

**Table 4: Determinants of VMWs' service quality**

	Beta coefficient	SE	t	p-value
Occupation	0.558	0.187	2.98	0.003
Length of VMW career	0.007	0.003	2.28	0.023
Reason for becoming VMW	-0.649	0.089	-7.33	<0.001
Knowledge of malaria transmission	0.989	0.136	7.30	<0.001
Knowledge of vector species	0.307	0.151	2.04	0.042
Knowledge of vector breeding places	0.574	0.139	4.13	<0.001

(Adjusted R<sup>2</sup> = 0.4815 for the best model by backward elimination)

malaria transmission and vector breeding places was associated with more variety of actions.

From the two regression models described above, occupation, reason for becoming a VMW, knowledge of malaria transmission, and knowledge of vector breeding places were found to be important determinants for both the quality of VMWs' services and VMWs' actions for malaria prevention and vector control.

**Discussion**

This study revealed that almost all VMWs were able to conduct diagnosis with RDTs and prescribe anti-malarials to those who had positive RDT results, skills that they had acquired through the VMW training programmes organized by the CNM. However, other service items were not performed well, and VMWs' actions for malaria prevention and vector control and knowledge of malaria epidemiology and vector ecology were limited. In fact, active detection, explanations about compliance, and follow-up of patients were carried out by only a small proportion of VMWs. Dissemination of preventive measures focused primarily on bed net use, and about 20% of the

VMWs spread wrong information about the transmission route. The variety of actions that VMWs took for malaria prevention and vector control was small, and their knowledge was extremely limited, with less than 20% of the VMWs giving correct answers to six out of seven questions on malaria epidemiology and vector ecology.

Several studies have described weaknesses in the community health worker approach in low- and middle-income countries. For example, one review concluded that community health workers did not consistently provide services that were likely to have substantial effects on health and that quality was usually poor [18,21]. A recent study reported poor performance of Village Health Workers in Viet Nam, a neighbouring country of Cambodia. It suggested that weaknesses in their malaria management were attributable to several underlying influences, including insufficient time to complete duties outside of normal working hours, inadequacies in pre- and in-service training, and some delays in rolling out the new guidelines for drugs in Village Health Worker kits [14].

**Table 5: Determinants of the variety of VMWs' actions for malaria prevention and vector control**

	Beta coefficient	SE	t	p-value
Occupation	5.634	0.961	5.86	<0.001
Most recent VMW training attended	-0.168	0.044	-3.79	<0.001
Reason for becoming VMW	-1.966	0.458	-4.30	<0.001
Knowledge of malaria transmission	2.185	0.706	3.09	0.002
Knowledge of vector breeding places	3.749	0.717	5.23	<0.001

(Adjusted R<sup>2</sup> = 0.3948 for the best model by backward elimination)

A number of studies have discussed different kinds of strategies for improving health-worker performance. A recent review reported that the simple dissemination of written guidelines is usually ineffective, supervision and audit with feedback is generally quite effective, and multi-faceted approaches (e.g., training plus supervision) may be more effective at changing practices than single-component interventions [13]. The importance of supervision is particularly emphasized because it can improve performance at least in the short-term [22], provide professional development, and improve health workers' job satisfaction and motivation [23].

One possible strategy to expand the range of VMWs' services and to improve their actions and knowledge would be to strengthen the VMW training curriculum. Since most of the VMWs were able to accomplish what they had learned in VMW trainings, there is a good possibility that improved training programmes could achieve wider service range and higher service quality. Although VMWs' services have been focused on diagnosis and treatment so far, they should be expanded to other aspects of malaria control, including prevention and vector control. In fact, regression analyses of this study demonstrated that knowledge of malaria transmission and that of vector ecology, especially regarding vector breeding places, are significant determinants for both VMWs' service quality and actions for malaria control. This is possibly because overall understanding of malaria control, including both malaria epidemiology and vector ecology, is necessary to provide better service quality and more actions. In order to further promote community-based malaria control in Cambodia, the range of VMWs' services should be widened to cover more aspects of malaria control, and VMWs should take the initiative in conducting a greater variety of measures for malaria prevention and vector control.

Specifically, the current VMW training curriculum can be improved by: 1) making its contents easier to understand for VMWs with limited education (three years of school education on average), especially technical terms, tables, and figures in flipcharts, leaflets, and handouts, 2) including a variety of topics regarding malaria and vector control, and 3) adding more participatory activities to provide hands on experience. Although there is a need to break away from an old paradigm that performance can be improved by training alone [13], some modifications in the curriculum and inclusion of more participatory activities in the training could lead to the acquisition of accurate knowledge and skills among VMWs in the long run. Further research is now underway to examine the effectiveness of a new training programme developed based on the results of this study in achieving higher VMW service quality.

As described in previous studies [13,22,23], strengthening supervision in combination with modifying the training curriculum might be effective in improving VMWs' service quality. Currently, supervision is conducted by the CNM staff in two ways: monthly meetings at health centers in each region and village visits twice a year. In monthly meetings, CNM staff check VMWs' records of fever cases and RDT positive cases, and resupply RDT kits and anti-malarials. They also visit each VMW village twice a year to directly monitor VMW activities and observe their relationship and communication with villagers. In addition to these components of current supervision, providing VMWs with opportunities to review their knowledge of malaria control (especially prevention) and to share their experiences and challenges could be an effective means to improve their knowledge and motivation. Also, increasing the frequency of village visits could facilitate professional development and improve the two-way flow of information between VMWs and the central government.

Some limitations of this research must be taken into account when interpreting study findings. To evaluate VMWs' service quality, only self-reported data were used, and actual villagers' experiences were not taken into account. This limitation can partly be covered by another recent study, which examined VMWs' service quality using data obtained from villagers. The validation of self-reported indices regarding service quality and action needs improvement. However, possible attempts were made: for example, self-reported data were double-checked with VMWs' records in their monthly reports, which are submitted to the CNM regularly. In addition, objective information about VMWs' service quality was obtained from local health workers as much as possible.

Several Asian and African countries are currently investing in community health workers as a major part of their strategies to reach the Millennium Development Goals [18]. For example, nearly 25,000 community health workers have been trained in Ethiopia and are delivering family planning, immunization, and health education to their communities [24]. In India, state-wide community health worker programmes are under way as a part of the National Rural Health Mission. Furthermore, several trials have been carried out to expand community health workers' roles. For example, the role of 54,000 women community volunteers in India evolved over time into two different sets of activities: one focuses on child survival and the other on women's empowerment and community action [25]. Also, a trial to expand Cambodian VMWs' role to the management of diarrhoea and acute respiratory diseases started in 2005 [11]. Since there is substantial interest in the potential contributions of community health workers to reach the Millennium Develop-

ment Goals, it is timely and vital to examine their performance and propose effective strategies to support them in their work and to improve the quality of their services in different settings.

## Conclusions

This study has demonstrated that Cambodian VMWs' services focused narrowly on diagnosis and treatment, and that their knowledge of malaria epidemiology and vector ecology as well as actions for malaria prevention and vector control require substantial improvement. Knowledge of malaria transmission and that of vector breeding places were found to be significant determinants of both VMWs' service quality and actions for malaria prevention and vector control. In addition to diagnosis and treatment, which have been the focus of VMWs' services so far, more aspects of malaria control should be covered in their training to further promote community-based malaria control in the country.

## Competing interests

The authors declare that they have no competing interests.

## Authors' contributions

JY conceived the study, developed the questionnaire, analysed data, and wrote the manuscript. KCP contributed to the study design, trained surveyors, conducted fieldwork, and improved the manuscript. KPT entered and analysed data and improved the manuscript. CN, PL, and DS supervised fieldwork. MJ monitored the study progress and provided guidance to improve the manuscript. All authors read and approved the final draft.

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