	HFs	%	HFs	%	HFs	%
Banteay Meanchey	Ou Chrov	12	11	92%	11	92%	11	92%	11	92%
Banteay Meanchey	Preah Net Preah	13	0	0%	7	54%	13	100%	13	100%
Banteay Meanchey	Thma Puok	10	10	100%	10	100%	10	100%	10	100%
Battambang	Battambang	23	23	100%	23	100%	23	100%	23	100%
Battambang	Mong Russei	13	13	100%	13	100%	13	100%	13	100%
Battambang	Sampov Luon	10	8	80%	8	80%	8	80%	8	80%
Battambang	Thma Koul	17	17	100%	17	100%	17	100%	17	100%
Kampong Cham	Chamkar Leu - Stueng Trang	15	15	100%	15	100%	15	100%	15	100%
Kampong Cham	Kampong Cham - Kampong Siem	23	23	100%	23	100%	23	100%	23	100%
Kampong Cham	Kroch Chhmar - Stueng Trang	11	11	100%	11	100%	11	100%	11	100%
Kampong Cham	Memut	11	10	91%	10	91%	10	91%	10	91%
Kampong Cham	Ponhea Krek - Dambae	16	16	100%	16	100%	16	100%	16	100%
Kampong Cham	Prey Chhor - Kang Meas	15	8	53%	9	60%	9	60%	13	87%
Kampong Cham	Tbong Khmum - Kroch Chhmar	16	16	100%	16	100%	16	100%	16	100%
Kampong Chhnang	Boribo	11	8	73%	8	73%	8	73%	11	100%
Kampong Chhnang	Kampong Chhnang	17	16	94%	16	94%	16	94%	16	94%
Kampong Chhnang	Kampong Tralach	12	11	92%	11	92%	11	92%	11	92%
Kampong Speu	Kampong Speu.	22	22	100%	22	100%	22	100%	22	100%
Kampong Speu	Kong Pisey	19	19	100%	19	100%	19	100%	19	100%
Kampong Speu	Ou Dongk	9	9	100%	9	100%	9	100%	9	100%
Kampong Thom	Baray and Santuk	19	19	100%	19	100%	19	100%	19	100%
Kampong Thom	Kampong Thom	21	12	57%	13	62%	13	62%	13	62%
Kampong Thom	Stong	10	3	30%	3	30%	3	30%	3	30%
Kampot	Chhouk	17	17	100%	17	100%	17	100%	17	100%
Kampot	Kampot	12	9	75%	9	75%	10	83%	12	100%
Kep	Kep	4	0	0%	4	100%	4	100%	4	100%
Koh Kong	Smach Mean Chey	7	5	71%	6	86%	6	86%	6	86%
Koh Kong	Srae Ambel	5	0	0%	1	20%	5	100%	5	100%
Kratie	Chhlong	8	8	100%	8	100%	8	100%	8	100%
Kratie	Kratie	18	11	61%	16	89%	16	89%	16	89%
Mondul Kiri	Sen Monorom	7	7	100%	7	100%	7	100%	7	100%
Oddar Meanchey	Samraong	19	12	63%	15	79%	15	79%	16	84%
Pailin	Pailin	6	6	100%	6	100%	6	100%	6	100%
Preah Vihear	Tbeng Meanchey	21	10	48%	12	57%	12	57%	13	62%
Pursat	Sampov Meas	22	8	36%	20	91%	22	100%	22	100%
Ratanak Kiri	Ratanakiri	11	1	9%	4	36%	4	36%	6	55%
Siem Reap	Ankor Chhum	19	6	32%	14	74%	16	84%	16	84%
Siem Reap	Kralanh	9	9	100%	9	100%	9	100%	9	100%
Siem Reap	Siem Reap	23	20	87%	22	96%	22	96%	22	96%
Siem Reap	Sot Nikum	23	23	100%	23	100%	23	100%	23	100%
Sihanoukville	Sihanouk	12	6	50%	12	100%	12	100%	12	100%
Stung Treng	Steung Treng	9	1	11%	6	67%	8	89%	8	89%
Takeo	Ang Rokar	10	10	100%	10	100%	10	100%	10	100%
Takeo	Kirivong	21	2	10%	2	10%	2	10%	13	62%

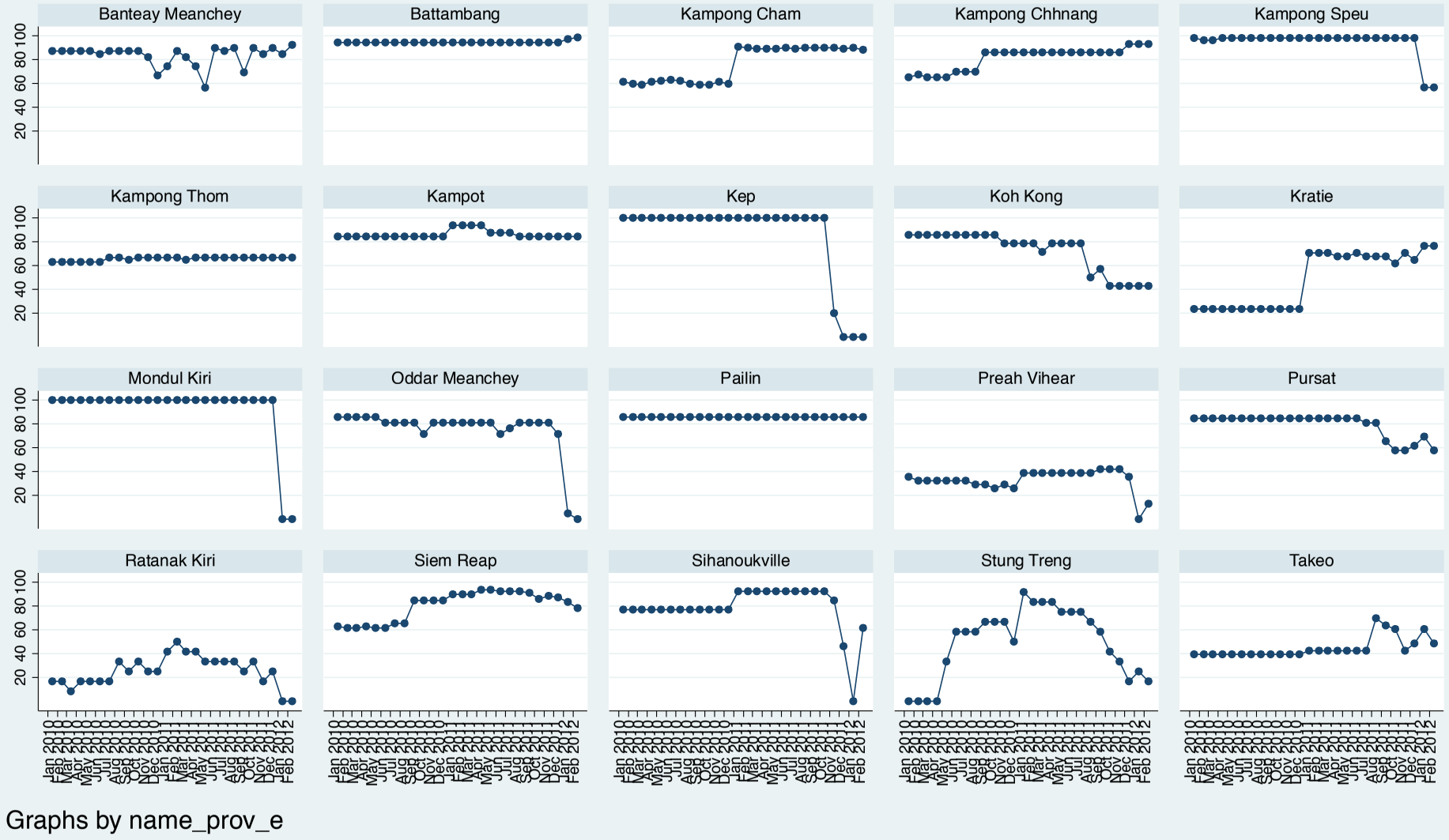


Figure A2. Monthly pattern of reporting rate for all health facilities in the MDB from January 2010-February 2012, by province. The y-axis indicates the proportion if individual facilities submitting reports in any given month